Dieter Unger

Lifts and Escalators

A user manual

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Contents

1 Historical facts about lifts

It is unknown when the first lift was installed in the early days of the earth's history. However, even in ancient times there were some aids in the form of levers or ropes with pulleys to lift heavy objects.

In 1586 the engineer Domenico Fontana built a pulley block in St. Peter's Square in Rome to erect an obelisk. The pulley block and its use remained unchanged until 1861.

When exactly this principle was implemented for the construction of an lift is not known. In 1853, the founder of the Otis Lift Company, Elisha Graves Otis, introduced a fall-safe lift. Otis had a lift platform ride up and the only suspension rope was cut by his assistant. The lift did not crash, but braked by itself. This was a decisive breakthrough, because the invention of this safety gear made it possible to build lift systems much safer, because until then there had been numerous accidents with crashed lifts, many of which ended fatally.

With this new invention, it was now possible to construct much higher buildings than was usual at the time, as it was now possible to approach much more floors of a building with one lift, because the safety gear made the lift system safer.

It was not until the 1870s that the lift was used in Europe, after it was presented at the 1867 World Fair in Paris. In 1880 the first electric lift was presented in Mannheim by Werner von Siemens [1]. From this point on, further development of the lift and its components began. The attempt to push the systems to the limit and push the limits has been shown in many things. Be it through the shape of, for example, polygonal cars, cars made of glass or other materials, or through new technologies such as alternative suspension means.

Currently (year 2023) the highest lift is located in Dubai, the Burj Khalifa. With a height of more than 828 m and 163 landings, there are 57 lifts inside with a travel height of up to 504 m and a speed of up to 10 m/s. It is only a question of time when the next skyscraper will be built with lift systems that have an even greater travel height than is technically possible today.

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1.1 Lift Companies

There are about 850 lift companies in Germany. In addition to the four large world market leaders Otis, Kone, Schindler and tke, referred to below as the Big 4, there are many small and medium-sized companies that are only active regionally. Some larger medium-sized companies such as Schmidt & Sohn, OSMA or Haushahn, located in Germany, also operate nationwide. Furthermore, Japanese manufacturers such as Mitsubishi or Fujitec are also represented in Europe and in Germany.

How many lift companies in the world are existing is not known. But all four market leader are present in almost all countries of the world. In Europe there are some mid-size companies like Orona, which is basically located in Spain and with distributions in UK, France and the Benelux.

1.2 The Profession of Lift Installer

The lift systems are installed by the new equipment installers. Service technicians take care of the lift systems after the lift has been putting into service during operation time. In accordance with a German national guideline DGUV Information 209-053 Activities on lift systems", they can work as experts in materials handling technology if they have preferably been trained in the profession of mechatronics technician as well as specialist training in the field of lift technology. Training in a metalworking or electrical profession as well as instruction in the other specialist area and specific training in lift technology are also recognized [2].

In the past, service technicians with training as metalworkers were mainly used for these activities. However, with the increasing importance of microprocessor technology, electronics has gained in importance, so that nowadays training exclusively in the metalworking trade is no longer sufficient. For this reason, more and more people with an electrical engineering education were employed in this field. With the introduction of the mechatronics technician as an apprenticed profession in Germany, which combines the knowledge of an electrical and metal profession, this occupational profile has become increasingly interesting for lift companies.

While additional training is required to introduce journeymen from other fields to the activities of an lift mechanic or lift service technician, this job description of an lift mechanic was trained and practiced in the former German Democratic Republic (GDR) as a skilled worker until 1990.

References

1. Lifts and escalators; technology, planning, design, Oliver Bachmann, Verlag Moderne Industrie, 1992
2. DGUV Information 209-053—Activities on lift systems, February 2017

2 Standards and Guidelines for Lifts

There is a large number of regulations, guidelines and standards which are important for the design, construction and operation of lift systems.

The following pages are only intended to give a brief overview from the author's point of view of the most important regulations, directives and standards. It should be shown in which standards and regulations environment an employee from the field of conveyor technology, operators of lift systems or a planner/architect should work during the planning process. The consideration of these regulations and standards should be applied in the daily work. Furthermore, they should enable the user, be it the service technician or the owner of lift systems, to better understand and discuss problems in the field of conveyor technology. It is essential that solutions are sought taking these regulations and standards into account.

Figure 2.1 shows schematically which regulations, directives and standards have a bearing on the subject of lift systems in Europe. The regulations, directives and standards presented do not represent completeness, but only the parts that are partially addressed in this book. In other non-European countries the influence is different, but also some national guidelines, codes and standards have to be followed.

2.1 National Regulations for Putting into Service/during Lifetime in Different Countries

There are various national regulations for the operation and testing of lift systems worldwide. Below are some examples of such kind of regulations in some coutries/continents.

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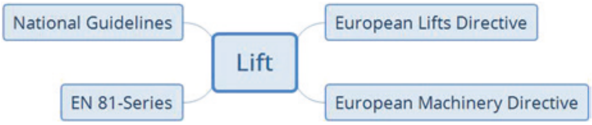

Fig. 2.1 Overview of some important directives and standards for lift systems in Europe

2.1.1 Europe

This chapter describes the procedure for putting a lift into service in Europe:

1. If the operator decides to purchase a lift system, it must comply with the Lifts Directive (2014/33/EU). This directive specifies the essential health and safety requirements that must be met. For example, this directive is considered to be fulfilled if a lift installation complies with a relevant harmonized standard, for example EN 81-20 (presumption of conformity).
2. If the operator has commissioned a lift company to design and install a lift system for him, he must make the necessary arrangements with the lift company (manufacturer) regarding the type of use of the system. What is to be transported, what ambient conditions are present? This is regulated in EN 81-20, 0.4.2.
   Note: It is advisable not to engage the contractor until it is clear which lift company will build the lift. This is because the required dimensions for the well are only defined by the lift company. With this information, the architect can enter the data in the construction plans as specifications from the building contractor.
3. When the lift system has been installed and is ready for handover, a declaration of conformity with a prior conformity assessment procedure must be carried out. This is to check whether the lift system complies with the basic health and safety requirements of the lift directive. The conformity assessment procedure is carried out by the Notified Body (NB). The lift manufacturer is responsible for commissioning this procedure. The lift manufacturer receives the EU certificate of conformity after successful completion of the conformity assessment procedure. He can then sign an EU Declaration of Conformity. This procedure is regulated in the Lifts Directive. There are also manufacturers who can carry out the conformity assessment procedure themselves. This is also regulated in the Lifts Directive and places additional requirements on the manufacturer. Under European law, the lift system may now be put into operation.

2.1.2 Germany

After declaration of conformity it is not allowed to put the lift into service in Germany. Before the owner could do that, a third party has to check the lift system. According to the “Ordinance on Industrial Safety and Health (BetrSichV)”, the third party has to check, the technical documentation, the lift system and the emergency call system. It is not allowed to check points, which have been already checked during conformity process. If everything is ok, the third party put an inspection sticker in the car. After that procedure, the owner can switch on the lift system.

During the lifeteime in Germany the "Ordinance on Industrial Safety and Health (BetrSichV)" regulates safety and health protection in the provision of work equipment and its use at work, safety in the operation of systems requiring monitoring and the organisation of occupational health and safety.

Instead of state specifications of e.g. the inspection intervals, since the introduction of the BetrSichV the **operator** is responsible for the determination of sufficient intervals. Since the BetrSichV came into force, the operator has therefore had a much greater responsibility.

A big inspection by third party has to be done every two years, in the years between only a small inspection.

2.1.3 South Korea

In South Korea, the elevator facilities safety management act defines the requirements for the owner. The aim of this Act is to ensure the safety of elevator installations. The inspection of an elevator should be done after completion of installation. Regular inspection after completion of installation not be longer than two years.

Irregular inspections are also defined after changing the following:

- type
- control mode
- rated speed
- rated capacity

2.1.4 India

In India, each district has its own regulations. Below are examples of some regulations in some districts on the different types of frequency of maintenance of a lift system.

The Maharashtra Lifts, Escalators and Moving Walks Act, 2017
In Maharashtra District every lift shall be inspected periodically at least once a year. The owner of a lift have to agree to a contract with an approved contractor for maintenance, cleaning, oiling, adjusting and repairing of he lift.

The Bombay Lift Act, 1939
This act is regulating the Union Territory of Delhi. It defines the amount of maintenance (every six month) and the application of a licence to use a lift by the owner.

The Assam Lifts and Escalators Act, 2006
In the Assam district, the lift must be inspected every six month by a authorized person and every three years by the State Government.

Below are some other regulations for different districts:

- The Himachal Pradesh Lifts Act, 2007
- The Haryana Lifts and Escalators Act, 2008
- The West Bengal Lifts And Escalators Act, 1955
- The Kerala Lifts and Escalators Act, 2013
- The Karnataka lifts act, 1974

2.1.5 Singapore

In Singapore the Building maintance and strata act defines the duties of the owner regarding maintenance and inspections.

2.1.6 Australia & New Zealand

At handover to the client there is final commissioning and inspection which is required under the WH&S act & regulations for 'high risk plant' and the lift industry uses a STO (safe to operate) certificate for the customer but this is not mandatory. There are very few 3rd party inspections on lifts at handover as the industry in Australia is self-regulating. Maintenance is required under WH&S act & regulations as well but its not stipulated or written down as to what and when. Generally speaking though the lift industry in Australia would do maintenance at least once a year. Most sites have maintenance contracts which stipulate the amount of visits or call rate requirements.

Most inspections are in house unless specified in the contracts for either installation or maintenance. Queensland however does have 3rd party inspections at time of handover. There is also a lot of industry consultants who make a living advising clients on final installation and maintenance.

The owner of a lift is responsible under WH&S for the safety of users and Risk assessment are under taken for certain issues. WH&S mandates, that owner must maintain, repair and modernize lifts to ensure the ongoing safety of the building and plant.

2.1.7 United States

All nationwide laws governing elevator maintenance are set by the Occupational Safety and Health Administration (OSHA) and the American Society of Mechanical Engineers (ASME). In addition, most states and cities have additional standards and codes. Lifts must be inspected once a year. Additional monthly inspections by authorised persons are possible to permanently observe the condition of the lift.

2.1.8 Switzerland

In Switzerland the Swiss Lifts Directive regulates the safety and putting into service of a lift in Switzerland. Some Counties have own regulation regarding inspection and maintenance, but generally the owner of the installation is responsible for the safe use of the lift.

2.2 European Machinery Directive 2006/42/EC

In Europe, there are some regulations and directives which defines the Safety and Health of technical equipment. One of them is the directive for machines 2006/42/EC of 17.05.2006 replaces the directive 98/37/EC which was valid until then. Furthermore, it simultaneously amends Directive 95/16/EC (Lifts Directive).

The EU Machinery Directive applies to the placing on the market and putting into service of machines and individually marketed safety components for machines. The placing on the market may not be hindered by any member state as long as the directive is fulfilled. If the directive is not fulfilled, the placing on the market can be prohibited.

With the publishing of the new machinery regulation, which will be replaces the machinery directive, the regulation is directly applicable in the member states. The main changes compared to the machinery directive is the inclusion of Artificial Intelligence and the risk of Cyber Security. Additional some editorial changes are made. It is planned to publish the machinery regulation in May 2023 and the application in 2026.

2.3 European Lifts Directive 2014/33/EC

The Lifts Directive came into force on 01.07.1997 and replaced the EC Directive 84/529/EEC which had existed until then. It became fully legally binding on 01.07.1999. The Lifts Directive was amended by the Machinery Directive 2006/42/EC. This created a distinction between the Machinery Directive and the

Lifts Directive, as all hoists with a speed of up to 0.15 m/s are not subject to the Lifts Directive. On April 20, 2016 an amended new directive came into force with the designation 2014/33/EU. Directive 2014/33/EU was restructured. The traceability of products was newly included. Furthermore, the list of safety components was extended by one item.

Scope of the Lifts Directive:

- Lifts/Lifts that serve buildings and structures permanently
- Lifts/Lifts for the transport of persons, passengers and goods or goods only
- For safety components used in Lifts/Lifts listed in Annex III

Annex I of the Lifts Directive explains the essential health and safety requirements. For example, the car, which is designated as a load carrier in the Directive, is described in rough terms. Furthermore, the lift requires a load control that prevents travel in the event of an overload and a overspeed governor. The risks that can be posed by the lift system are described. There are no design notes, these can be taken from the harmonized standards, the EN 81 series.

The safety components are set out in Annex III. One component has been added to the list of safety components compared with the previous Directive. The list of safety components is therefore as follows:

- Locking devices of the landing doors
- Devices that prevent a fall or uncontrolled movement of the car. This includes the uncontrolled movement of the car at the landing. In technical terminology this function is also called UCM-Device (Unintendant Car Movement).
- Speed limiter
- Energy storing, energy consuming buffers
- Safety devices on cylinders of hydraulic main circuits when used as safety gears.
- Electrical safety devices in the form of safety circuits with electronic components [2].

2.4 European Standards Series 81 (EN 81)

EN 81 is the general term for “Safety rules for the construction and installation of lifts”. This standard consists of different parts:

EN 81-20	Safety rules for the construction and installation of lifts—Lifts for the transport of persons and goods—Part 20 Passenger and goods passenger lifts
EN 81-21	Safety rules for the construction and installation of lifts—Lifts for the transport of persons and goods—Part 21—New passenger and goods passenger lifts in existing buildings

EN 81-22	Safety rules for the construction and installation of lifts—Lifts for the transport of persons and goods—Part 22: Passenger and goods passenger lifts with inclined travel path
EN 81-28	Safety rules for the construction and installation of lifts, Part 28—Remote emergency call for passenger and goods passenger lifts
EN 81-30	Safety rules for the construction and installation of lifts, Part 30—Electric and hydraulic service lifts
EN 81-31	Safety rules for the construction and installation of lifts, Part 31—Accessible goods passenger lifts
EN 81-40	Safety rules for the construction and installation of lifts, Part 40—Stairlifts and inclined platform lifts for disabled persons
EN 81-41	Safety rules for the construction and installation of lifts, Part 41—Vertical platform lifts for disabled persons
EN 81-42	Safety rules for the construction and installation of lifts, Part 41—Vertical lifting appliances with closed beam intended for use by persons, including persons with impaired mobility
EN 81-43	Safety rules for the construction and installation of lifts, Part 43—Crane operator lifts
EN 81-44	Safety rules for the construction and installation of lifts, Part 44—Wind turbine lifts
EN 81-50	Safety rules for the construction and installation of lifts—Tests—Part 50 Design rules, calculation and testing of lift components
EN 81-58	Safety rules for the construction and installation of lifts, Part 58—Lift landing doors fire resistance test
EN 81-70	Safety rules for the construction and installation of lifts, Part 70—Accessibility of lifts for persons including persons with impaired mobility
EN 81-71	Safety rules for the construction and installation of lifts, Part 71—Safety measures to prevent wilful destruction
EN 81-72	Safety rules for the construction and installation of lifts, Part 72—Firefighters lifts
EN 81-73	Safety rules for the construction and installation of lifts, Part 73—Performance of lifts in the event of fire
EN 81-77	Safety rules for the construction and installation of lifts—Particular applications for passenger and goods passenger lifts—Part 77—Lifts under seismic conditions
EN 81-80	Safety rules for the construction and installation of lifts, Part 80—Rules for increasing the safety of existing passenger and goods passenger lifts
EN 12,015	Electromagnetic compatibility—Product family standard for lifts, escalators and moving walks—Emission
EN 12,016	Electromagnetic compatibility—Product family standard for lifts, escalators and moving walks—Immunity

The standards described above are constantly being monitored and revised by the standardization organization. CEN (Comité Européen de Normalisation), Technical Committee 10 (TC10) is responsible for this series of standards. Here, in various working groups, the standards are prepared by experts from various circles such as manufacturers, operators, professional associations, planners, consumer associations and testing organizations. This ensures that the processing of the standards has taken place with due consideration of all stakeholders. Participation in the working groups is voluntary. In addition, the constant review of them ensures that the standards reflect the state of the art. During the processing of standards, they go through different processing steps and designations. A first draft of a standard, which is made available for comments in the in the member states, is designated as “pr” (preliminary) (prEN 81-xx). In this procedure, the member states can submit technical as well as editorial comments. After this process, the standard is circulated by the working groups after a fixed processing time, which leads to publication. At this stage the standard is given the designation “Fpr”. (Formal vote preliminary—FprEN 81-xx). During this phase, comments can be made again by the Member States, but only editorial comments. After publication, all preliminary designations are dropped, so that the standard is then referred to as EN (EN 81-xx). Between the procedures described above, there are other processes for the editing and publication of standards which not discussed further here.

When a European Standard (EN) is published in the Official Journal of the European Commission, it is considered harmonised and must then be transposed into national law by the EU Member States. At the same time, national standards that contradict the harmonized standards must be withdrawn. For this purpose, a transitional period is set within which the withdrawal must take place.

If a European standard is adopted in Germany, it is given the suffix DIN in the designation, i.e. the standard then bears the designation DIN EN. If an international standard of the ISO standardization organization is adopted in Germany and published in Europe at the same time, the standard is given the designation DIN EN ISO. This procedure is the same in all European Countries.

The EN 81 series is applied in many countries of the world. Due to this worldwide recognition, there was a plan to convert the EN 81-20 and the EN 81-50 each into a separate ISO standard. This standards were then published in March 2019 with the designations ISO 8100-1 (EN 81-20) and ISO 8100-2 (EN 81-50).

2.4.1 EN 81-20 Lifts for the Transport of Persons and Goods

In the following chapter the most important points from this standard are described from the author's point of view. This standard specifies the safety rules for the design and installation of lift systems which have an electrically operated rope, drum or chain drive or a hydraulic drive.

This standard was drawn up under the mandate of the European Commission in support of the Lifts Directive and applies to all new lifts placed on the market. It does not apply to systems with a nominal speed of ≤ 0.15 m/s or to hydraulic systems with a nominal speed of more than 1 m/s. This standard also does not apply to systems that were installed before the publication of this standard [3].

▶ In the general assumptions it is specified that there have been agreements between the customer and the supplier about, for example, the type of goods to be transported, the environmental conditions or other important information concerning the building and its surroundings. Furthermore, it is assumed that the average temperature in the well should be between + 5 °C and + 40 °C.

If these temperatures cannot be maintained (for example, in the case of outdoor lifts), the parties must agree whether additional equipment must be installed to guarantee these temperature conditions and who will install this additional equipment. Usually it is advisable to install a suitable air conditioning system in connection with the lift and connected to the control system. This will ensure that the air conditioning system is activated in the event of excess temperature in the control system and that the temperature does not fall below the operating temperature of the control system if the ambient temperature is too cold.

▶ Non-lift equipment in the well or in the machine room, such as media from other disciplines (electrical lines, heating pipes) are not permitted.

Sufficient lighting must be available in the well. The illuminance must be at least 50 lx at a height of 1 m above the car at any position of the car. In addition, it must be permanently installed. The lighting in installation locations for the drive and control system must be at least 200 lx on the ground.

▶ Installation locations means an existing machine room or, in the case of systems without a machine room, the room available for maintenance of the drive. Usually this is the headroom.

There must be no accessible rooms under the well. If there are accessible rooms underneath, the well pit must have a load-bearing capacity of at least 5 000 N/m^2 must be dimensioned. In this case, the counterweight or balance weight must be equipped with a safety gear.

In contrast to EN 81-1/-2, the refuge spaces have been modified. Two types of refuge spaces for the headroom and three refuge spaces for the well pit have been defined, as shown in Table 2.1.

When closed, landing doors must have a clearance of no more than 6 mm between the door panels or between the door panels and uprights. This value may increase to 10 mm due to wear. When attempting to open the closed door only by hand, this clearance may be larger. This clearance is defined as 30 mm for doors opening on one side and 45 mm for doors opening centrally.

▶ These values should be checked during each maintenance to be able to readjust.

Tab. 2.1 Refuge spaces

Headroom	Dimensions of the refuge space
Type 1—upright posture	$0.4 \times 0.5 \times 2.00$ m
Type 2—crouching posture	$0.5 \times 0.7 \times 1.0$ m
Pit	**Dimensions of the refuge space**
Type 1—upright posture	$0.4 \times 0.5 \times 2.00$ m
Type 2 —crouching posture	$0.5 \times 0.7 \times 1.0$ m
Type 3—laying position	$0.7 \times 1.0 \times 0.5$ m

The following options for protecting the retraction of children's hands are mentioned in point 5.3.5.2.8:

> "a) Opacity of the glass...
> (b) detection of the presence of fingers ...
> (c) limiting the gap between the door leaves and the frame to a maximum of 4 mm". [3].

In accordance with point 5.3.6.2.1.1, power-operated horizontal sliding doors shall be fitted with a guard to monitor a zone extending from 25 mm to a height of 1600 mm above the car door sill. This can be achieved by means of a light curtain. This monitoring must be effective over the entire closing process, but may be ineffective in the last 20 mm.

When dimensioning the car, Table 2.2 must be taken into account. It represents the ratio between the car base area and the rated load. For example, a car with a rated load of 100 kg may have a maximum car area of 0.37 m^2. Table 2.2 can be found in principle in EN 81-20 under point 5.4 as table 6. These specified values are intended to prevent an overload of the car.

For hydraulically operated freight lifts, the rated load may be greater than that indicated in Table 2.2. For this type of lifts, Table 2.3 is applied, which can be found in principle in EN 81-20 as Table 7.

Tab. 2.2 Nominal load and largest useful area [3]

Rated load (mass) Kg	Maximum available car area m2	Rated load (mass) kg	Maximum available car area m2
225	0.70	900	2.20
300	0.90	975	2.35
375	1.10	1000	2.40
400	1.17	1050	2.50
600	1.60	1125	2.65
630	1.66	1200	2.80
675	1.75	1250	2.90

Tab. 2.3 Nominal load and largest usable area for hydraulically operated lifts

Rated load (mass) Kg	Maximum available car area m2	Rated load (mass) kg	Maximum available car area m2
525	2.08	1000	3.60
600	2.32	1050	3.72
630	2.42	1275	4.26
900	3.28	1350	4.44
975	3.52	1425	4.62

In addition to calculating the maximum available car area, the number of passengers must also be taken into account. There are two possibilities here. Either the value is determined from the nominal load/75 (value must be rounded down) or from Table 2.4 In any case, the smaller of the two values must be taken. Table 2.4 can be found in EN 81-20 as Table 8.

If there are more than 20 persons, an additional area of 0.115 ^{m2} per person must be available.

When planning lift systems today, special attention is paid to the use of people with limited mobility. Under this consideration, at least one car with a nominal load of 630 kg is required, as far as structurally possible.

In addition to the possibility of adapting a car to any well dimension, the following standard car sizes are usually used:

630 kg =	8 persons (wheelchair accessible)
800 kg =	10 persons
1000 kg =	13 persons (stretchers suitable)
1600 kg =	21 persons (suitable as bed lift)

Point 5.6 specifies measures to prevent a fall, overspeed, unintentional movement of the car or lowering of the car. Table 11 of EN 81-20 specifies protective

Tab. 2.4 Number of passengers [3]

Number of people	Minimum useful area in the car m2	number of people	Minimum useful area in the car m2
5	0.98	11	1.87
6	1.17	13	2.15
7	1.31	14	2.29
8	1.45	18	2.85
9	1.59	19	2.99
10	1.73	20	3.13

measures for traction sheave, drum and chain lifts and Table 12 of EN 81-20 for hydraulically operated lifts.

According to this standard, the following documents, among others, are to be handed over to the operator in a lift logbook after completion:

- Technical data of the lift
- Information about the ropes
- Information on components for which proof of type examination is required
- System drawing
- electric circuit diagrams
- Storage possibility for the test records of the in-service inspections or special tests

For hydraulic drives, only indirect and direct drives are permitted according to point 5.9.3. In the case of a central hydraulic ram which is embedded in the ground, it must be surrounded by a protective tube.

An emergency call device according to EN 81-28 must be available.

2.4.2 EN 81-28 Remote Emergency Call for Passenger and Goods Transport

EN 81-28 specifies the requirements for alarm systems installed in lifts that comply with EN 81-20. This standard is not designed to allow calls for help to be made via emergency call systems, e.g. for heart attacks.

The alarm system must remain functional even if the power supply fails. Emergency electrical power supplies must be available for this purpose. In addition, the rescue organisation must be automatically notified when the battery of the alarm system has failed.

After pressing the alarm initiation device, acoustic and optical signals must inform the passenger that the alarm call has been made. After that, no further action may be taken by the passenger; the alarm call must be forwarded independently to the designated location. The alarm initiation device must be located on the car operating panel.

The alarm system should have a 2-way communication.

After the alarm call has been made, the time until a rescue organisation arrives on site should not exceed 1 h [4]. National requirements may be different.

It is planned to change the title of this standard to “Two-way communication system to contact a rescue service”.

2.4.3 EN 81-70 Accessibility of Lifts for Persons Including Persons with Disabilities

This standard EN 81-70 defines the minimum requirements necessary when persons and persons with reduced mobility have to use the lift. When inviting tenders for non-public buildings, the standard can be adopted in full or in part. For installations in German public buildings planned in accordance with DIN 18,040-1, the standard must be applied in full.

The standard describes 5 car types. The access to the car for type 1 has a minimum width of 800 mm. National regulations may require larger accesses. Depending on the type of car, there are different access widths, which are listed in Table 3 of EN 81-70. The following car types are possible:

Type 1 - 1000 mm × 1300 mm (450 kg).

Type 2 - 1100 mm × 1400 mm (630 kg).

Type 3 - 1100 mm × 2100 mm (1 000 kg).

Type 4 - 1600 mm × 1400 mm.

1400 mm × 1600 mm (1 000 kg).

Type 5 - 2000 mm × 1400 mm.

1400 mm × 2000 mm (1 275 kg) [5].

The floor of the car must be anti-slip andmay be derived from the material as it was used for the corridor or lift lobby.

The car shall have a handrail on at least one side wall, the height of the handrail being fixed at 900 ± 25 mm above the finished floor. To make it easier for the wheelchair user to exit the car of type 1, 2 or 3, a device shall be fitted to the rear wall of the car to provide a view to the rear to facilitate reversing. This can be done by means of a half-height mirror on the rear wall of the car, from the top edge of the handrail or by means of a small mirror on the car ceiling.

If lift systems areinstalled in hospitals, for example, a transverse panel is used in addition to the standard car operating panel. This is usually integrated in the handrail. The size of the buttons in this transverse panel is 50 mm × 50 mm (alternative Ø 50 mm). In this case, Appendix B. These buttons offer the possibility that persons with a movement restriction on their arms can operate the buttons more easily. The number and type of the individual buttons are identical to those of the standard car operating panel on the side wall.

If a panel is used as a touch screen panel, this must be done in conjunction with an additional button, the accessibility button. The requirements for this can be found in Appendix C.

The next changes in content will be the changes in contrast values. This revised version is expected to be released in 2021.

2.4.4 EN 81-73 Behaviour of Lifts in Case of Fire

This standard EN 81-73 specifies minimum requirements for in the behaviour of lift in the event of fire in a building, when they receive fire alarm signals. The aim is to reduce the risk of users being trapped in the car in the event of a fire. Furthermore, the fire brigade should be able to inspect the car to ensure that there are no people in the car in the event of fire when the car arrives at its destination stop. This standard does not apply to firefighters lifts that comply with EN 81-72 or in the event of a fire in the well.

Below are just a few of the characteristics of the lift system from this standard:

- In case of fire, the lift must be sent to a destination stop. In this case it must not be possible to operate the lift in normal operation.
- If door safety units such as a light curtain are present, they must be bridged by the system so that the doors can close even if the lift lobby is smoky.
- The travel commands at the landings are made ineffective and all stored travel commands are deleted.
- The destination stop to be approached in case of fire is usually the ground floor. However, the prerequisite is that there is an escape route from the building to the outside. If a landing other than the ground floor is to be approached, this must be specified. This can be specified in a fire protection concept. Such a fire protection concept can also specify whether a lift must comply with this standard [6].

2.5 ISO Standards

In addition to the European standards, a number of International Standards (ISO standards) are also relevant.

The previously known numbering of the ISO standards will be changed and given a new structure. This will be done successively in the course of the next revisions of the standards. The new structure will then look as follows:

- ISO 8100 – x, Lifts for the transport of persons and goods
- ISO 8101 – x, Fire safety on lifts
- ISO 8102 – x, Electrical requirements for lifts, escalators and moving walks
- ISO 8103 – x, Escalators and moving walks
- ISO 8104 – x, Improvement of safety on existing lifts and escalators
- ISO 8105 – x, Rules for safety dimensions and functional operation on lifting appliances

As already mentioned in chapter 2.4, ISO 8100-1 and ISO 8100-2 were published in March 2019 and represent a 1:1 transfer of EN 81-20/50. The official designation is.

- ISO 8100-1, *Lifts for the transport of persons and goods, Part 1: Safety requirements for passenger and goods passenger lifts*
- ISO 8100-2, *Lifts for the transport of persons and goods, Part 2: Design rules, calculations, examinations and tests of lift components*

In addition to these two standards, EN 81-80 "*Safety rules for the construction and installation of lifts—Existing lifts—Part 80: Rules for improving the safety of existing passenger and goods passenger lifts*" will also be incorporated into ISO

8104-1 "*Improvement of safety on existing lifts—Part 1: Passengers and goods passenger lifts*".

Other relevant ISO standards exist amongst others as follows:

- ISO 8100-3, *Lifts for the transport of persons and goods—Part 3: Requirements from other standards (ASME A17.1/CSAB44 and JIS A 43XX-1/ JIS A 43XX-2)* not included in ISO 8100-1 or ISO 8100-2
- ISO 8100-7, *Safety rules for the construction and installation of lift—Lifts for the transport of persons and goods—Part 7: Control devices, signals and accessibility* (former ISO 4190-5)
- ISO 8102-1, *Electrical requirements for lifts, escalators and moving walks—Part 1: Electromagnetic compatibility with regard to emission* (former ISO 22,199)
- ISO 8102-2, *Electrical requirements for lifts, escalators and moving walks—Part 2: Electromagnetic compatibility with regard to immunity* (former ISO 22,200)
- ISO 8102-6, *Electrical requirements for lifts, escalators and moving walks—Part 6: Programmable electronic systems in safety-related applications for escalators and moving walks (PESSRAE)* (former ISO 22,201)
- ISO 25745-1, *Energy measurement and verification*
- ISO 25745-2, *Energy calculation and classification of lifts*

2.6 Codes and Standards in Different Countries in the World Outside Europe

The EN 81-series were adopted in many countries of the world. Some of them were adopted identically, some partial with modifications. In this chapter is a short overview of codes in some countries.

Australia

Australia has adopted some standards of the EN 81 series, but its application must comply with local laws or regulations. Following are some standards which are currently available:

AS1735.1:2016, "*Lifts, escalators and moving walks—Part 1: General requirements*" refers to EN 81-20 and EN 81-50. The application of these codes have to comply e.g. with AS3000 "*Wiring rules for Installation, Building code*".

AS1735.3:2002, "*Lifts, escalators and moving walks—Part 3: Passenger and goods lifts—Electrohydraulic*".

AS1735.4:1986, "*Lifts, escalators and moving walks (known as the SAA Lift Code)—Part 4:Service lifts—Power-operated*".

AS1735.7:1998, "*Lifts, escalators and moving walks—Part 7: Stairway lifts"*.

AS1735.12:2020, "Lifts, escalators and moving walks—Part 12: Facilities for persons with disabilities (EN 81-70:2018, MOD)" refers to EN 81-70.

AS1735.19:2019, " *Lifts, escalators and moving walks—Part 19: Safety rule for the construction and installation of lifts—Lifts for the transport of persons and goods—Remote alarm on passenger and goods passenger lifts*" is an identical text adoption of EN81-28 2018 + AC:2019.

Australia has its own standards for seismic, fire rated landing doors, and the Building code of Australia which also has specific requirements needs to comply.

United States

United States have it own codes. The following codes for lifts are as follows:

ANSI/ASME A17.1-2007, "*Safety Code for Elevators and Escalators (Bi-national standard with CSA B44-07)*". This Code covers the design, construction, operation of elevators.

ANSI/ASME A17.2-2007, "*Guide for Inspection of Elevators, Escalators, and Moving Walks".*

A17.2 covers recommended inspection and testing procedures for electric and hydraulic elevators.

ANSI/ASME A17.3-2005, "*Safety Code for Existing Elevators and Escalators*". This Code of safety standards covers existing elevators, escalators, and their hoistways (except as modified by 1.1.2).

New Zealand

Adoption of EN 81-20 and EN 81-50 in 2017.

South Korea

Publishing of new Design code of Practice in 2018 based on EN 81-20 and EN 81-50. Also some local Korean requirements are included in this code.

Malaysia

Aproval of EN 81-20 and EN 81-20 as MS EN 81-20 and MS EN 81-50 from the Ministry.

China

China adopt European Standards sometimes identical or modified into their own Standardisation systems. Also some ISO standards have been adopted identical or modified.

GB 7588.1, *Safety rules for the construction and installation of lifts—Part 1: Passenger and goods passenger lifts*. This is a modified version of EN 81-20:2014.

GB 7588.2, *Safety rules for the construction and installation of lifts—Part 2: Design rules, calculations*, *examinations and tests of lift*. This is a modified version of EN 81-50:2014.

GB/T 24,475-2009, *Remote alarm on lifts (elevators)*. This is an identical adoption of EN 81-28:2003.

GB/T 24,477-2009, *Accessibility to lifts for persons including persons with disability*. This is an identical adoption of EN 81-70:2003.

GB/T 24,479-2009, *Behavior of lifts in the event of fire*. This is an identical adoption of EN 81-73:2005.

GB/T 24,804-2009, *Rules for the improvement of safety of existing lifts*. This is an identical adoption of EN 81-80:2003.

GB/T 26,465-2011, *Safety rules for the construction and installation of firefighters lifts*. This is a modified version of EN 81-72:2003.

GB/T 30,559.1-2014, *Energy performance of lifts, escalators and moving walks—Part 1: Energy measurement and verification*. This is an identical adoption of ISO 25745-1:2012.

GB/T 30.559.2-2017, *Energy performance of lifts, escalators and moving walks—Part 2: Energy calculation and classification of lifts(elevators)*. This is a modified version of ISO 25745-2:2015.

References

1. Directive 2006/42/EC of the European Parliament and of the Council of 17.05.2006 (Machinery Directive)
2. Directive 2014/33/EU of the European Parliament and of the Council of 26 February 2014 on the approximation of the laws of the Member States relating to lifts and safety components for lifts
3. EN 81-20, *Safety rules for the construction and installation of lifts—Lifts for the transport of persons and goods Part 20: Passenger and goods passenger lifts*
4. EN 81-28, *Safety rules for the construction and installation of lifts—Lifts for the transport of persons and goods—Part 28: Remote emergency call for passenger and goods passenger lifts;*
5. EN 81-70, *Safety rules for the construction and installation of lifts—Particular applications for passenger and goods passenger lifts—Part 70: Accessibility of lifts for persons including persons with impaired mobility*
6. EN 81-73, *Safety rules for the construction and installation of lifts—Particular applications for passenger and goods passenger lifts—Part 73: Behaviour of lifts in the event of fire*

Structural Engineering Basics

3

3.1 General points

Concrete
Lift wells are mostly made of reinforced concrete. Steel and concrete are joined together, the steel is then called reinforcement. Concrete can be divided into two groups with its main components:

a. General supporting structures
b. Surface bearing structures

Concrete is an artificial stone that consists of a cement–water mixture. Concrete can be differentiated according to its bulk density in:

Lightweight concrete	Bulk density 800 … 2000 kg/m3
Normal Concrete	bulk density > 2000 … 2600 kg/m3
Heavy Concrete	Bulk density > 2600 kg/m3

or according to the compressive strength.

Concrete can also be divided according to the place of production. A distinction is made between:

Lift wells are usually constructed with in-situ concrete. However, there are also precast plants that produce the well in panels in the factory and then transport it to the construction site. If the well is manufactured in a precast plant, good preliminary planning is of utmost importance. While it is still possible to make changes, for example to the formwork, when the well is manufactured on site, it is no longer possible to make changes to a finished cast part. Changes in the headroom, for example resulting in a different arrangement of the profile rails, may mean that profile rails have already been installed may no longer be usable. This means that

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dowels have to be subsequently inserted in the correct places in order to be able to mount the fixings for the guide rails. This in turn causes additional costs for material and installation and delays the construction process [1].

Structural Fire Protection
In the event of fire, the components of a building must be able to withstand the fire. These components are divided into fire resistance classes as follows:

F 30	≥ 30 min functional integrity
F 60	≥ 60 min functional integrity
F 90	≥ 90 min functional integrity
F 120	≥ 120 min functional integrity
F 180	≥ 180 min functional integrity

For non-load-bearing walls the fire resistance classes are W 30 to W 180, for doors T 30 to T 180 and for fire-resistant glazing G 30 to G 180.

Note: These values are valid for Germany. Deviations in other coutries are possible.

3.1.1 Fire Barriers:

Buildings are divided into fire compartments. Each fire compartment must prevent the spread of a fire to other fire compartments by means of fire walls.

In this context, it should be mentioned that lift wells are usually located in the stairwell of staircases, as the staircases are separate fire compartments. Therefore, when planning lift systems, care must be taken to ensure that the lift vestibules are protected against fire. Lift wells connect the floors with each other. If the lift vestibules are not fire-protected, there is a possibility that in the event of a fire, smoke could spread to the other parts of the floor since the landing doors are not smoketight.

Sound Insulation
Noise insulation is of great importance when constructing buildings. Particularly in hotels, hospitals or schools, special demands are placed on sound insulation. If lift wells are located in the stairwell, the noise can penetrate the building less effectively during operation. However, the best sound insulation can be achieved by separating lift wells completely from the building. This is achieved by creating a gap of approximately 3 cm between the lift well and the building. This means that the lift well must be doubled (well within the well). However, care must be taken to ensure that this is done accurately, otherwise sound bridges may be created.

The source of the noise is usually the drive in the machine room or the drive in the headroom in machine room-less lift systems. For this reason, care must be taken to ensure noise decoupling. Other noises can be caused by door movements or by the brakes. The contactors in the control cabinet can also be heard sometimes. In lift systems with a sliding guide, noise can also be caused by the grinding movements.

3.2 Structural Components of an Installation

3.2.1 Engine Room

The machine room serves to accommodate the drive, the control system and the speed limiter. The classic lift has its machine room.

a) above the well
b) at the top next to the well or
c) at the bottom next of the well.

Above means that the machine room is located directly above the lift well, regardless of whether the floor area of the machine room is larger than that of the well, as shown in Fig. 3.1. Top next to the well means, directly above the lift well is the pulley room with the deflection sheaves to guide the ropes down into the well and next to that room is the machine room. In the version below next to the well, the situation is the same as above next to the well. Figure 3.2 shows an lift installation with a machine room at the bottom next to the well [2].

According to EN 81-20, non-lift equipment may not be installed in the machine room. Exceptions are, for example, air conditioning units to ensure ventilation in the machine room. Other non-lift equipment must be fitted with fire protection cladding.

▶ However, this is only permissible in agreement with an improved inspection body and is only approved in rare exceptional cases and is based on the author's experience. For this reason, operators should always follow this recommendation before carrying out the work. It may be necessary to perform a risk analysis.

The minimum size of free maintenance areas is defined in EN 81-20. It is important that the headroom is at least 2 m. The size of the machine room should be as large as possible to ensure safe working. Furthermore, according to EN 81-20, sufficient lighting of 200 lx on the floor and a power socket must be provided. The machine room is only accessible to competent persons. Therefore, the machine room door must be lockable. To be able to leave the machine room in an emergency, the machine room door must have a panic lock. Furthermore, any fire that develops in the engine room must not be allowed to escape to the outside, which requires an machine room door corresponding to a fire resistance class. In the case of hydraulically driven lifts, an oil leakage threshold is additionally required at the

Fig. 3.1 Lift system with machine room above. (Source: Schindler Deutschland AG & Co. KG, Germany)

machine room door so that any hydraulic oil that may leak out is collected in the event of damage to the piping system or unit and cannot penetrate to the outside. In the case of hydraulic systems, the machine room floor must be painted with an oil-resistant paint, the height of the paint being at least equal to the filling level that would occur if the hydraulic power unit were to run out completely. The oil-resistant paint must be applied in three layers so that the three coats can be visually seen.

Since the end of the 1990s, there have also been lift systems with traction lifts without a machine room, as shown in Fig. 3.3. In this case the control system and the drive are located in the well. Most manufacturers place the drive on a cross-beam in the headroom. There are also systems where the drive is located in the well pit. In the author's opinion, however, this version should only be implemented in exceptional cases, since installing the drive in the well pit causes the ropes to undergo a great deal of deflection, which increases wear and tear on the ropes compared to a system where the machine is located in the headroom.

In order to be able to operate the lift outside the well in an emergency, a small part of the control system is located outside the well, usually near the well door at

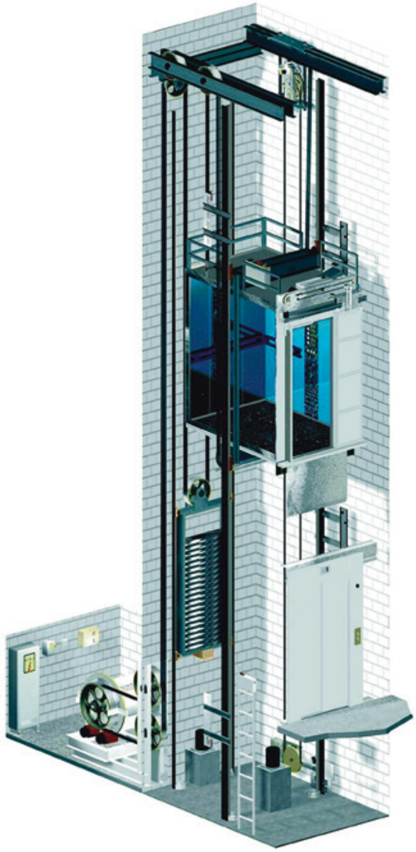

Fig. 3.2 Lift system with machine room below next. (Source: Schindler Deutschland AG & Co. KG, Germany)

the top landing. The advantage of such installations is the saving of the machine room. In times of rising construction costs, these lifts are particularly popular. In addition, architects have more options when designing buildings, since the "annoying" machine room is no longer required. However, there are also disadvantages in using such lift systems. During maintenance, the controller and drive can only be checked from the car roof. This requires increased attention by the service technician during maintenance.

Even with hydraulic lift systems, it is possible to realize an lift without machine room. A compact unit consisting of a small unit with an attached control unit and an enclosing oil sump around the unit also makes a machine room unnecessary. The compact unit can be installed either next to or behind the well. Alternatively, it can also be installed directly in the well wall in a niche. In this case, the niche must be closed with a fire protection door. When planning such systems, it must be ensured that the unit is not located in the escape route area. However, there are limits to the application of a compact unit. Depending on the manufacturer, the payload is limited to 630 kg or 1000 kg.

Fig. 3.3 **Lift** system without machine room (Source: Schindler Deutschland AG & Co. KG, Germany)

Figures 3.4 show a narrow unit which can be accommodated in the well pit between the guide rails. The control unit can be installed outside the well with sufficient maintenance space. The oil-proof well pit also serves as an oil collecting trough.

3.2.2 Well

The lift well is usually made of reinforced concrete. The necessary dimensions and tolerances are specified by the lift manufacturer. These tolerance limits are usually specified as ± 2 cm and must be strictly adhered to. These tolerances are smaller than the tolerance values usually specified in the construction. As a rule, the construction of the well is a service provided by the customer, i.e. the owner

Fig. 3.4 Compact power pack for machine room-less version, installation in the well (Source: Bucher Hydraulics, Neuheim, Switzerland)

must have this well built. However, the well can only be built once the order has been placed with the lift company, as it specifies the dimensions required for the construction of the well. This is also shown in his system drawings. The guide rails and counterweight are accommodated in the lift well. In addition, the external call panels is supplied via cable harnesses running in the well. These cable harnesses are delivered to the construction site prefabricated, so that the fitter only has to fix them in the well and plug them together.

In the well pit is the buffer and the deflection pulley of the overspeed governor. Figure 3.5 shows a part of an lift well from the inside.

If wells are made of masonry, it must be ensured that the C-profile rails are embedded in concrete in the toroidal core at the points provided by the lift manufacturer.

The lift well consists of the pit, the headroom and the travel height. In the well pit are the buffer and the deflection roller of the overspeed governor. The service technician can enter the pit via a ladder. The well rises upwards, depending on the number of landings, and accommodates the guide rails and the well components. At the end is the headroom. The height of the headroom is defined in EN 81-20

Fig. 3.5 Lift well from inside (Source: Author)

and depends on the nominal speed of the lift. The distance between the upper edge of the finished floor of the lowest landing and the finished floor of the top landing is called the travel height. The distance between the finished floor of the top landing and the bottom of the well ceiling is called headroom. The well pit is defined as the dimension from the finished floor lowest landing to the bottom of the pit.

However, there is also the possibility of constructing lift wells from a steel frame with laminated safety glass. Glass wells are very often seen in railway stations to create transparency for safety reasons. But such lift wells can also be found in representative buildings such as banks or shopping centres. In order to reduce the number of interfaces between the installer of the lift system and the builder of the lift well, this work is usually completely outsourced to the lift manufacturer. The coordination required here is sometimes very detailed, so that an individual contract should only be awarded to a well frame manufacturer and the coordination of the interfaces with the lift manufacturer should only be carried out by experienced building owners, site managers or architects. As an alternative to the glazed lift wells, the steel scaffolds can also be clad with sheet metal or thermally insulated panels.

In shopping centres, where atria can be located, you will usually only find partially enclosed wells. Here only the lower area in the main stop is surrounded. The well door side is concreted and the rest of the well up to the headroom is free of a defensive wall.

Figure 3.6 shows a steel framework for an lift system with glazing.

Fig. 3.6 Lift well made of steel frame with glazing (Source: Meiller Aufzugstüren GmbH, Munich)

References

1. Technical concrete data, Heidelberg Cement, 2011 edition
2. EN 81-20, *Safety rules for the construction and installation of lifts—Lifts for the transport of persons and goods Part 20: Passenger and goods passenger lifts*

4 Lift Types

In this chapter the different types of lifts are discussed. Lift systems can be classified according to the type of load to be transported, as shown in Fig. 4.1 below, according to the type of drive or according to the function. Some types of lifts are listed below according to the classification described above. 4.1

4.1 Passenger Lift

A pure passenger lift, regardless of the type of drive, is used exclusively for the transport of persons. The fact that goods can also be transported is undisputed due to its design, but a pure passenger lift is not necessarily suitable for the transport of goods due to its car equipment.

For example, when it comes to high-quality car equipment. Here, the walls can be made of glass or high-quality stainless steel. The car floor can be covered with granite or stone. The transport of goods with the aid of lift trucks or pallet cages involves the risk that the car can be damaged by the bulky load.

The lighting is housed in the ceiling and in modern lift systems consists either of a glass ceiling with lights underneath or halogen spotlights embedded directly in the ceiling. With an increasing tendency, LED light fields are also being used today due to their low energy consumption and long service life.

4.2 Goods Lift

Freight lifts are used for the transport of goods. The car is manufactured very simply and robustly. The walls are usually made of galvanized sheet steel and only provided with a primer coat. Sometimes they also remain in their original form without a coat of paint. The floor is usually made of checker plate, so that the use of forklifts cannot cause any damage. In addition, there are hardwood or plastic

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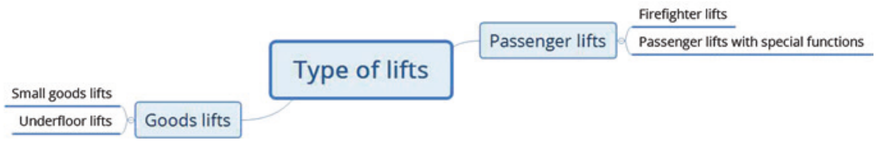

Fig. 4.1 Lift types, not complete

Fig. 4.2 View of a freight lift car with safety light grid. (Source: Author)

bumpers on the walls to absorb the impact of the goods and protect the walls. As with the passenger lifts, the lighting is also housed in the ceiling. Figure 4.2 shows the car of a freight lift with walls made of sheet steel and a gray primer coat. Two wooden battens have been provided as impact protection. There is no car end door. Alternatively, the car was equipped with a self-monitoring safety light grid.

4.3 Small Goods Lift

The small goods lift is used for the vertical transport of small goods, as the name already suggests. The first lifts of this type were built as manual lifts. With the help of deflection pulleys and a rope through the well, the car could be moved vertically. The car was secured with a brake. In order to move the car, the brake had to be released with the foot beforehand, the only way to move the car with the help of the rope.

The doors were closed with a vertical sliding door, as is the case with the lifts in use today, which moved halfway up and halfway down.

Fig. 4.3 Wooden counterweight. (Source: Author)

This lift also had a counterweight, as shown in Fig. 4.3. Springs were used as buffers, which were arranged below the car. The car as well as the rope pulleys and the guide rails were made of wood. Figure 4.4 shows a wooden car, Fig. 4.5 shows the rope rolls in the well head.

Today the small goods lift is often used in the catering trade as a kitchen lift. The lift cages are often manufactured with a height of 80 cm. The doors are set at a parapet wall height of 80 cm. However, other dimensions are also possible according to the standard. The car can be opened by means of a vertical two-part sliding door. As the name kitchen lift already suggests, such a lift is mainly used to transport food, drinks or tableware. In large restaurants over several floors this lift is ideal. Due to hygiene regulations, the car must be made of stainless steel. However, this type of lift can also be found in workshops where it is used for transporting materials or in office buildings for transporting files.

Other versions with a flush-floor revolving door and a car height of 120 cm also allow the transport of larger goods such as beer kegs or high crates, which can be brought directly into the car with a wheelbarrow.

The small goods lift are today mainly manufactured as traction lift with a 1:1 suspension. The machine is located above the well head. There are still applications today where there is a drum drive in the machine room, which guides the car vertically through the well by winding or lowering it. The maximum load of the small goods lift is limited to 300 kg according to EN 81-30. The maximum car size is 1.00×1.20 m [1].

Fig. 4.4 Wooden car. (Source: Author)

Fig. 4.5 Rope pulleys in the well head. (Source: Author)

4.4 Simplified Goods Lift

The Simplified Goods lift is used exclusively for the transport of goods. The transport of persons is prohibited. It is also not possible to make a call in the car due to the missing car panel. The equipment is the same as for goods lifts. No emergency call system is required for this type of lift (according to German national rules). The drive is either with a hydraulic aggregate or with an electric motor as cable lift. The operation is exclusively carried out via the outside operating panels. The car is brought to the desired stop by a fetch and send control. After loading, the car is sent to the desired destination stop via the same panel.

4.5 Underfloor Lift

The underfloor lift is also a goods lift without passenger transport. It is mostly used to bridge one landing. It is often found at the edge of a building for transporting goods directly outside the building. On the lower floor, the load can be moved into the car after opening the landing door. At the upper landing there is no landing door, but a cover. This cover is also called a canopy. The canopy covers the well opening from above. The car opens this cover during the ascent and takes it with it. The underfloor lift is only built as a hydraulic lift.

The system may only be operated from the top landing, so that the area of the canopy can be seen and the danger area for people can be seen here.

4.6 Wheelchair Lift

The wheelchair lift consists of a platform with a framing on the right and left side. The drives are housed in these frames. The drive used here is a rack and pinion output with a small thread. Due to this small thread, this type of lift only achieves low speeds of up to 0.1 m/s. The platform is not enclosed, i.e. it is open at the top and the entrances are only secured with a barrier, as shown in Fig. 4.6 or a small door, as shown in Fig. 4.7. These lifts can be installed without a well. They are used in department stores or in public buildings to bridge only a few steps.

4.7 Lifting Platform

Lifting platforms are used in outdoor areas. They are often found on loading ramps at commercial enterprises to facilitate the unloading of trucks. They consist of only one platform, which is moved by a hydraulic system. Below the platform there are two crossed hydraulic jacks. Due to this arrangement they are also called scissor lifts. They are operated by a remote control located on the cable. The platform is raised or lowered by a hydraulic unit. The operator must use this remote

Fig. 4.6 Wheelchair lift for bridging stairs. A barrier at the lower landing serves as a closure. (Source: Liftwerk GmbH, Kaufungen, Germany)

Fig. 4.7 Wheelchair lift with a swinging door at the end of the upper landing. (Source: HIRO Lift ®, Bielefeld, Germany)

control to move the platform. The remote control has the function of a hold-to-run control. This means that the platform stops when the remote control is released. Another advantage of this type of control is that the operator can see the danger area underneath the platform.

4.8 Paternoster Lift

The paternoster lift consists of several cars lined up next to each other and moving vertically through the building on a chain. Figure 4.8 shows the car of a paternoster. Figure 4.9 the back of the car. Figure 4.10 shows one of the chains on which the cars are suspended. These run endlessly through the well to the upper and lower diverter pulley (turning points).

The cars have no car doors and there are no landing doors at the stops. The user must enter or exit the open cars during the journey. The speed is very low at approx. 0.3 m/s. The advantage of this lift is the permanent transport of passengers. The disadvantage is the lack of load transport, as the permanent movement of the cars prevents the introduction of bulky goods such as ladders or poles into the cars. The use is therefore only permitted for persons and requires some practice, as they are not often found. There is a risk of bumping your head or stumbling when getting in or out.

The engine room is located above the well. There you will find the drive as well as the diverter pulleys, as shown in Fig. 4.11. Figure 4.12 shows a drive in the machine room, Fig. 4.13 shows again a drive and the diverter pulley of the upper turning point. The components shown there are located in the engine room.

When the car has reached the end stop, the car is transferred at the turning point and changes its direction of travel. The upper turning point is shown in Fig. 4.14. To be able to lubricate and check the guide rails, there is a car that can be opened

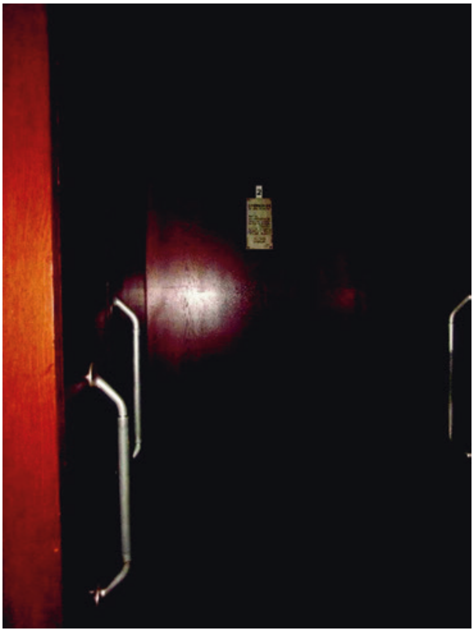

Fig. 4.8 Car of a paternoster. (Source: TECHNOSEUM (State Museum for Technology and Labour), Mannheim, Germany)

Fig. 4.9 View of the cars from the rear. (Source: TECHNOSEUM (State Museum for Technology and Labour), Mannheim, Germany)

Fig. 4.10 View of a chain for transporting the cars. (Source: TECHNOSEUM (State Museum for Technology and Labour), Mannheim, Germany)

sideways for maintenance purposes. In Germany, this type of lift is no longer used today and is also increasingly being taken out of service due to the high risk of accidents. New construction has been prohibited in Germany since 1974.

Fig. 4.11 Diverter pulley in the engine room of a paternoster. (Source: Author)

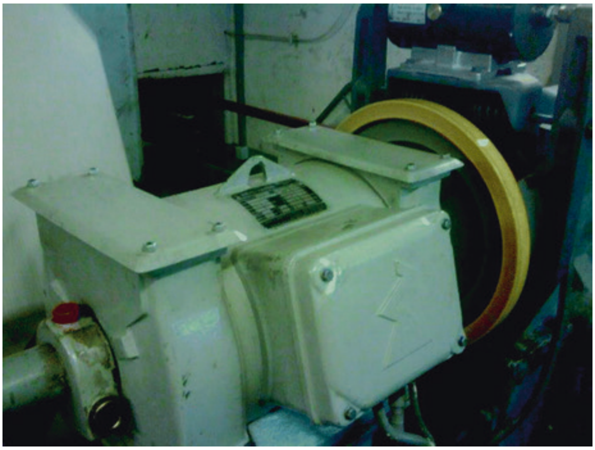

Fig. 4.12 Drive unit in engine room. (Source: Author)

4.9 Building Hoists

Building hoists are used in the construction of buildings, mostly high-rise buildings. They consist of a simple tubular scaffold as shown in Fig. 4.15, on which the car is transported. These lifts are attached to the outside wall of outdoor buildings. Depending on the progress of the building, the lift grows with it. The design is very robust and simple. In the technical language they are called rack and pinion lifts.

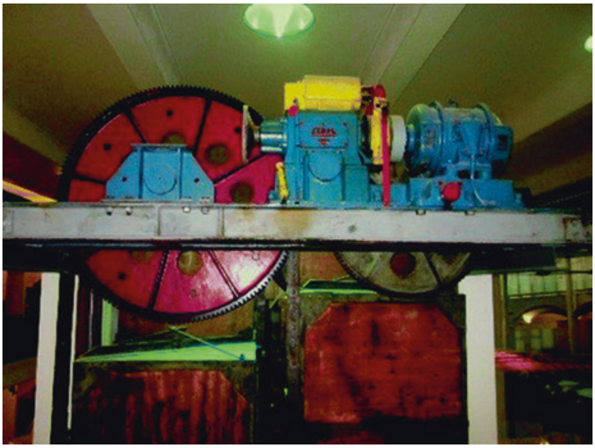

Fig. 4.13 Drive with diverter pulley. (Source: TECHNOSEUM (State Museum for Technology and Labour), Mannheim, Germany)

Fig. 4.14 Diverter pulley upper turning point. (Source: Author)

The car is driven by means of gear wheels along pinions fixed to the tubular scaffolding, as shown in Fig. 4.16. Platforms with a protective scaffolding or stirrup as well as fully enclosed cars can be used as load carriers. Figure 4.17 shows a load carrier designed as a platform with a protective hoop. The control unit is located outside directly next to the tubular steel scaffold, as shown in Fig. 4.18.

Fig. 4.15 Tubular steel scaffolding of a building hoist. (Source: Author)

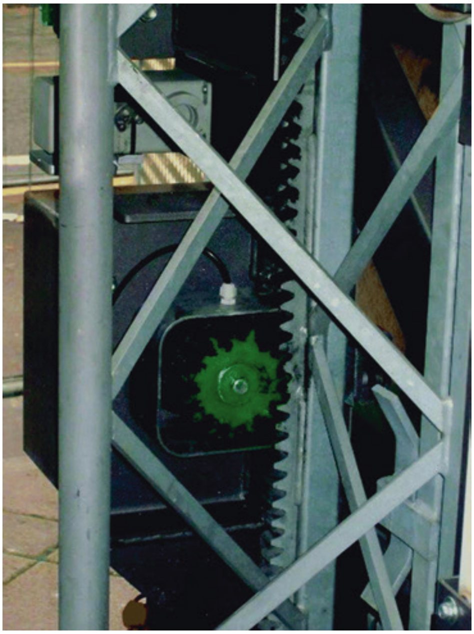

Fig. 4.16 Drive unit gear, pinion. (Source: Author)

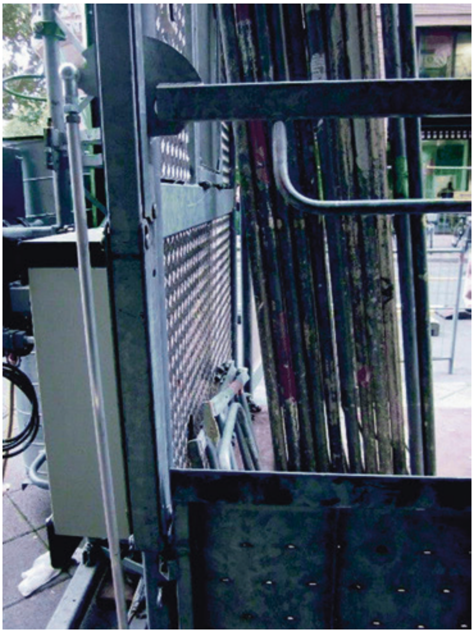

Fig. 4.17 Platform with guard. (Source: Author)

Fig. 4.18 Control of the construction hoist, mounted next to the tubular steel scaffolding. (Source: Author)

4.10 Vehicle Lift

The vehicle lift is usually a hydraulically driven goods lift, which is moved by two hydraulic jacks. The lifters are arranged to the right and left of the car. This arrangement is also called double piston drive. The car length is usually approx. 6000 mm long and 2500 mm wide with a nominal load of 6 t or more. This lift is used in apartment buildings as access to an underground parking facility where there is no possibility of access.

4.11 Firefighters Lift

The firefighters' lift is a passenger lift that complies with the additional standard EN 81-72 in addition to the main standard EN 81-20. The firefighters lift can be used if not all floors in high-rise buildings can be evacuated with the turntable ladder of the fire brigade. In addition, the fire brigade or the building inspectorate may require the construction of a firefighters lift for other reasons. In Germany, basic information can be found in the German model high-rise guidelines or from the local fire brigades. In other countries outside of Germany, the national guidelines has to be taken into consideration.

In terms of control technology, additional functions are included which enable the fire brigade to get as close as possible to the source of the fire. Direction reversal while driving or the input of several calls are only some of the functions. The fire brigade function is activated by means of a special key switch (fire brigade switch) in the main stop.

Additional requirements are the size of the cars of at least 1100×2100 mm, an emergency trap door and ladder in the car. The vestibules of the landing doors must be in a fireproof area. If the drive is located in a common machine room for several lifts, this drive must be isolated from the rest of the drives in terms of fire protection.

4.12 Drum Lift

This type of lift is often found in older installations such as small goods lifts. The advantage of this lift type is the maximum utilization of the car, as no counterweight is required. This allows the car to be built larger than in traction lifts with a counterweight. For this reason, the drum lift has been rediscovered and is ideal for modernizing lift systems, especially when replacing systems without a car door.

When modernizing lift systems that have been placed on the market under an old standard or even earlier, it is possible to encounter a system that does not have a car door. When replacing the lift system, the state of the art must be observed, which means that the application of EN 81 is mandatory. By installing a state-of-the-art lift system with a car door, the new car will be smaller, as the necessary car doors will reduce the depth of the car by approx. 160 to 230 mm. If sliding well doors are also used instead of swing doors, a further 130 to 180 mm in depth is lost. By using a drum lift and by eliminating the counterweight in this type of lift, additional space can be gained in the well when replacing the existing installation with this type of lift. This gained space can be used for a larger car.

However, the speed for this type of lift is limited to 0.63 m/s by EN 81-20. Depending on the type of suspension, however, only travel heights of up to 40 m can be realized here.

4.13 Stairlifts

Stairlifts are mainly used in the private sector. As the name suggests, they are installed along stairs. A stair seat travels along a rail, the carriageway, to the next floor. During installation, the track is adapted to the staircase run. Depending on the nature of the walls, the carriageway can also be mounted on the wall. If the statics of this wall are not sufficient, the carriageway can also be mounted on the staircase steps using feet, as shown in Fig. 4.19.

The stair seat contains the drive in the lower part, which moves the seat up or down along the roadway. A built-in safety brake ensures that in case of a fault, the staircase seat is prevented from moving too fast. The drive can consist of a motor with an attached gear wheel, which moves along the sprockets attached to the roadway similar to a rack railway, as shown in Fig. 4.20. There are also tracks

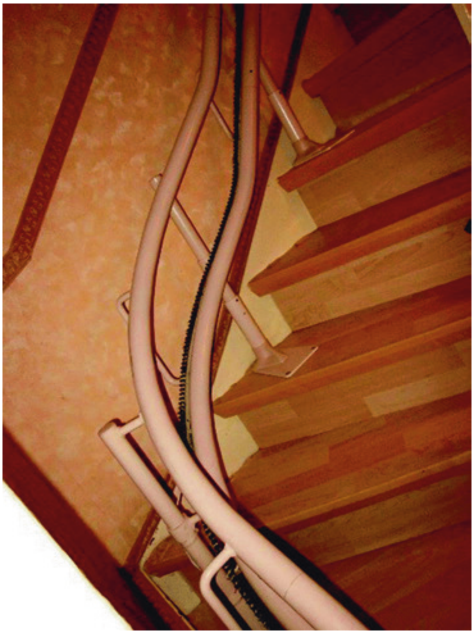

Fig. 4.19 Roadway mounted on steps. (Source: Author)

Fig. 4.20 Gear drive. (Source: Author)

Fig. 4.21 Stair seat. (Source: Author)

that consist only of pipes. In this case the drive has a pressure roller to move the stair seat along the track. Figure 4.21 shows a stair seat.

The seat is operated via a joystick, which is installed on the stair seat. There is also the possibility of a remote control, which is connected to the stairlift via a spiral cable. This control device allows the user to move the seat up or down by moving it to the left or right. A footrest is located under the seat for increased safety. The user must place their feet on this footrest while driving. The stair seat can also be optionally equipped with a safety belt for users to fasten their seat belts.

Regarding the equipment all variations are also possible here. The roadway can be made of stainless steel, also a colour design of the roadway pipe is possible. For the seats there are different possibilities of the material selection like for example a seat cushion made of leather. When the stairlift is not in use, the track can also be used as a handrail.

4.14 Inclined Wheelchair Lift

Similar to the stair lifts, the inclined wheelchair lift are constructed in a similar way. The principle is the same, a load, in this case a wheelchair, is moved up or down the staircase along a railing. These installations are often found outside public buildings. The two versions for outdoor and indoor use are shown in Figs. 4.22 and 4.23. The platform has small ramps on both sides of the entrance, which fold up when driving to secure the wheelchair. When arriving at the landing, the ramps fold down to make it easier to get on and off the platform.

4.15 Installations with Reduced Well Pit and Head

In the EN 81-20, refufe spaces are prescribed for the well head and the well pit. Deviations from this standard occur often. The installer must document the deviations and take substitute measures that guarantee the same protection goal as if he had taken the prescribed refuge spaces into account according to the standard.

Fig. 4.22 Outdoor inclined wheelchair lift. (Source: HIRO Lift ®, Bielefeld, Germany)

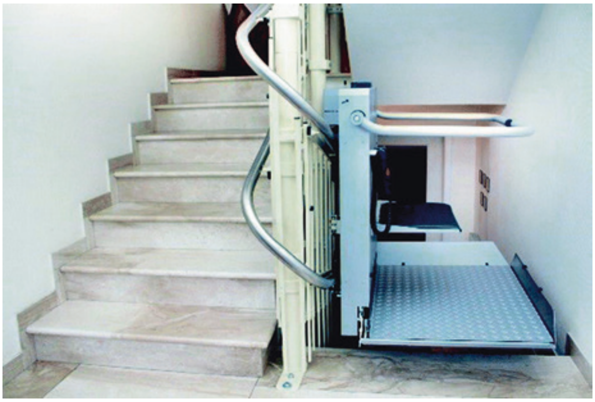

Fig. 4.23 Indoor inclined wheelchair lift. (Source: HIRO Lift ®, Bielefeld, Germany)

There can be various reasons for deviations. Plausible reasons for a reduced well pit can be problems with the foundation, that you want to erect a building in an area where there are problems with the ground water. Other reasons can be the high costs of penetrating the cellar floor and subsequent sealing when connecting the well pit to the cellar floor in existing buildings.

Reasons for a reduced well head are, on the one hand, architectural aspects or difficulties in roof sealing, as the well head protrudes over the roof.

In order to create the refuge space in an lift system with a reduced well head, a movable stop can be installed in the well pit under the counterweight. This is automatically folded under the counterweight as soon as the inspection control is activated. Due to the limited travel of the counterweight in the pit, the car cannot enter the well head completely, i.e. the temporary refuge space is created.

The same is done for a reduced well pit. In this case, a movable stop is placed under the car, which is folded out when the inspection control is activated and thus creates the temporary refuge space. These solutions are described in EN 81-21, *Safety rules for the construction and installation of lifts—Lifts for the transport of persons and goods—Part 21: New passenger and goods passenger lifts in existing buildings* The application of this harmonized standard confers a presumption of conformity and compliance with the European Lifts Directive.

Reference

1. EN 81-30, *Safety rules for the construction and installation of lifts - Part 30: Electric and hydraulic service lifts*

Well Installation Components

5

5.1 General

The well installation components essentially consist of the guide rails with the associated fastenings on the wall of the well, the buffer in the pit, the counter-weight with its counterweight guides, and the lighting in the well. Furthermore, all connecting lines from the control system to the external call panels are located in the well, as well as the lift positioning system and the control line from the car to the control system, the so-called travelling cable.

In the case of machineroomless lifts, the components that support the drive can still be counted as well components. Additional components such as a movable stop in the pit in the event of reduced headroom or pit depth can also be counted as well installations in the broadest sense.

5.2 Guide Rails

The task of the guide rails is to guide the car through the well. In order to achieve a good ride comfort, the guide rails must have a certain stiffness and good quality, as well as being mounted correctly in the perpendicular and the required gauge.

▶ The gauge is the distance between the guide rails.

During mounting, it must be ensured that the guide rails have clean guide surfaces and clean joints. The joints are located between the guide rails. There is a groove on one end of the guide rail and a tongue on the other end. When moving from one guide rail to the next, the tongue must fit cleanly in the groove. It is also important to ensure that the guide rails are correctly mounted on the joints. In addition, the guide rails are fitted with a counter plate at the joints on the back of the guide rail to prevent them from slipping. The guide rails are divided into drawn profiles and

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additionally machined profiles. Very narrow tolerance limits apply to high-quality guide rails. The smaller the tolerance of the guide rails, the faster the lift can be designed, i.e. the faster the drive can be selected.

The guide rails are mounted to the well wall using guide rail brackets. These guide rail brackets must allow and compensate for vertical changes in the building, as the guide rails must be able to absorb forces in all directions (x, y and z). The verification of guide rails is described in EN 81-50, point 5.10 (*formerly Annex G of EN 81-1/2*) [1].

The size of the guide rails is described in the form of three consecutive numbers. For example, 90/75/16 means that the rail width is 90 mm, the height is 75 mm and the bar width is 16 mm, as shown in Fig. 5.1a.

In order to be able to mount the guide rail brackets on the well wall, C-profile rails are concreted into the well side walls when constructing a new building. The distances between the fixings depend on the rated load and the forces to be expected to be dissipated.

For passenger lifts with a rated load of 630 kg, the fastenings have a distance of approx. 1200 mm to 1500 mm. For heavy goods lifts with a large rated load, the distance can also be smaller. These construction-related specifications must be specified by the lift company and are noted in the system drawings. These specifications must be strictly adhered to by the contractor building the well.

For wells made of masonry (brick, sand-lime brick), the C-profile rails must be embedded in concrete at the designated points in the well by means of ring cores. The guide rail brackets for the guide rails are then attached to these cores with

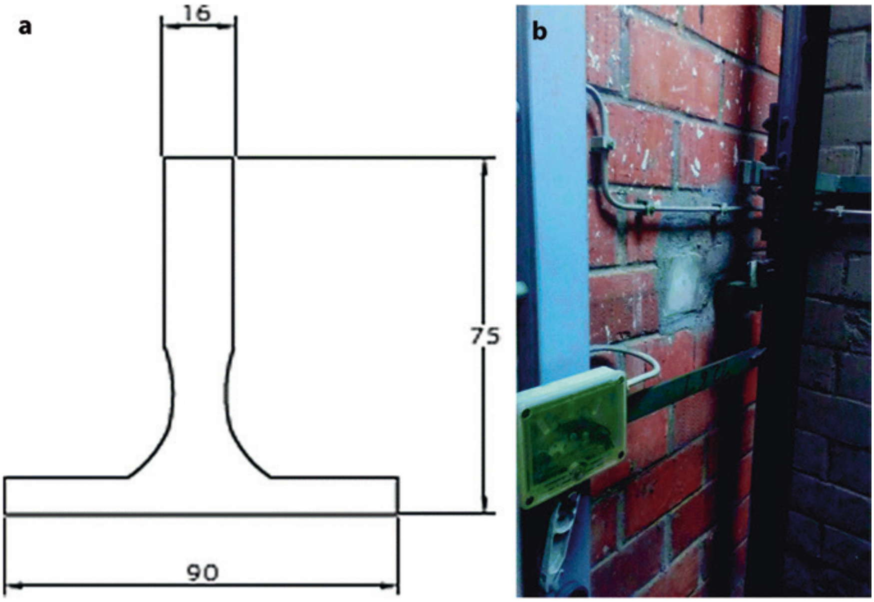

Fig. 5.1 **(a)** View of a guide rail, **(b)** Guide rail bracket for guide rails. (Source: Author)

Fig. 5.2 Special screw for mounting in C-profile. (Source: Author)

special screws. These special screws consist of a rectangular block with a short thread. The thread has a groove milled into the end face. If the special screw is mounted correctly, this groove is visible in a vertical position as can be seen in Fig. 5.2. In Germany, the position of the groove is also checked by third party during the recurring inspections. The guide rail brackets for the guide rails have slotted holes so that a small perpendicular or well inaccuracy can be compensated for during mounting.

If someone wants to modernize lift systems, especially in older buildings, there are often wells, made of bricks. The guide rail brackets in these wells used to be bricked in directly and cannot be moved, as can be seen in Fig. 5.1b. These are rarely used for safety reasons. In this case, push-through anchors must be used for the installation of the new guide rail brackets in order to be able to mount them according to the regulations. However, through-hole anchors have the disadvantage that the counter plates on the rear side of the well wall must be mounted under the plaster. This solution can result in further costs (plaster and painting work). Through-hole anchors are steel plates with a welded-on threaded rod. The threaded rod is inserted from the outside through the masonry into the well by means of drilled holes so that the steel plate acts as a counter plate. The fixing brackets can be mounted to the threaded rods.

However, as an alternative to the through-hole anchors, there are also specially developed adhesive dowels that meet the requirements and provide a good hold in the masonry. These must be approved for corresponding dynamic and static tensile forces. The glued dowels are available depending on the type and condition

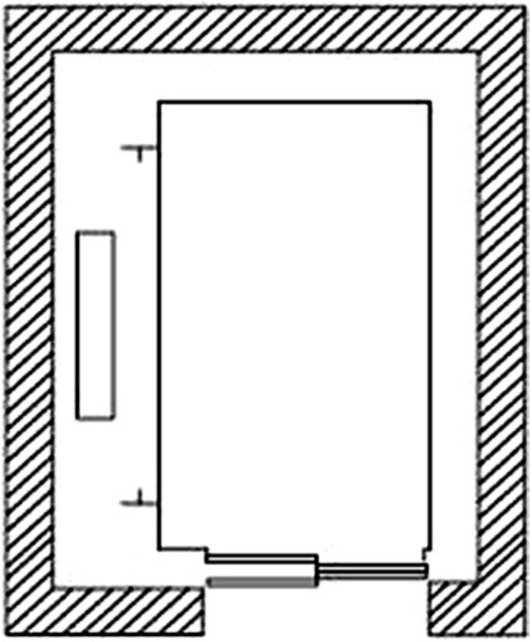

Fig. 5.3 Guide rails, arranged on one side

of the masonry. Installation using adhesive dowels requires more time, because if the correct procedure is followed, the drill holes must first be blown out before the adhesive is fixed in the drill hole with the dowel. In addition, a drying time per anchor must be observed according to the manufacturer's specifications. When using these glued dowels, the suitability for the specific application must be agreed with the manufacturer in advance.

Depending on the type of car frame (see Sect. 11.1 for details), the guide rails are arranged on one side or on two opposite sides in the well. If the guide rails are mounted on one side only, a backpack suspension is used (see Sect. 11.1 for details). When using a backpack suspension, the safety gear has an L-shape to accommodate the car. Figure 5.3 shows the arrangement of the guide rails on only one side. If the guide rails are arranged on two opposite sides, as shown in Fig. 5.4 the car sling is guided on two sides. This car sling is then called the central frame.

5.3 Buffer

According to EN 81-20, a buffer must be installed in the well pit, which can cushion the car in an emergency. According to EN 81-20, the buffers belong to the safety components of the European Lift Directive and must be tested according to the specifications of EN 81-50.

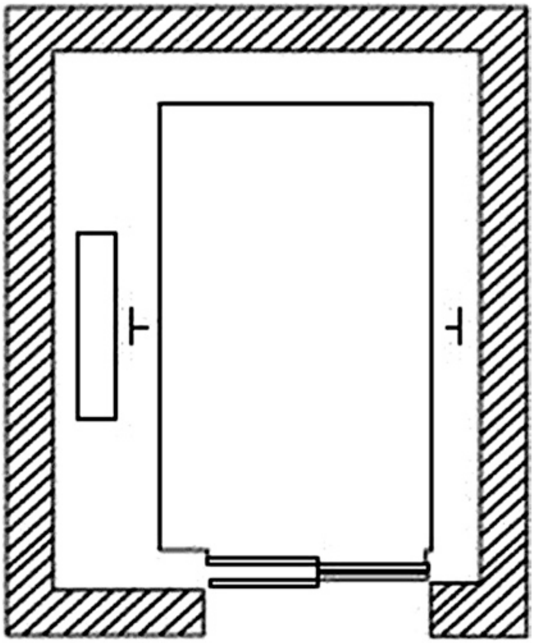

Fig. 5.4 Guide rails, arranged opposite

A distinction is made between energy storing and energy consuming buffers. Energy-storing buffers are used as cellular volcano buffers for speeds < 1 m/s. Energy-consuming buffers are used as oil buffers. Energy-consuming buffers may be used in all lift systems, regardless of the respective nominal speed. Fig. 5.5 shows an energy storing buffer and Fig. 5.6 an energy consuming buffer.

Fig. 5.5 Energy storing buffer with buffer support. (Source: Author)

Fig. 5.6 Oil buffer for speeds > 1 m/s. (Source: Author)

▶ Defective buffers are generally recorded by the German improved inspection body as a deficiency, and if necessary also as a significant deficiency. In the course of time, cellular volcano buffers become porous. Due to the porosity, the buffer loses its safety properties and must therefore be replaced.

5.4 Counterweight

The counterweight is guided on its own counterweight guide rails. The nature of the counterweight guide rails is similar to the guide rails for the car. The dimensioning is usually somewhat smaller, but for small lift systems (very low rated load or small goods lifts), a sheet metal plate bent several times and having the shape of a guide rail is also used. The counterweight can be guided laterally or behind the car and consists of a metal frame filled with weights made of either lead, concrete, cast iron or steel. Shoes or rollers can be used as guide elements. If rollers are used as guides, the guide losses are lower. Furthermore, lubrication is not necessary. When using a sliding guide shoes, lubricate the rails lightly to increase the sliding ability. This can also prevent possible squealing.

The counterweight frame can also be equipped with a safety gear. According to EN 81-20, this must be taken into account for accessible rooms under the well.

The mass of the counterweight depends on the rated load and the car weight. The weight of the counterweight is usually as large as the car weight plus half the rated load. However, it is also possible to deviate from this.

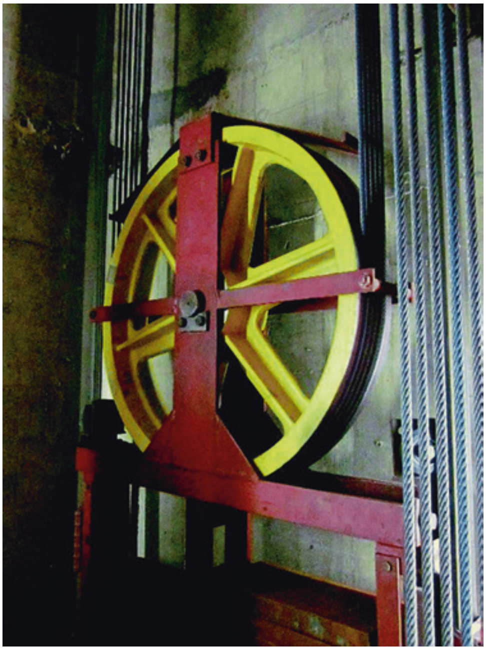

Fig. 5.7 Upper part of a counterweight with deflection roller. (Source: Author)

Older lift systems can also have counterweights in the form of a bar weight. This type of design is no longer permitted today. If the lift system is modernized, the replacement is required by the German improved inspection body. In the case of the rod weight, two rod threads are inserted through the weights, which are screwed together with a nut at the lower end and thus hold the weights together. With this design there is a risk that the weights will fall off if the nuts are corroded.

Figure 5.7 shows the upper part of a counterweight consisting of a metal frame filled with steel weights.

5.5 Guides

Both the car and the counterweight must be guided. A distinction is made between sliding and roller guides.

The sliding guide is the simplest way to guide a car or counterweight. Here, guide shoes in U-shape are mounted in a bracket on the safety gear or counterweight in order to guide the car or counterweight safely along the guide rails. The guide shoes must be lubricated in order to ensure that they glide smoothly. This is done by means of a rail oiler on each side, as shown in Fig. 5.8 for a counterweight. The rail lubricator consists of a container filled with oil. It has a wiper at the bottom, which leaves oil on the guide rails during up and down travel. Figure 5.9 shows a rail oiler on the car roof for a car guide.

Fig. 5.8 Rail oiler mounted on the counterweight. (Source: Author)

Fig. 5.9 Rail oiler on the car roof for lubricating the guide rails. System with sliding guide. (Source: Author)

- In principle, the sliding guides do not need to be lubricated, as they are considered to be low-maintenance. In practice, however, they are lubricated to prevent squeaking noises. The rail oiler applies a light lubricating film to the guide shoes.

- If the guide shoes are defective, the car may jerk or even squeak in some places.

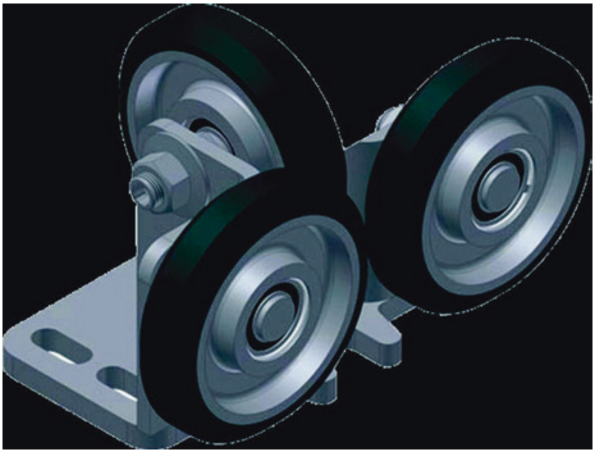

Fig. 5.10 Roller guide. (Source: Lift Technology G. Schlosser, Dachau, Germany)

In roller guidance, roller packages are attached to the safety gear frame, which then guide the car through the well along the guide rails. Two roller packages are attached to each side of the safety gear. One package at the top and one package at the bottom of the safety gear. A roller package usually consists of three rollers. One roller for the front side of the rail and two on the side. Figure 5.10 shows a roller package for a roller guide. In high-speed lifts, roller packs consisting of 6 rollers are used.

Spring-loaded rollers are used in lifts for high speeds. Lubrication is not required when using a roller guide.

▶ Due to wear and tear, the rollers become porous and cracks appear. If the rollers are not replaced in time, the lift's ride characteristics will deteriorate, as the damage can make the rollers out-of-round.

5.6 Lift Positioning System

The lift positioning system transmits the current position of the car to the lift controls. Without this component, it is impossible for the control unit to determine the position of the car and control the drive. This control is necessary because the speed must be reduced at the destination stops.

The first copying machines consisted of a mechanism in the form of a turntable in the machine room, which was driven by a chain or belt attached to the car. There was a switch for each stop. This enabled the control system to detect at which landing the car was located.

The further development of the mechanical copying units was a mounted cam switch at each stop in the well, which was actuated via switching cams as the car passed. The cam switches were later replaced by magnetic switches. Magnets or magnetic strips were attached to the stops. When the car passed, the magnets were moved away by sensors and the current position of the car could be determined.

> The adjustment of the magnets is complex. Furthermore, the controller loses the car position in case of a power failure, so that a learning trip through the well is necessary. During the learning trip, the car moves down the entire well and "learns", where the stops are located.

There are also systems in which a magnetic belt is fixed in the well over the entire height of the well. Magnets are placed on this magnetic belt to define the stops. The position of the car can be determined by means of a reading head on the car.

Another simple system can be seen, for example, in Fig. 5.11. A rope, which is fixed in the well headroom and in the well pit, is connected to a counting unit fixed to the car. The counting unit then provides the position of the car and transmits this value to the controller. The information is generated by rotary movements, as shown in Fig. 5.12. These are generated by the car movements in the well. However, this system can only be used up to speeds of 0.63 m/s, as at higher speeds a slip occurs which falsifies the measurement. If the power supply fails, the car must also perform a learning trip with this system.

Another lift positioning system works by means of an ultrasonic system. In this system a receiver is mounted in the well headroom and a transmitter on the car. The connection is made by a wire through the well, which connects the transmitter and receiver. The transmitter emits ultrasonic waves in the direction of the well headroom and pit. The receiver can now calculate the distance between the transmitter and receiver based on the transit time and can thus determine the absolute position of the car. By programming the building heights into the system, the car can directly approach the landings. As an orientation, a reference point is installed at a point in the well. This reference point must be passed over if the information for recalibration is lost [2].

A lift positioning system in which, in conjunction with the appropriate control system, the requirements of point 5.6.7 of EN 81-20, protection against unintentional car movement, are met is, for example, the Silent Move from Wachendorff Automation. In this system two independent encoders work together. A revolving studded belt ensures that the information is generated reliably. This system is additionally equipped with a safety function. The dimpled belt runs around a moving roller in the well pit. If the tension force of the dimpled belt slackens or tears, the roller drops due to the weight force and actuates a switch that stops the lift system from operating. Figure 5.13 shows the complete system. Figure 5.14 shows the two independent encoders and the safety function in the form of the roller, which is located in the well pit [3].

A system still in use today is the installation of a continuous steel band in the well. In the well pit and in the machine room there is one deflection wheel each,

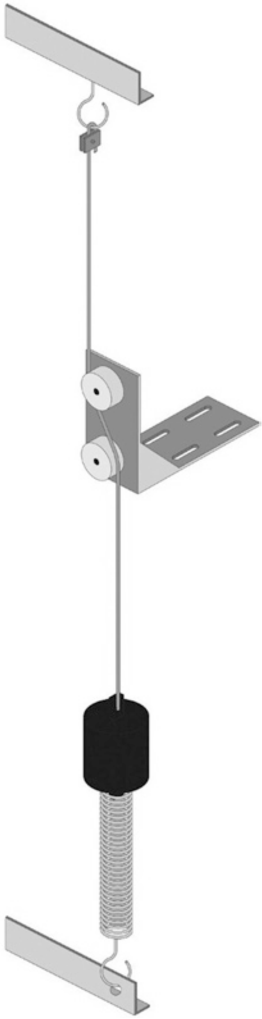

Fig. 5.11 Lift positioning system with tensioned rope up to 0.63 m/s. (Source: Wachendorff Automation, Geisenheim, Germany)

around which the steel strip is guided. In the machine room, the deflection wheel on the well is fitted with a counting unit that determines the exact position of the car by assigning a defined travel height to each revolution at the deflection wheel. Such a system can still be seen in lifts in high-rise buildings.

A combination of a lift positioning system and an overspeed governor was developed by the company Cedes. In this system, a tape with a printed barcode is attached to the well, as shown in Fig. 5.15. A reading unit on the car, shown in Fig. 5.16, reads the information and recognizes the position of the car. By attaching position clips to the barcode, which are mounted at the level of the landing

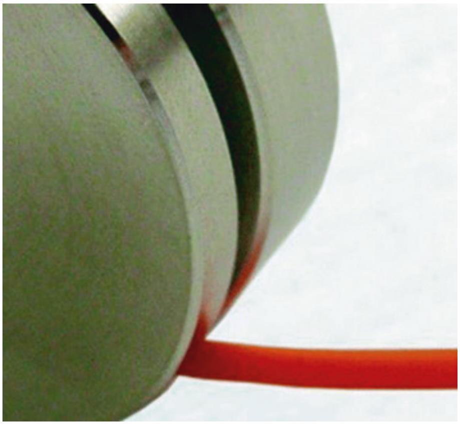

Fig. 5.12 Detail of a rope at the guide roller. (Source: Wachendorff Automation, Geisenheim, Germany)

door sills or landing door linters, the position of the landings is detected, as shown in Fig. 5.17. In addition, as mentioned above, this system measures the speed of the car, so that if overspeed is detected, the lift is shut down. This system belongs to the PESSRAL equipment. PESSRAL devices are Programmable Electronic Systems in Safety Related Applications for Lifts. The information is evaluated in the control system.

5.7 Well Lighting

The well lighting in the well is an important component to provide adequate lighting for the service technician or inspector in the well. According to DIN EN 81-20, illuminance must be at least 50 lx at a height of 1 m above the car roof [4]. The well lighting is operated either in the machine room or in the well pit. It is also possible to switch on the lighting at each landing using a rope installed in the well. The lighting is supplied with 230VAC, which is fed via the control system and is separately fused. In the meantime, LED lamps are used as lighting fixtures, as the energy consumption here is very low.

Whereas in the past, the first lift systems did not have adequate lighting in the well, which was achieved by a simple luminaire with an incandescent lamp, great attention is now paid to lighting. Not least due to the regulations of occupational safety, but also the detection of damage is not guaranteed without sufficient lighting in the well.

Modern well lighting systems are available today as pre-assembled systems. This simplifies installation, as only the luminaires and cables need to be fixed and electrical connection work is no longer necessary, as all connections are equipped with plug-in systems. In Germany, this installation method only requires the fitter to be qualified as a qualified electrician for specified activities.

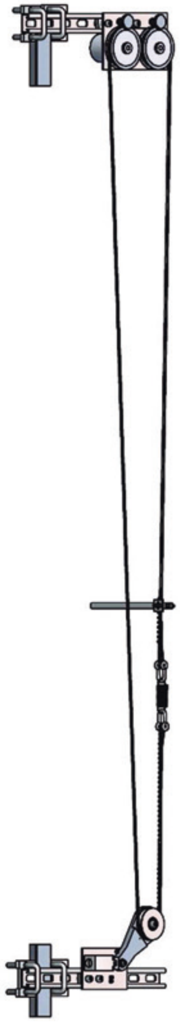

Fig. 5.13 Silent Move. (Source: Wachendorff Automation, Geisenheim)

Fig. 5.14 Mimic of Silent Move in the well headroom and in the well pit (safety function). (Source: Wachendorff Automation, Geisenheim)

Fig. 5.15 Barcode tape. (Source: Cedes GmbH, Landquart, Switzerland)

Fig. 5.16 Barcode reader. (Source: Cedes GmbH, Landquart, Switzerland)

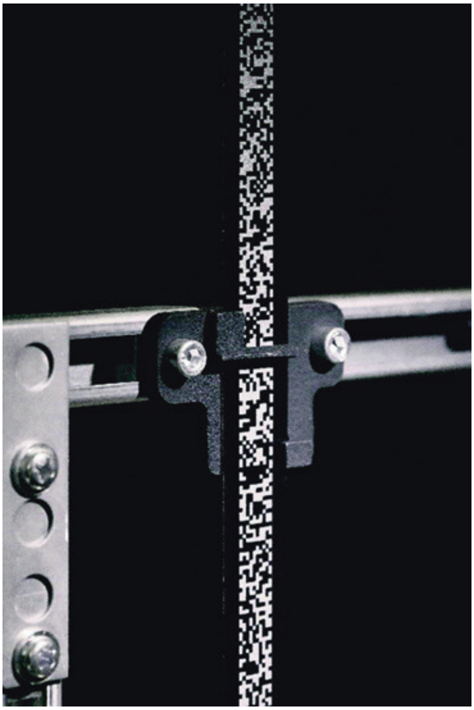

Fig. 5.17 Position clip. (Source: Cedes GmbH, Landquart, Switzerland)

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2. EN 81-80, *Safety rules for the construction and installation of lifts - Existing lifts - Part 80: Rules for increasing the safety of existing passenger and goods passenger lifts*
3. Product brochure “Magnetic absolute encoders”, Wachendorff Automation, Geisenheim
4. EN 81-20, *Safety rules for the construction and installation of lifts - Lifts for the transport of persons and goods Part 20: Passenger and goods passenger lifts*

Drives

6

Lift drives can be divided into three main categories as shown in Fig. 6.1 below. Other drives include other types of drives such as chain, spindle or rack and pinion drives. These have been grouped together, as the author believes that these are available in smaller numbers in comparison.

6.1 Rope drive

Motor Operating principle of the electric motor

By deflecting a current-carrying conductor in the magnetic field a movement is generated. This force, which is generated in this process, is called Lorentz force. This principle is used to generate a rotary motion of e.g. a rotor in a magnetic field [1].

$F = Q \bullet v \bullet B$ Lorentz Force

Now you arrange the coils around their center, each offset by 120°. When current flows through these coils, a rotating field is created. These coils are then called a stator winding. If a well with a wound coil is now brought into this rotating field, the well moves in a circle in this magnetic field. The well with a coil or a lamination package is also called a rotor.

A distinction is made between synchronous and asynchronous machines. In synchronous machines, the rotor field moves at the same speed as the stator rotating field. In asynchronous machines, the rotor field moves at a higher speed than the stator rotating field. The difference between the speed of the rotor and the speed of the stator is called slip. This slip must be present, because a torque is only generated when the magnetic flux changes. If the two speeds were the same, the torque would be zero.

D. Unger, *Lifts and Escalators*, https://doi.org/10.1007/978-3-662-67822-0_6

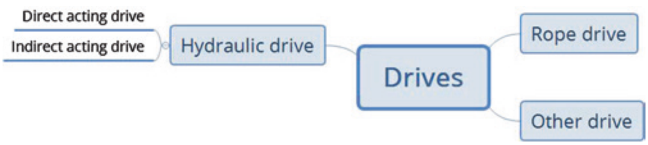


Fig. 6.1 Overview of drive types

The speed of the motor can be calculated. This depends on the frequency, the time and the number of pole pairs. Since a motor has at least two poles, there is at least one pole pair.

$$n = 60 \times \frac{f}{p}$$

n = speed of the motor
f = frequency
p = number of pole pairs

Performance
The energy absorbed by the supply network is converted into mechanical energy. However, not all the energy is converted into rotary motion, because the motor also has losses. The losses are divided into iron losses, winding losses and friction losses.

The iron losses are caused by eddy currents and re-magnetisation processes in the rotor. The winding losses are caused in the winding resistances and the friction losses are caused by the bearing as well as by the air resistance during self-ventilation.

The remaining power is converted into motion. The difference between the energy absorbed and the energy given off is called efficiency.

The efficiency is calculated from:

$\eta = \frac{W_{out}}{W_{in}}$

η(eta) = efficiency
Wout = power output
Win = absorbed power

Gear
Gears are used behind the electric motor to reduce the speed or increase the torque. The gearboxes are encapsulated so that the essential components are not visible. When using a gearbox, you must ensure that it is sufficiently lubricated. Due to the constant left–right movements (change of direction of the car) or due to the high number of starts from standstill, gearboxes are subject to very high stress. Therefore, great importance should be attached to care and regular oil checks.

The following gearboxes are widely used:

- Worm gear units
- Planetary Gearhead
- Helical gear units.

The **worm gear unit**, as shown in Fig. 6.2, is the most widely used gear unit in lift technology. It consists of a well with one screw thread, the worm and a wheel offset by 90°, the worm wheel. Both units are toothed together.

The advantages are the large reduction ratio, the simple design, the high self-locking effect. In addition, the worm gear is low-noise.

The disadvantage is the poor efficiency.

The **planetary gear**, consists of a gear set. The sun gear, the planet carriers and the ring gear with internal teeth. The well is located on the sun gear. The advantages are a good efficiency and compact design. The disadvantages are the high noise level. Furthermore there is a high effort in the production.

The **helical gear** consists of parallel arranged axes. The simplest design is the single-stage helical gear unit, which consists of two wells, each of which has a gear wheel mounted on it. However, multi-stage gears can be formed by adding further gear wheels and intermediate wells.

The advantages are the large reduction ratio, the simple design, the low self-locking and the high efficiency.

The disadvantages are the high noise level and the unfavourable ratio of traction sheave to gear wheels.

With gearless **drives,** the traction sheave is mounted directly on the motor well. Due to the high torques, a high material input is required, since large designs are necessary here. When this drive was first used many years ago, it was only used in high-speed lifts.

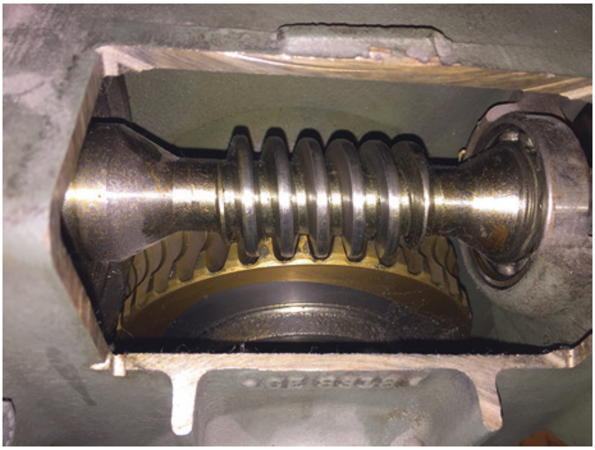


Fig. 6.2 Worm gear unit. (Source: Author)

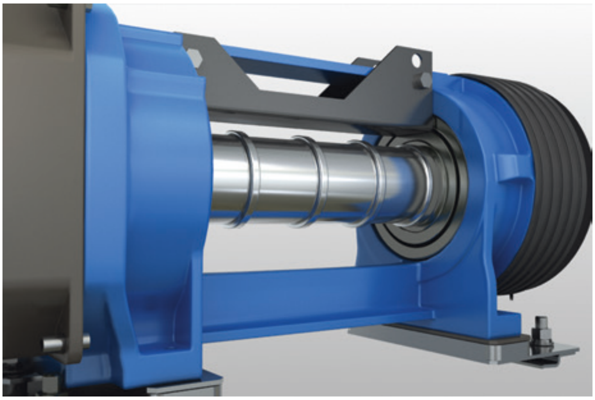


Fig. 6.3 Gearless drive for machine roomless systems, Gen2. (Source: OTIS GmbH & Co. OHG, Deutschland)

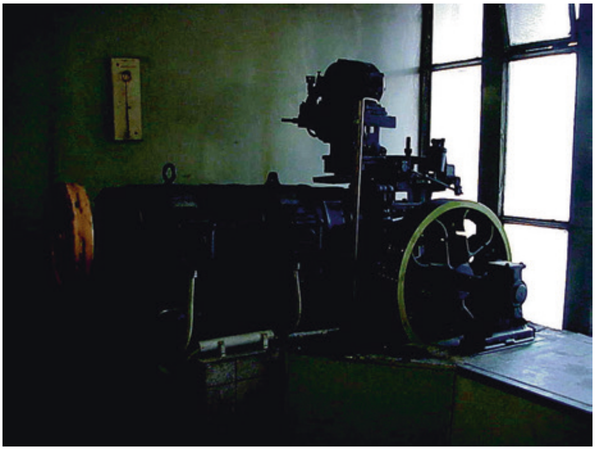


Fig. 6.4 Geared lift machinery built in 1956 with 3-point bearing. (Source: Author)

In the further development of these drives, the use of permanent magnets made it possible to build the drives much smaller in size. Today, synchronous motors are equipped with a permanent magnet so that higher speeds can also be achieved, see Fig. 6.3

The advantages lie in the quiet running. Furthermore, the brake is directly on the traction sheave, which ensures a high level of safety.

The disadvantages in the past were the slightly higher production costs. However, this has been put into perspective by the increase in quantities due to rising demand.

Figure 6.4 shows a lift machinery from 1956 with a 3-point bearing.

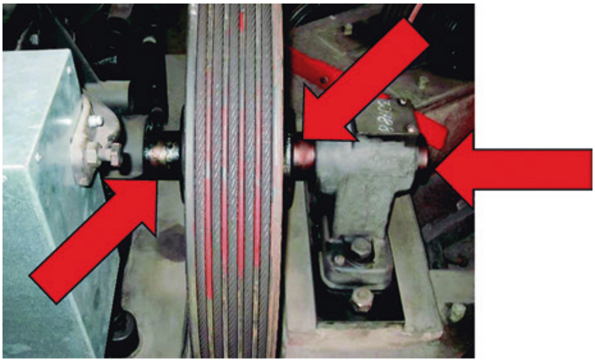


Fig. 6.5 3-point bearing. (Source: Author)

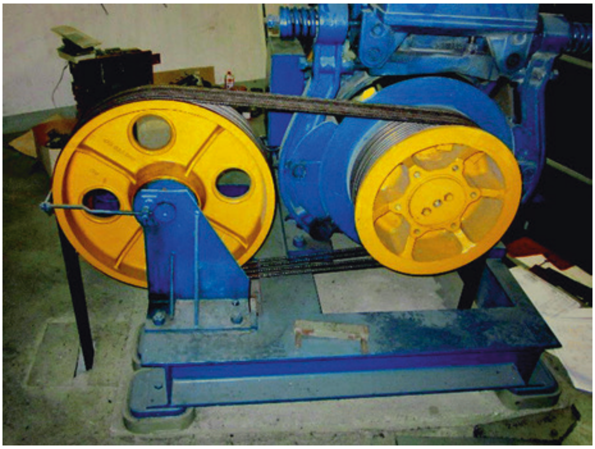


Fig. 6.6 DC drive with double wrap. (Source: Author)

A 3-point bearing arrangement is created when the traction sheave is mounted on a long well and this well is supported at three points, as shown in Fig. 6.5. The arrows show the bearing arrangement. A distinction is made between a statically determinate and a statically indeterminate bearing arrangement. With the statically indeterminate bearing arrangement, well breakage can occur due to displacement of the drive or incorrect reinstallation of the traction sheave after a change. Some specialist companies regularly carry out an ultrasonic measurement of the well in such systems. In the case of statically determinate bearing arrangements, displacement is unproblematic due to the mobility of the bearing arrangement.

Direct Current Drive

It should also be mentioned that there are also drives that are operated with direct current. To operate these motors, a generator is required which converts the AC voltage taken from the mains into a DC voltage. These generators are housed in a separate generator room. Figure 6.6 shows a DC drive with a double wrap.

Traction Sheaves

The traction sheave is used to convert the rotational movement of the machine into a linear movement of the car. Friction transfers the movement to the suspension means. This chapter only describes traction sheaves on which steel ropes are placed as suspension means. The shape of the grooves plays an important role. In general, a distinction can be made between the following groove shapes:

- Seat groove
- V-groove
- Semicircular groove
- Grooves with undercut

With the semi-circular groove, as shown in Fig. 6.7 b), the rope is subjected to the least stress. However, the traction capacity is not sufficient for single wrap, so double wrap is necessary. This type of groove is therefore often used for high-speed lifts. Figure 6.7 a) shows a rope without a groove.

In the V-groove shown in Fig. 6.7 d), the ropes are subjected to very high stress due to the wedge effect. Lower car weights are the better solution here. However, if the car weights are high, the tapered groove should be hardened, which reduces wear.

The seat groove is the optimum shape when the rope radius and the seat groove radius match. However, this is only the case with new ropes, as the rope stretches over time, it no longer fits optimally in the groove. Solid steel ropes in particular stretch more. Alternatively, a rope with a fibre core can be used, as it can adapt better. Figure 6.7 c) shows a semi-circular undercut groove. Figure e) shows a V-groove with an undercut.

Traction sheaves 6.7 can be hardened to reduce wear. The rope impressions can also be reduced. From a hardness of over 200 HB (Brinell hardness), wear is very low.

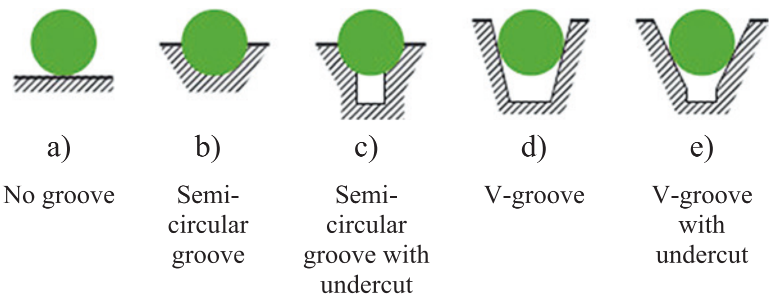


Fig. 6.7 Different grooves. (Source: Gustav Wolf GmbH, Gütersloh, Germany)

▶ When replacing traction sheaves, it is advisable to replace the ropes as well. A traction sheave with worn grooves has already changed the shape of the rope. If the ropes are not replaced, the already damaged rope would damage the traction sheave again. The same applies in reverse, i.e. when replacing the ropes, the traction sheave should be inspected carefully. If there is also damage to the grooves, it is also recommended to replace both (traction sheave and ropes).

During regular maintenance, the condition of the ropes and traction sheave grooves must be checked in particular. This is because car movements are only possible if there is sufficient friction between the rope and traction sheave. Furthermore, when lubricating ropes, the service technician must ensure that the correct rope care product is used and that excessive lubrication does not reduce traction.

Control/Frequency Control

To move the car in the well, a drive is required. To make this drive work, a control system is needed. Each time the drive is started, the car moves out of the landing up to the nominal speed. If the destination landing is too close, the nominal speed is not reached. At the destination, the car moves into the landing at reduced speed until it comes to a standstill.

Now there are two ways to realize this. In older lift systems, a Dahlander switch was used to switch between two speeds. A slow speed, the so-called creep speed, and the nominal speed, the faster. The change was made by changing the number of pole pairs. Detectors in the well (magnetic switches) have marked an unlocking zone within the landing. Inside this unlocking zone, the car is in creep speed, outside at nominal speed.

The current state of the art is frequency control. Frequency control is made possible by using a frequency converter. Here the frequency converter converts an alternating current or three-phase current into a voltage with changed frequency and amplitude. With conventional control, the motor can only operate at a fixed speed because the mains frequency is constant. By using a frequency converter, the speed can be controlled continuously from zero to the nominal speed without the torque decreasing. Figure 6.8 shows such a frequency converter.

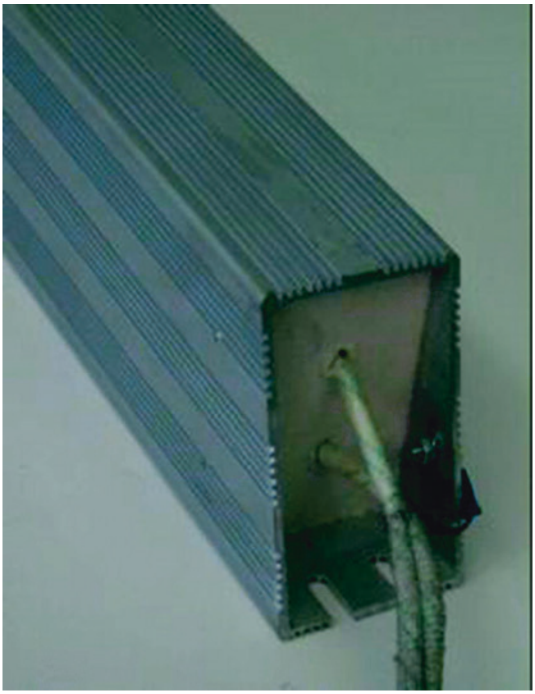
In asynchronous machines, control can be achieved by changing the voltage. This is realized by a phase angle control, but this is no longer common today.

Loadresistance

The load resistance as shown in Fig. 6.9 is a component that absorbs the excess energy of the frequency control. This resistor is mounted near the controller and is fitted with a grid for protection, as these resistors can reach very high temperatures during operation.

Fig. 6.8 Frequency converter. (Source: KW Aufzugstechnik GmbH, Oberursel, Germany)

Fig. 6.9 Load resistance. (Source: KW Aufzugstechnik GmbH, Oberursel, Germany)



Energy Recovery

Instead of consuming excess energy in a load resistor, it is also possible to feed back the energy. This means that the excess energy can be used by another consumer in the same building. In the event that no consumer is available and the excess energy is fed back into the supply network, the quality must comply with national regulations. According to the information currently available, no compensation is envisaged since lift systems are not originally used to generate energy.

Value Transmitter

Each drive must be controlled as described above. However, a complete control loop also includes the feedback of the actual value. This feedback is realized by means of value transmitters. The encoders are mounted on the traction sheave well and measure the actual speed, which is then fed back to the control system.

A distinction is made here between **pulse encoder** and **absolute value encoder**.

The pulse generators are used in asynchronous machines. The output signal is a square wave signal. In principle, the pulse generator can be imagined as a perforated disc with an LED lamp behind it. One pulse is counted with each light penetration.

The synchronous motor requires an absolute encoder. Synchronous motors have a permanent magnet, therefore the exact position of the rotor (armature) in relation to the poles must be determined so that the windings can work exactly.

Figure 6.10 shows an electrically driven traction lift. The machine room is located above the well and houses the drive, the control system and the overspeed governor. Only one landing door for one landing is shown here as an example. The counterweight is located behind the car. From the rope guide you can see that it is a 1:1 suspension.

6.2 Hydraulic Drive

Mode of Operation

The hydraulic oil is pressurized in the hydraulic power unit, as shown in Fig. 6.11, by means of the motor located in the power pack and pumped through the pressure relief valve via the pressure hose to the jack. Valves control the oil supply. This is where most of the energy is consumed. During the downward movement only the valves are opened and the oil is drained into the power unit. In the first hydraulic systems, magnetic valves were used to control the lifter movements. The further development of magnetic valves were electronically controlled valves, as shown in Fig. 6.12. Today, fully electronic intelligent control valves are already available. These have the advantage that they are self-adjusting and can be operated by remote monitoring. Error logs as well as current status data can be called up, even parameters can be changed remotely. Figure 6.13 shows an intelligent control valve.

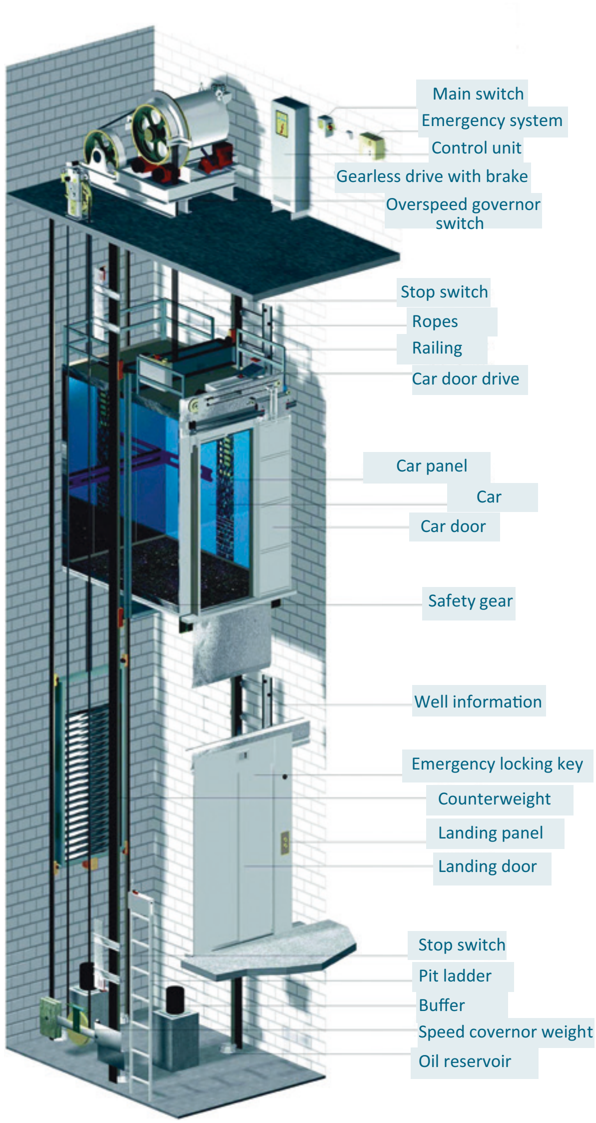


Fig. 6.10 Electrically driven cable lift. (Source: Schindler Deutschland AG & Co. KG, Germany)

Figure 6.14 shows a pressure gauge which indicates the pressure at the regulator block.

Hydraulic lifts are used up to a rise of about 25 m. Beyond that, they are used less, since on the one hand the pistons become unwieldy for the assembly due to large delivery heights and on the other hand the system reaches its limits. Despite

Fig. 6.11 Hydraulic power unit. (Source: Bucher Hydraulics, Neuheim, Switzerland)

the use of hydraulic oil, which is often controversial, the hydraulic drive still has its justification. A popular area of application is for large loads over short distances, for example as a freight lift or as a vehicle lift, which can have a rated load of up to 6 tons.

According to EN 81-20, hydraulic lift systems must have an electronic descent correction system that moves the car to the lowest landing no later than 15 min after the last trip. This is due to the safety of the user, since pressure losses can cause the car to lower. Minor lowering is compensated by the hydraulic system. This can be observed with some hydraulic systems, which are entered by persons and the car sinks slightly. With the readjustment option, the car is immediately raised again, i.e. the system detects the pressure loss and pumps hydraulic oil back into the jack at short notice, thereby bringing the car back to the correct level.

Hydraulically operated lifts systems require an oil-resistant coating in the well pit as well as in the machine room. The oil-resistant coating must be applied in three layers. The individual layers must be visible on the wall in the lower area,

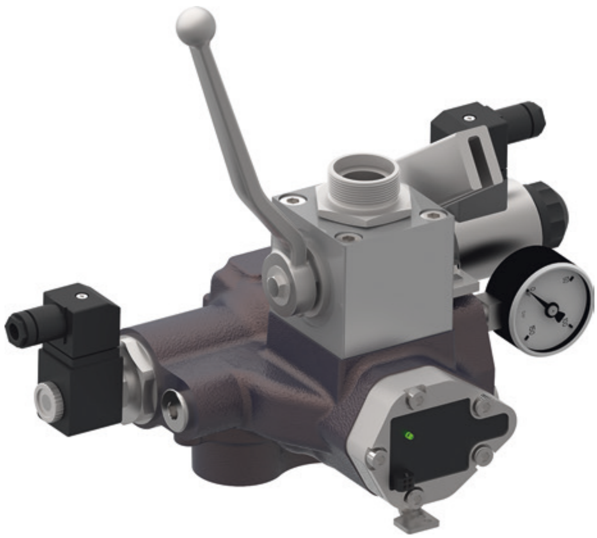


Fig. 6.12 Electronically controlled valve. (Source: Bucher Hydraulics, Neuheim, Switzerland)

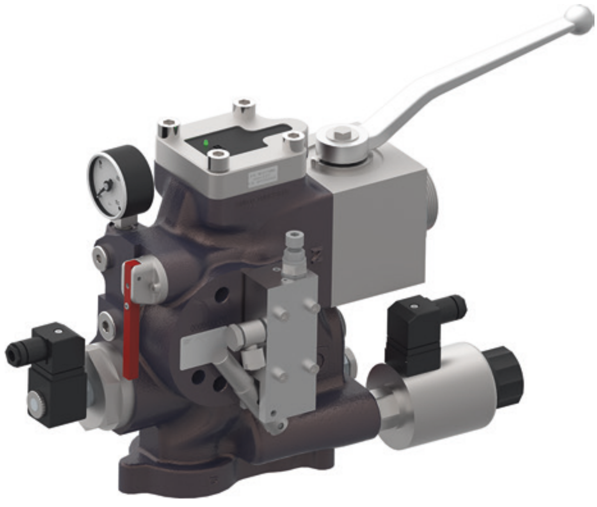


Fig. 6.13 Intelligent valve. (Source: Bucher Hydraulics, Neuheim, Switzerland)

each with a different colour contrast. The minimum height of the bottom coat must be at least the height of the oil level when the unit is completely drained.

The oil-resistant coating is intended to prevent leaking oil from penetrating into the masonry and then being transferred to the ground.

The machine room is located directly next to the well, so that the hydraulic hose line can be laid from the power unit directly into the well. If the machine

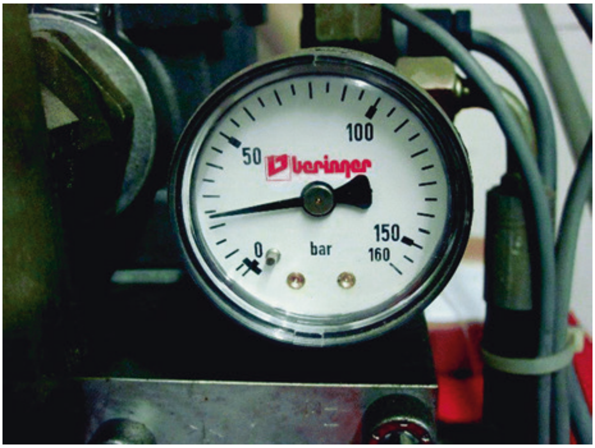


Fig. 6.14 Pressure gauge on the control block. (Source: Author)

room is not in the immediate vicinity of the well, the hydraulic line must be laid in a fixed pipe over the distance. The pipe must be visible for inspection purposes. As protection, a larger protective pipe can be used, which is laid under the floor. Alternatively, sheet metal ducts are also used which have an opening on the upper side over the entire length for inspection. There must be no connections within the protective pipe/sheet metal ducts, i.e. the hydraulic line must be laid in one piece from the engine room to the well.

The oil tank of the hydraulic power unit is not only used to hold the oil, but also for oil cooling. The larger the tank, the better the heat can be distributed. However, there are also circumstances which mean that the oil is not sufficiently cooled. This leads to the oil overheating and the lift system shutting down when the temperature reaches its maximum limit. Insufficient ventilation of the machine room can cause the oil to heat up too much. In such cases oil coolers can be used. Oil coolers remove some of the oil in the unit and cool it down to a lower temperature using a fan. Figure 6.15 shows such an oil cooler.

Hydraulic oils belong to the environmentally hazardous substances and must therefore be labelled. When filling the hydraulic unit with oil, the water hazard class in Germany must therefore be indicated on the unit by means of an oil passport. This allows you to identify the hazardous substance with which you come into contact in the event of damage. In other countries national regulations could have other requirements. A distinction is made between the following water hazard classes (WGK):

WGK 1 =	Weakly water endangering
WGK 2 =	Hazardous to water
WGK 3 =	Strongly water-endangering

Fig. 6.15 Oil cooler. (Source: Author)

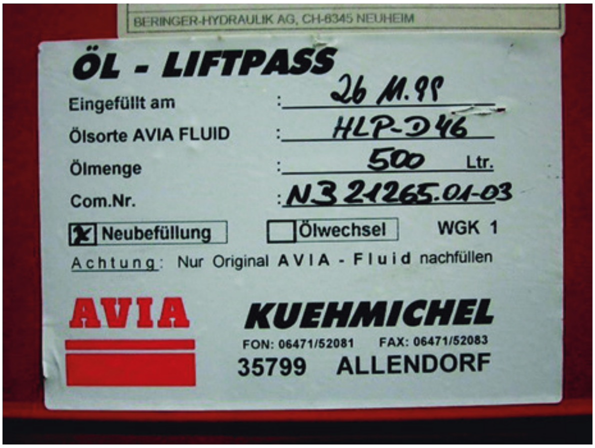


Fig. 6.16 Oil marking hydraulic unit. (Source: Author)

Figure 6.16 shows an oil pass. It shows the date of filling, oil type, oil quantity and water hazard class. Furthermore, it must be noted whether it is a new filling or an oil change.

6.2.1 Indirect Drive

With indirect drive, the jack is located on the side of the car. Steel ropes are guided over a rope pulley located at the upper end of the jack and are attached to the safety gear and to a suspension point at the lower edge of the jack. This arrangement results in a 2:1 suspension. This means that when the jack is lifted over 1 m, the car moves 2 m upwards. This has the advantage that the length of the jack is only half the height of the rise and also facilitates installation in new buildings. This means that when the jack is used at lift systems with a lower rise, it can be transported in the building over the floors / storeys and installed in the well. This is no longer possible with large rises. In these cases the jack must be inserted into the well from above the roof level with the help of a crane. This operation must be carried out before the well is closed by the well cover.

In the event of a fault in the event of overspeed in the downward direction, an overspeed governor and a safety gear on the frame are used here for safety purposes.

A non-return valve is still used as a safety component according to the European Lift Directive. This allows oil leaking from a defective hydraulic jack, for example, to be stopped quickly. For larger systems with large rated loads, for example vehicle lifts with a rated load of 6 t, the arrangement of two jacks is necessary. These are arranged opposite each other and are supplied by one power unit. The pressure lines are divided in the well. This division ensures that both jacks are subjected to the same pressure.

Figure 6.17 shows a backpack frame with a jack in a 2:1 suspension. At the upper end of the jack the deflection pulley is visible. The guide rails are located on one side, the front sides of the guide rails look at each other. The mounting brackets on the guide rail side are clearly visible. These fixing brackets are attached to the C-profile rails on the well wall.

Figure 6.18 shows some examples of hydraulic jacks.

6.2.2 Direct Drive

With the direct drive, the jack is located at the side or under the car and is attached directly to the car frame. The length of the jack corresponds to the travel height. This type of drive is only used in lift systems with 2 or 3 landings. Figure 6.19 shows a system with a 1:1 suspension.

Alternatively, long jacks can be sunk into the ground with an earth borehole. Due to the regulations imposed by the authorities for handling water-hazardous substances, these installations are rarely built today. Due to the high requirements regarding the testability of the protective tube, older plants, for example, are no longer modernised but are dismantled and replaced by other types of drives. In older plants, a steel tube was used to protect the siphon in the ground. This steel pipe is exposed to the moisture in the soil, which promotes corrosion and bears the risk that hydraulic oil escaping from the pipe due to damage to the pipe will penetrate the soil and contaminate the soil. The costs of soil remediation are enormous. For this reason, these lift types are examined in detail during the recurring inspection. If the earth pipes are too deep for a visual inspection, a cost-intensive camera inspection must be carried out.

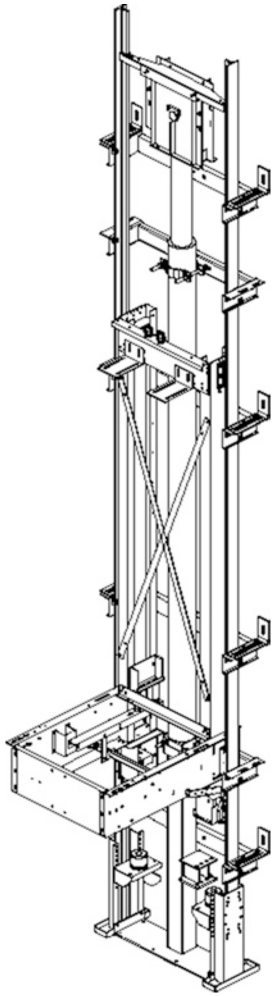


Fig. 6.17 Indirect hydraulic lift, suspension 2:1. (Source: Bucher Hydraulics, Neuheim, Switzerland)

An alternative is the renovation of the protective pipe.

▶ In this procedure, the existing steel pipe is lined on the inside with a plastic pipe. This protects the siphon against moisture from the ground and any oil leaking from the siphon is collected in the plastic pipe.

Figure 6.20 shows a hydraulic jack installed in the ground as a central jack.

The jack must be disassembled when the protective pipe is being renovated. The hydraulic system in the well is partially dismantled. Then a plastic pipe is

Fig. 6.18 Hydraulic jack (cylinder). (Source: Bucher Hydraulics, Neuheim, Switzerland)

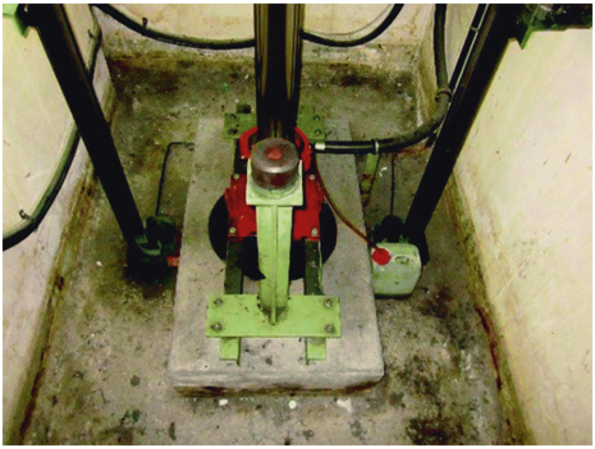


Fig. 6.19 Direct hydraulic lift, suspension 1:1. (Source: Author)

inserted into the existing steel pipe. After the plastic pipe has been inserted, the siphon is reassembled. During the work the car has to be secured, because the siphon has to be separated from it.

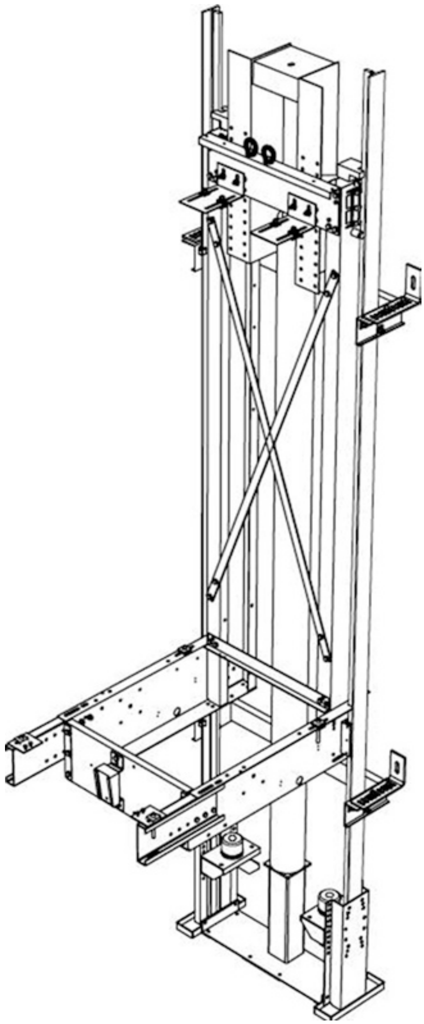


Fig. 6.20 View into the well pit of a direct hydraulic lift with central ram in the ground. (Source: Author)

A non-return valve, which is monitored by the controller, serves as a safety feature in the event of a fault.

Start Procedure Star-Delta Connection

Since the inrush currents of the motors of a hydraulic pump are very high, the starting current is limited in the starting torque of the star-delta connection. This avoids tripping of miniature circuit breakers in the sub-distribution boards and also prevents voltage drops.

Fig. 6.21 Softstart device. (Source: Author)

Soft Starter

The soft starter as shown in Fig. 6.21 or also called soft starter is an electronic control to reduce the starting current. With a phase-angle control, the voltage is reduced at the start and slowly increased to nominal load.

Frequency regulation

Frequency controls are also increasingly used for hydraulic power units. One advantage is energy saving. There are power packs that achieve energy savings of up to 60% compared to conventional power packs without frequency control. Driving performance with frequency controlled drives is also higher without the need for additional measures for oil cooling, as there is less heat generation.

Figure 6.22 shows an example of a rope hydraulic lift with a 2:1 suspension. The machine room is located next to the well and accommodates the hydraulic unit and the control system.

6.3 Comparison Between Electrically Driven Traction Lift and Hydraulically Driven Lift

There is often a discussion about which lift system is most suitable, the electrically driven traction lift or the hydraulically driven lift. Both lift systems have their advantages.

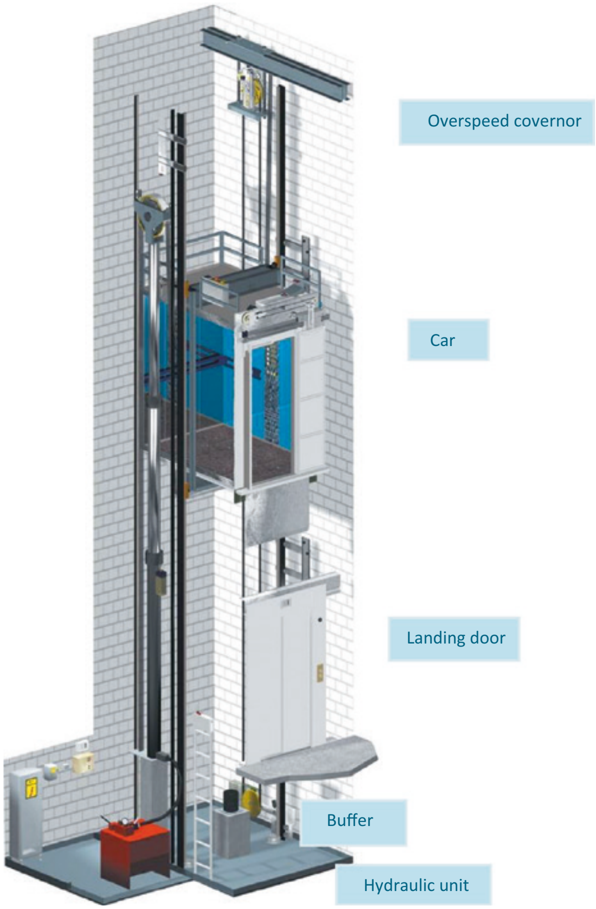


Fig. 6.22 Hydraulically driven lift with machine room. (Source: Schindler Deutschland AG & Co. KG, Germany)

The advantage of the electric traction lift is the possibility of realizing very large travel heights. The electrical connection values are approx. 4–7 KW (depending on the motor manufacturer) for an lift with a single-clad car (no glass) and a rated load of 630 kg at a speed of 1 m/s. In comparison, the connected loads can be up to 18 KW for a hydraulic system with the same equipment. These values are reduced when using a frequency-controlled drive.

According to a study by the Swiss Agency for Energy Efficiency, hydraulic systems do not perform worse than electrical systems when modern technologies are used. This study examined lift systems from various manufacturers and different drive technologies. The performances were recorded and classified and compared in different areas such as performance during travel, stand-by consumption, consumption of auxiliary equipment. More on this topic can also be found in chapter 24 [2].

Oil disposal issues are always taken into consideration when planning a hydraulic lift system. The oil must be disposed of during an oil change. In addition, the premises such as the well pit and machine room must be made oil-proof. With regard to environmental compatibility, it is possible to use biodegradable oil.

In the case of a rope drive, a dust-binding paint coat in the well pit is sufficient and what represents the oil change in terms of costs in a hydraulic lift system is the rope and traction sheave change in a traction lift system.

Many points play a role and it is up to each operator to decide which system to use.

6.4 Chain Drive

In the case of the chain drive, instead of a steel cable as the load-bearing element, a circulating chain is used to transport the car. This is done by means of sprockets in the well head and in the well pit and a circulating chain. By turning the motors to the left or right, the lift travels in an upward or downward direction. Today, this type of drive is only found in freight lifts of older design. Figures 6.23, 6.24 and 6.25 show an lift with chain drive.

6.5 Rack and Pinion Drive

Today, the rack and pinion drive is often used in wheelchair platforms, also known as wheelchair lifts. The platform is moved in a vertical direction by means of a rack and pinion. The left/right rotation moves the platform up or down. The drive is located in the side jaws, the platform is located between the jaws. A bracket

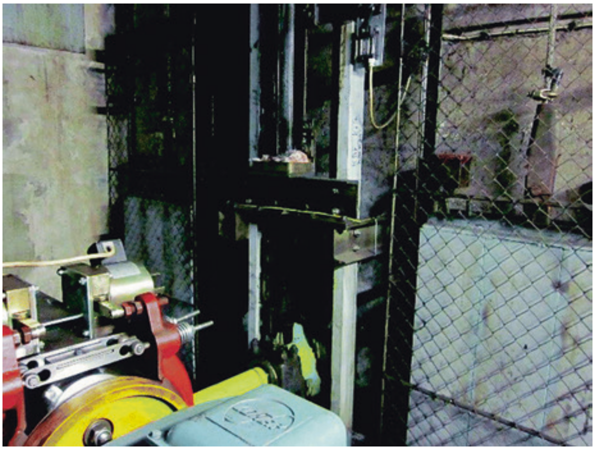


Fig. 6.23 Machine with well, gear wheel and supporting chain. (Source: Author)

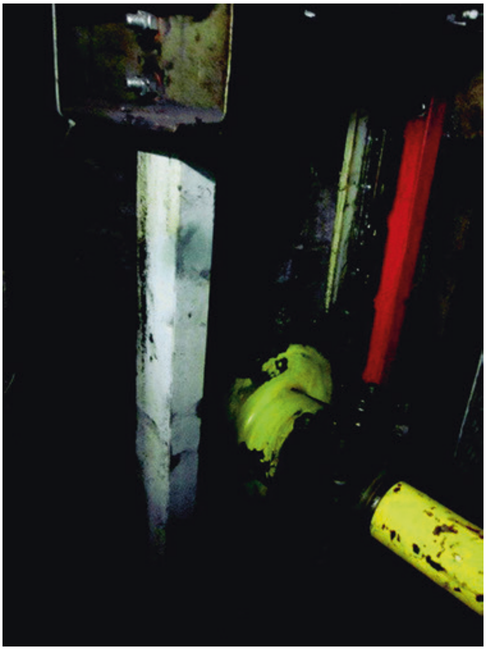


Fig. 6.24 Gear wheel on drive well with supporting chain. (Source: Author)

Fig. 6.25 Support chain with counterweights. (Source: Author)

on the platform serves as a fall protection. At the upper landing there is a revolving door as a fall protection. These platforms have a speed of 1.8 m/min. A small ramp is available at the lowest landing to assist in getting onto the platform. It is operated by means of a dead man's control. This control is located in the side wall of the platform. In addition, it is also possible to control the platform via a remote control [2].

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2. Electricity consumption and potential savings for lifts, final report November 2005, S.A.F.E Swiss Agency for Energy Efficiency, Zurich

7 Electrical Controls and Control Modes

The control cabinet contains everything that is necessary to control the individual electrical components. The control unit consist of a control circuit and a main circuit.

7.1 Control cabinet

The control cabinet contains everything that is necessary to control the individual electrical components. The control unit consist of a control circuit and a main circuit.

The main circuit controls the electric motor of the traction lift or the motor of the hydraulic unit via its main contactors. The supply voltage is 230/400 VAC. In the control circuit the supply voltage is usually 24 VDC or 48 VDC. Depending on the manufacturer or year of manufacture, other voltages are also available. The control circuit supplies all electronic components of a lift system. These include, for example, the landing control panels at the landings. Further tasks are the monitoring of the safety circuit, the exchange of information between the controller and the external call panels (landing and car panels) via bus lines.

The logical connections of the inputs and outputs were realized in old lift controls by relays as shown in Fig. 7.1. The disadvantage of this technique was the enormous space required for the part of the logical links. The logical connections consisting of relays, as shown in Fig. 7.2, are now made up of electronic boards. With the advent of microprocessor technology, the logical connections can be implemented even more easily, since they are only programmed. Changes to the programs are easier to implement, as there is no need for wiring. Programming is carried out via a control panel or via programming devices, which allow convenient access to all parameterization functions, shown in Fig. 7.3.

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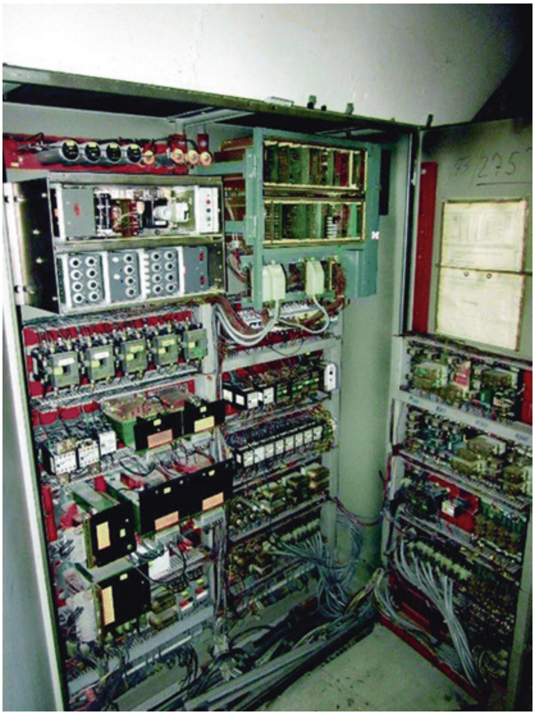

Fig. 7.1 Relay control. (Source: Author)

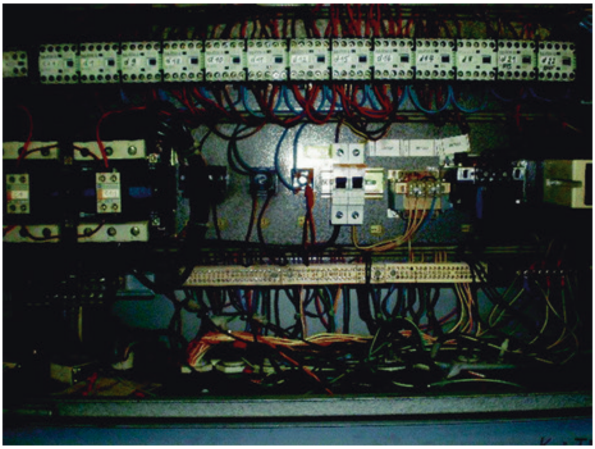

Fig. 7.2 Control cabinet. The electronic boards are located in the upper part of the control cabinet. (Source: Author)

In the case of the classic lift installation with an existing machine room, the control unit is located there. Easy access for maintenance or repair purposes must be ensured. In the case of lifts without a machine room, the machine room is not

Fig. 7.3 Programming device. (Source: KW Aufzugstechnik GmbH, Oberursel, Germany)

required. The controls are located in a small control cabinet. They are installed in the well and a small part outside the well, which is located next to the landing door in a narrow control cabinet.

There are also control systems that can be installed completely outside the well. These are placed in a small niche near the well. With these systems, the work to be carried out on the control system is no longer carried out inside the well, but outside. This increases safety during maintenance or repair by maintenance personnel. During planning, care must be taken to ensure that the view to the drive is guaranteed when the control unit is installed. During passenger rescue, it must be possible to see the movement of the drive when operating the control system. If a direct view is not possible, camera systems are used which display the movement of the traction sheave on a small screen.

Figure 7.4 shows a control system as used in lift systems that have a machine room. Figure 7.5 a) shows a control system as used in lift systems without a machine room. However, the compact design also allows it to be used in the machine room if space is limited. Figure 7.5 b) shows a service panel for operation of the lift outside the well.

All components of the lift system are connected to the control system. These include the main circuit to the drive, the connecting lines to the landing call panels, the connecting line via the travelling cable to the car. All information such as travel commands, operation of the emergency call button or of the car operating panel is transmitted to the control system. Furthermore, the safety circuit is integrated into the control system. The safety circuit contains important switches, which are designed as break contacts and, when actuated, bring the lift system to a standstill by interrupting the power circuit to the drive. The safety switches can be found on the landing doors, the overspeed governor and the safety gear.

If, for example, the landing door is opened from the outside during travel, the system must stop. Other safety contacts can also be integrated. For example, a door to an accessible well pit must also be integrated into the safety circuit, since

Fig. 7.4 Control system for a lift system with machine room. (Source: KW Aufzugstechnik GmbH, Oberursel, Germany)

the lift system have to stop when the door is opened in order to prevent accidents. Afterwards, safe entry is possible with the inclusion of further precautionary measures (actuation of an emergency stop button). Figure 7.6 shows in principle the components connected to the control system.

If the control system is optimally adjusted to the components in the lift system, it will also have optimum driving characteristics.

7.2 Single-Button Control

With single-button control, there is no collective function for the landing calls. This means that there is a panel at each floor with only one call button without directional preference. When a travel command is received in the car, this command is processed in the selected direction of travel. All landing calls are processed in the same direction until a new travel command is given in the car. Passengers boarding the car will travel in the car until all trips that were previously saved are executed. This type of control is rarely used today. The following two types are available:

Fig. 7.5 **a)** Control system for a lift without machine room **b)** Service panel (Source: KW Aufzugstechnik GmbH, Oberursel, Germany)
(Source: KW Aufzugstechnik GmbH, Oberursel, Germany)

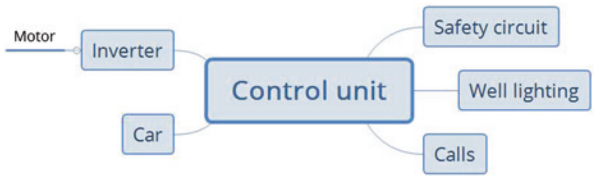

Fig. 7.6 Representation of the components connected to the controller

In the case of single-button down collective control, all run commands and landing calls are processed in the down direction until the run command entered is processed.

With the single-button upward collective control, all run commands and landing calls are processed in the upward direction until the entered run command is processed.

Fig. 7.7 One-button external call panel with integrated display. (Source: KW Aufzugstechnik GmbH, Oberursel, Germany)

This type of control is used in systems with only a few stops. Through the use of only one button, faulty operation by the user is not possible. Figure 7.7 shows an external call panel for a one-button control.

7.3 Two-Button Control

With two-button control, each landing call panel has two call buttons as shown in Fig. 7.8, one for up and one for down direction. Only one call button is required at each of the end stops, as shown in Fig. 7.9 a + b. With an external call in downward direction, the car only stops during downward travel. The same applies to the button for upward travel. With this type of control, the users can be sorted for the up and down travel, provided that they are operated correctly. The advantage is that no unwanted trips are made in the wrong direction and the car roundtrip time is increased in contrast to the single-button control.

▶ With this type of control, the rate of operating errors is high, as often impatient users press both call buttons. If a destination is desired in the down direction and both call buttons are pressed, the car stops once in the up direction and then in the down direction. The car roundtrip time is extended by the undesired additional stop.

Fig. 7.8 External call panel Two-button control of the intermediate stops. (Source: Author)

Fig. 7.9 **a + b** External call panels at the terminal stops (Source: Author)

7.4 Group Control

A group control is present if at least two lift systems are connected to each other in terms of control technology. In this case, one speaks of a duplex system. Three, four or six lift systems in a group are also possible by interconnecting the individual controls.

Each lift installation is given its own control system, which is linked to the control systems of the other lift installations in the group. This ensures that in the event of failure of one control system, the remaining systems can remain in operation. When a landing call is activated, it is calculated which cars can process the landing calls in question most economically.

With a group control, not every system receives its own landing call panel. Two cars are assigned to one landing call panel. This means that if there are three lift systems, there are only two landing call panels between the systems. The car circulation time and thus the waiting time of the users can be reduced by the group control.

In office buildings, clever programming of the control systems at the start of work in the morning hours allows the cars to be left ready in the main landing and the filling operation to be processed quickly. In the evening hours, the cars can be distributed throughout the building so that downward traffic can be handled more quickly.

With a group control it is also possible to couple the intermediate circuits of the frequency inverters. For example, in a group of two, one lift system processes the travel commands and calls in the downward direction, while the other system operates in the upward direction. The upward-moving system is in generator operation, so it does not have to use any energy. Instead, the energy generated is made available to the other frequency inverter via the DC link.

7.5 Destination Dialling Control

In very large buildings where a large number of users have to be brought from the main landing to the destination landings within a short time every day, the destination dialling control is suitable. The user has to enter the desired stop at a central panel using a ten-digit number field or also called a ten-digit panel, as shown in Fig. 7.10 and 7.11. The system then assigns a car to the user. The cars are labeled with letters or numbers above the landing doors, so that the user can already go to the assigned lift after being informed via the control panel.

The advantage of this control system is that users are assigned a lift and the subjective waiting time in the lift lobby is reduced. The footpath from the call column to the lift already counts towards the so-called waiting time, since the assigned car has already started its journey to the lobby. This gives the user the impression that the waiting time is short, since he does not perceive the footpath to the lift as waiting time.

Fig. 7.10 Numeric keypad. (Source: Schindler Deutschland AG & Co. KG, Germany)

Fig. 7.11 Numeric keypad. (Source: OTIS GmbH & Co OHG, Deutschland)

Another advantage is that the lift lobby is “tidied up” by this system, since the users are directly in front of the cars they have to use. It is therefore no longer necessary to “search” for a free space when a car arrives.

The system divides the users so that the cars never run completely filled. This allows the car to return to the main landing in a relatively short time and accommodate more users. This shortens the car rotation time.

A disadvantage is the missing call panel in the car. For example, it is not possible to enter a different floor in the car during the journey. The user must first travel to and alight at the selected floor and enter a new call on the landing call panel. For users who use this system infrequently, the operation takes some getting used to.

Destination dialling control or also called destination call control can also be coupled with a time recording system. When using the time recording card at the terminal, the user is immediately assigned a car, since the work location is stored in the time recording card.

7.6 Fire Evacuation Control

The fire evacuation control is a function of the control system in which the car moves to a defined evacuation stop after receiving a signal from a fire alarm control panel. In addition, the lift switches off and the car door remains open. This enables the fire brigade to look into the car when it arrives in the building to see that there are no more people in the car.

The incoming signal can also be triggered by a central building control system or manually, for example by the doorman via a fire alarm panel.

In Germany, the evacuation stop is determined by the local fire brigade or by a fire safety expert. Usually the main stop is specified.

7.7 Evacuation Control in Case of Power Failure

In addition to fire evacuation control, there is also the option of evacuating users while driving after a power failure. In addition to the control system, a battery unit is provided which supplies the lift system with the necessary power to drive the car to the nearest landing, as shown in Fig. 12. By connecting large emergency power generators, it is also possible to drive the car to the main landing. In large buildings, e.g. in hospitals, diesel emergency power generators are available in order to be able to continue supplying power to several systems in the event of a power failure. The lift systems can also be connected to such a genset if other trade-specific guidelines do not contradict this.

By connecting larger battery units to the lift control system, an evacuation trip to the main landing can also be carried out autonomously. Furthermore, these battery units can also supply the car light, the processor unit and the door drive with power. When this trip is completed, the batteries must be fully recharged.

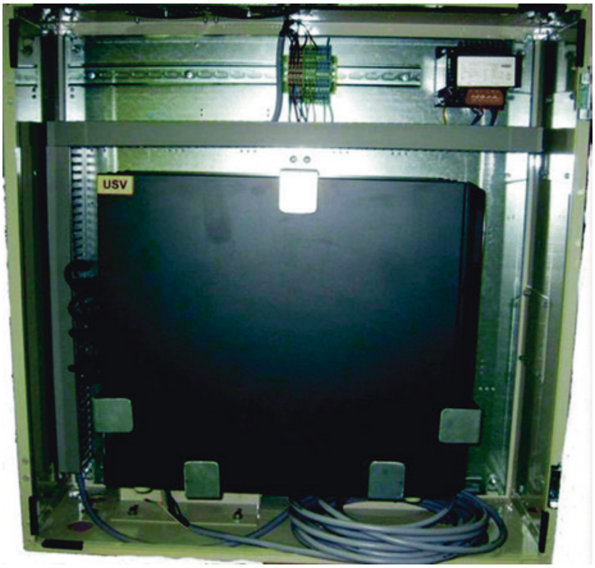

Fig. 7.12 Battery unit for evacuation to the main stop. (Source: KW Aufzugstechnik GmbH, Oberursel)

7.8 Access Authorizations

Access authorizations can be integrated into the control system. Thus key switches can be installed instead of call buttons on the landing call panels or in the car operating panel. Code card readers can also be used. A card is used to establish the release before the call can be entered. In this way, floors are only made available to a defined group of users. This is often used in hotels.

8 Car and Panels

8.1 General

The lift car is the center of a lift system. It is used to transport the load. The equipment and shape of a car can be designed in many different ways. The cars are rectangular in shape and are usually used in the following standard sizes.

1100 × 1400 mm	Rated load 630 kg
1300 × 1400 mm	Rated load 800 kg
1100 × 2100 mm	Rated load 1000 kg
1100 × 2400 mm	Rated load 1600 kg

The car is constructed from a fixed base plate in the shape of a tub. The walls are built onto the floor plate. The walls of the car are screwed or riveted together directly and are made of either stainless steel or zinc sheet. It is also possible to subsequently cover the zinc sheets with stainless steel. The strength of the walls must be taken into account when building the car. It is specified in EN 81–20 and must be strictly adhered to. The car ceiling, which also contains the lighting, serves as a closure.

There are no limits to the design of the car. Exclusive lift cars are fitted with walls made of high-quality stainless steel, brass or artificial stone. Walls made of glass with a colour design on the back or with background lighting are also possible. Figures 8.1 and 8.2 show exclusive cars with walls made of cast stone. Figure 8.3 shows a car with coloured laminated safety glass. The range of floors extends from simple plastic floors to high-quality stone floors. When selecting the flooring, care should be taken to ensure that it is sufficiently slip-resistant and easy to clean.

In atriums people like to install panoramic lifts. In the case of panorama lifts, the car walls are completely or partially made of glass. The car can be either in the

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Fig. 8.1 Exclusive car with mirror and artificial stone as wall covering. (Source: OSMA-Aufzüge, Albert Schenk GmbH & Co. KG, Osnabrück, Germany)

Fig. 8.2 Exclusive car with mirror and artificial stone as partly wall covering. (Source: OSMA-Aufzüge, Albert Schenk GmbH & Co. KG, Osnabrück, Germany)

usual rectangular shape or in round, semicircular or even polygonal form. If lift cars with glass walls are manufactured, the glass must be made of laminated safety glass. In addition, the glass must be subjected to a pendulum impact test according

Fig. 8.3 Car made of glass, colored. (Source: OSMA-Aufzüge, Albert Schenk GmbH & Co. KG, Osnabrück, Germany)

to EN 81-50. The thickness of these glasses is specified in EN 81-20. Figure 8.4 shows an assembled glass lift car in an atrium.

If the car entrance is from only one side, this is called a one-sided load. If it is a system with two-sided loading, then there are two car doors opposite each other. In this case, one door machine is required for each car door. For special cases, we also build over-corner solutions. The maximum possibility is a three-sided load, since the car guide is located on the fourth side. A lift system with a three-sided or corner loading can therefore only be realized with a backpack frame.

8.2 Car Protective Device

Car protective device is used to monitor the door area and is intended to protect users from door impact. This task is performed by light curtains which are mounted laterally behind the car door. If an object or person is detected in the door area, the commands for reversing the direction of movement are forwarded to the door machine so that the door stops moving and opens again. Figure 8.5 shows such a light curtain.

There are several types of car protecting device systems. The simplest type consists of a light beam with a transmitter on one side and a reflector on the opposite side. This type of door monitoring can be found in simple car equipment in older installations. The light beam is mounted at knee height. In the case of slightly

Fig. 8.4 Glass lift car in an atrium. (Source: OSMA-Aufzüge, Albert Schenk GmbH & Co. KG, Osnabrück, Germany)

Fig. 8.5 Light curtain. (Source: Cedes GmbH, Landquart, Switzerland)

higher quality car equipment, electronic receivers are used instead of the reflector. Such solutions are no longer state of the art.

With the use of LED's and microprocessor technology the light curtains were developed. Today, light curtains with a monitoring height of 180 cm and more are used. 32 or 64 light beams cross the monitoring level and can thus detect any object or person in the door area at an early stage. In addition, these systems can also be equipped with 3D anteroom monitoring. 3D anteroom monitoring systems are used in hospitals. This is used for early detection of beds or wheelchair users. This allows the door to be opened and closed very early.

8.3 Panels

The panels on a lift system are required for the travel commands or the request of the car at the landings. A distinction is made between the landing call panels at the landings to request the car and the car panel in the car to be able to enter the destination landing and thus the direction of travel.

8.3.1 Landing Call panels

Landing call panels are required to request the car at the landings. Depending on whether the control unit is a one-button or two-button control unit, the appropriate landing call panels are located at the landings. After pressing the button, a coloured ring around the button lights up, which goes out when the car arrives. In the case of two call buttons, the colours for up and down travel may also be different.

It is also common to integrate display devices. The display devices can optionally contain an arrow as direction indicator or the stop indicator. The arrows indicate the direction in which the car will continue its journey.

For a defined group of users, a key switch can be integrated or serve as a replacement for a push button, so that it is possible to call the car directly. In this case, all pending landing calls and internal calls are deleted. This function is then called priority drive.

8.3.2 Car Operating panel

Car operating panels are used for the input of travel commands in the car. Components of a panel are the call buttons in number of stops, an emergency call button and a door open button. Additional buttons such as door-close button or a button for switching on a fan can be optionally accommodated. To prevent access by unauthorised persons, a coding device can be optionally installed, which can be operated with a number combination or a chip card. Figure 8.6 and shows a car operating panel made of stone. Figure 8.7 shows a car operating panel in a high-rise building for a lift that only approaches some of the stops in the lower area and the remaining stops of the building from halfway up. The middle part of the building is skipped. It is common practice to divide large buildings into zones and the lift systems only operate in these zones. In the main landing of such buildings, the users are then directed to the respective lifts in the individual zones by means of signs.

In hospitals or public facilities, a vertical panel is installed in addition to the car operating panel. In this panel the call buttons are arranged in a row with a size

Fig. 8.6 Car operating panel in a stone finish. (Source: OSMA-Aufzüge, Albert Schenk GmbH & Co. KG, Osnabrück, Germany)

Fig. 8.7 Car operating panel of a lift for the upper part of the building. (Source: Author)

of 50 × 50 mm, shown in Fig. 8.8. The panel is located vertically between the handrails. The regulations for the use and design of these panels are regulated in EN 81-70.

Fig. 8.8 Vertical car operating panel with big buttons. (Source: OSMA-Aufzüge, Albert Schenk GmbH & Co. KG, Osnabrück, Germany)

8.4 Display Units

In order to inform the user where the lift is located, floor indicators can be installed above the landing door. These are connected to the floor information of the controller and show the current location of the car. When the car arrives at the landing, an additional gong can also be sounded to inform the user acoustically of the arrival of the car. This is especially helpful for blind or severely visually impaired users. Figure 8.9 shows a floor indicator with direction indication.

The car display is located in the car panel above the buttons. This indicates the current position of the car and the direction of travel as shown in Fig. 8.10.

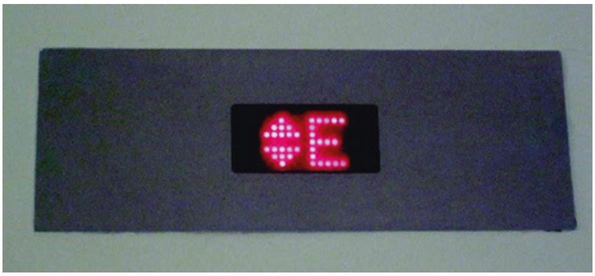

Fig. 8.9 Floor indicator above the landing door. (Source: Author)

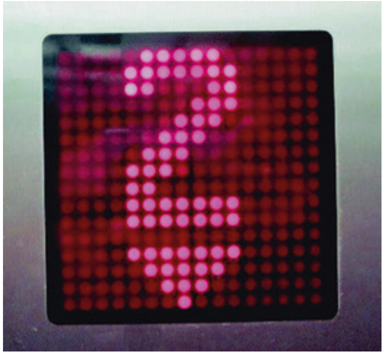

Fig. 8.10 Display unit in car operating panel. (Source: Author)

8.5 Inspection Operation

Every lift installation must be able to be safely operated in the event of repair or maintenance work. For this purpose, EN 81–20 require the use of an inspection operation system. This is located on the car roof. The inspection operation is an electrical distribution box to which a socket is connected and a remote control. The remote control allows the service technician to move the car through the well at inspection speed. The inspection speed is a reduced speed of the nominal speed and must not be faster than 0.63 m/s. Figure 8.11 shows an inspection operation with a remote control.

The number of buttons and devices on the remote control is prescribed as follows:

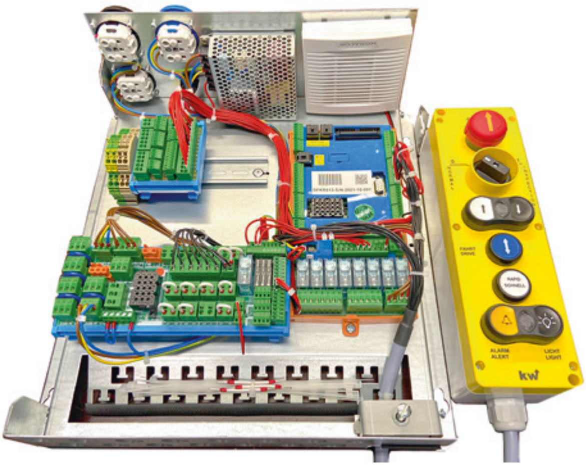

Fig. 8.11 Inspection operation with remote control. (Source: KW Aufzugstechnik GmbH, Oberursel, Germany)

- Selector switch for normal operation and inspection
- Emergency stop button
- Emergency call button
- One button each for up and down movement
- A button for the movement

When travelling through the well, always press the button for the travel motion and at the same time a button for the direction (up, down).

8.6 Load Weighing Equipment

Every lift installation must have a device to prevent the car starting in the event of overload. This means that the car weight and load are measured before each trip. If the permissible total weight is exceeded, the control system receives a signal so that the drive does not start moving.

This measurement can be carried out with load weighing equipment, for example. The load weighing devices are mounted below the car and carry out these measurements.

Another possibility is to measure the permissible weight by means of a rope load measurement. The load sensors are permanently mounted in the well on the ropes and transmit the measured values to an evaluation unit as shown in Fig. 8.12.

Fig. 8.12 Evaluation unit load weighing device via rope load measurement. (Source: Henning GmbH & Co KG, Schwelm, Germany)

8.7 Travelling Cable

The traveling cable is used for the electrical supply of the car as well as for the exchange of information. All electrical consumers such as the lighting in the car, the car operating panel or the inspection operation on the car roof are supplied via this cable. Furthermore, all information between the car operating panel and the control unit runs via this travelling cable.

The travelling cable as shown in Fig. 8.13 consists of a ribbon cable which is attached to the well wall. The rest of the cable hangs below the car and travels with the car in the well.

The travelling cable must be checked during maintenance. If the travelling cable is damaged, the information is no longer passed on to the control system or the electrical supply to the car is no longer guaranteed. The travelling cable is checked for mechanical damage such as abrasions or missing insulation as well as for twisting. If the travelling cable is damaged, a defect is also certified by the improved inspection body, because if the travelling cable is damaged there is a risk that emergency calls can no longer be made. Depending on the type of damage, it may also lead to a shutdown of the system.

Fig. 8.13 Travelling cable. (Source: KW Aufzugstechnik GmbH, Oberursel, Germany)

9 Doors

9.1 General

The lift doors are an essential part of a lift system. A distinction is generally made between landing doors and car doors.

The landing doors serve as fall protection for users who are at the landing in the lift lobby. The car door also serves as a fall protection for passengers and at the same time provides protection against contact with the passing well wall. In older lifts, there are still cars without a car door. The risk of injury is here very high, since unsecured goods and passengers' limbs can be trapped between the car and the well wall if they are not careful.

If landing doors are required as fire stops on the basis of fire protection reports, they must be tested according to EN 81-58 in order to meet the requirements. This standard specifies test procedures that landing doors must meet in the event of fire. Doors are also used that were built in accordance with DIN 18091 "*Lifts, sliding landing doors for lift shafts with walls of fire resistance class F90*". This is a construction standard which states that doors meet the requirements of fire protection if they were built according to this standard.

The doors are available as hinged, folding or sliding doors. Sliding doors are differentiated between telescopic side opening doors and centre opening doors. The doors are built with a building authority approval. Therefore, changes to these doors are not permitted, otherwise the approval will expire.

9.2 Hinged Doors

In the past, hinged doors were used as standard landing doors. Today they are still used in freight lifts or in lift systems in existing buildings where there is little space for a sliding landing door when the car must be designed to its maximum

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Fig. 9.1 Four-panel swing door of a freight lift system with flap lock. (Source: Meiller Aufzugstüren GmbH, Munich, Germany)

capacity. Hinged doors are manufactured in single or double-panel design. There is also the option of integrating an inspection glass into the door panel. The inspection glass is used to detect whether the car is at the landing, i.e. behind the landing door. If there is no inspection glass on the swing door, the landing call panels must have a display to show that the car is at the landing. This can be recognised by a coloured illuminated ring around the button of the landing call panel, which goes out as soon as the car has entered the landing. Figure 9.1 shows a four-panel swing door with inspection glass and flap lock as a heavy industrial version. Figure 9.2 shows a double-panel swing door with inspection glass for forklift operation (heavy duty version).

9.3 Sliding Doors

With sliding doors, the lift system has a comfortable facility for getting in and out of the car. A distinction is made between telescopic side open doors and centre open doors. The advantage of sliding doors in general is that they disappear into the well and hide behind a wall or portal.

With side open doors, the individual door elements, slide one behind the other to the right or left. A distinction is then made between doors opening to the right

Fig. 9.2 Centre-opening swing door of a goods lift for forklift operation. (Source: Meiller Aufzugstüren GmbH, Munich, Germany)

or left. Depending on the width of the complete door, the door panels can be obtained as a two- or three-panel door. Double-panel doors are the most common and most frequently used. Sheet steel or stainless steel is used for production. It is also possible to cover the sheet steel doors with stainless steel. However, this variant should rather be used indoors due to the risk of corrosion.

Sliding landing doors have a locking device which locks firmly when the door is closed and can only be opened by the door machine or the emergency unlocking key. In addition, an interlocking contact switch is installed, which also closes when the door is closed. This switch is designed as a break contact and is integrated into the safety circuit, i.e. when the door is opened by the door machine or the emergency unlocking key, the safety circuit is opened by this switch and the system is put out of operation. If, for example, the landing door is opened during travel, the interruption of the safety circuit also brings the system to a standstill. The car comes to a standstill when the brakes are applied. If the landing door is opened at a landing, further travel is prevented, even if a call is made in the car or at a landing.

The centre open doors are available as double, four or six-panel doors. The door panels slide simultaneously to the right and left behind the wall of the well at landings. A locking device is also available for this type of door. In addition to the interlocking contact switch, there is also a door contact switch which monitors the door closing position. The door contact switch is also integrated into the safety circuit. This contact is necessary as it monitors the closed position of both door panels, as the door mechanism is designed in such a way that when one door panel is opened, the second door panel is opened by a rope, which is installed on the first panel, in the opposite direction. If the rope breaks or the second door panel does not open due to another fault, the interlocking contact closes, but the door contact remains open because only one door panel has been closed. The consequence is that the safety circuit remains open and the system cannot move.

The doors have a forced closure. This is usually implemented with weights that are located in the door frame. The forced closure is ensured by a rope on which the weights are suspended. When the landing door is opened, for example during inspection activities when entering the car roof, the doors can close again automatically.

▶ The locking element of the locking device must be set to a minimum value in accordance with EN 81-20. The dimension is set at 7 mm in EN 81-20. The adjustment of the locking element must be checked at every maintenance. This dimension can be altered by knocks on the front of the door.

Figure 9.3 shows a locking element with the engagement depth of 7 mm required by EN 81-20.

The car doors used must be of the same design as the landing doors installed. This means that a double-panel telescopic sliding door as landing door also requires a double-panel telescopic sliding door of the same opening direction as the car door, otherwise the doors cannot open. An exception to this is a hinged door as landing door, which can be combined with a telescopic sliding door as car door. Also, the manufacturers cannot be combined arbitrarily among themselves, since the opening function cannot be guaranteed due to different types and

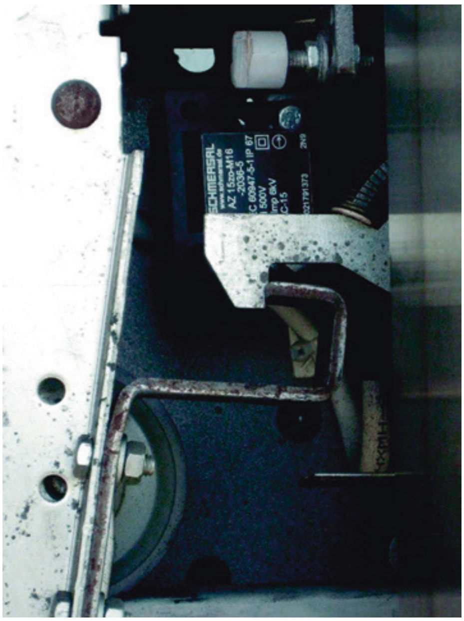

Fig. 9.3 Locking element of a telescopic sliding door (manufacturer-dependent version). (Source: Author)

designs. With the aid of conversion sets, however, landing doors and car doors from different manufacturers can be combined. A prerequisite for this is, however, that all landing doors are from the same manufacturer. These conversion sets are now offered by some door manufacturers.

If, in accordance with EN 81-20, the maximum distance between the car sill and the wall of the well exceed 15 cm, a mechanically locked car door must be provided. This is regulated, for example, in point 5.2.5.3.2, c) of EN 81-20 [1]. Figures 9.4 and 9.5 show an additional car door interlock. This device is intended to prevent the car doors being opened by passengers in the case of lift systems that get stuck between two landings and this distance required by the standard is not

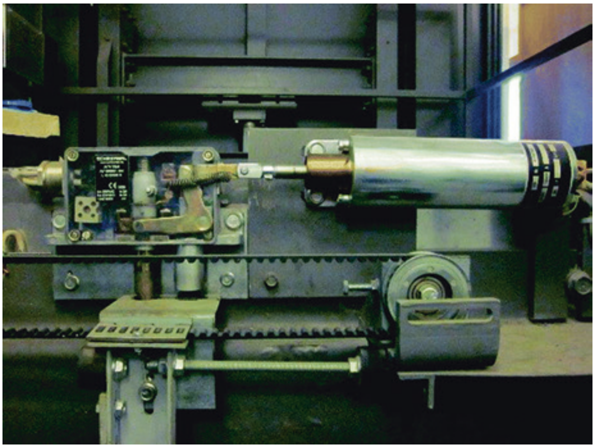

Fig. 9.4 View of a car door locking device. (Source: Author)

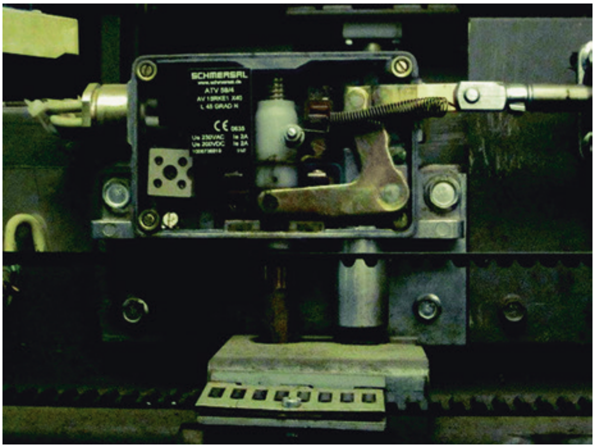

Fig. 9.5 Locking mechanism with door contact. (Source: Author)

maintained. This is because a distance greater than that specified in the standard entails the risk that narrow persons or small children could fall into the well as a result. The additional locking device can be omitted if the distance in the well is reduced by suitable measures. Suitable measures can be plates that are fixed to the wall of the well between the landings. However, the above-mentioned point of EN 81-20 also provides information on the circumstances under which the distance may be increased.

The door sills are located in the lower part of the door. The doors are guided there. Grooves are milled into the sills so that the doors can slide in the grooves with metal or plastic guides. The door machine is located on the top of the car. It is used to open and close the doors automatically. A toothed belt or spindle drive can be used as drive type. With a door sword both doors are opened or closed simultaneously with the direction of travel of the doors.

The door sword is a kind of flat bar in the shape of a sword, which projects into the door area from above. There are devices on the car door and the landing door to allow the sword to hook into the door and thus take the doors with it during the opening process.

The door machine is electrically controlled by the door control system, which receives its signals and commands from the lift control system. It gives the door machine the commands to open and close when the car has entered the landing. The rollers are located above the head on the door in the well. The doors are hooked into the rails with the rollers and ensure smooth and quiet running. The rollers have ball bearings and are fitted with plastic or rubber on the outside.

The picture above right shows the view from the side. This is important for the well cross-section. This picture also shows the depth of the door. The picture below shows the view from above with the door dimensions.

For the planning of lift systems, these types of technical drawings can be obtained from the component suppliers. This means that what is to be used can be planned directly with the product. After receipt of the order, the system drawings are created from these.

▶ During maintenance, the rollers and the running rails must be cleaned particularly well. Small objects or dirt can damage the rollers. In addition, the dirt prevents smooth running and damages the rollers. Door malfunctions are thus pre-programmed.

The door control unit contains electronics for setting the door parameters. For example, the door speeds for the opening and closing direction are adjustable. Other functions such as a pushing-control, adjustment of the closing forces or the reading of error codes are just some of the features. Figure 9.6 shows a toothed belt door drive.

The landing doors are fastened with special screws to C-profiles above and below the landing door opening in the well. A precondition is that the C-profiles have been concreted into the wall of the well beforehand. In the case of a new installation, they are already provided for when planning the well. However, the

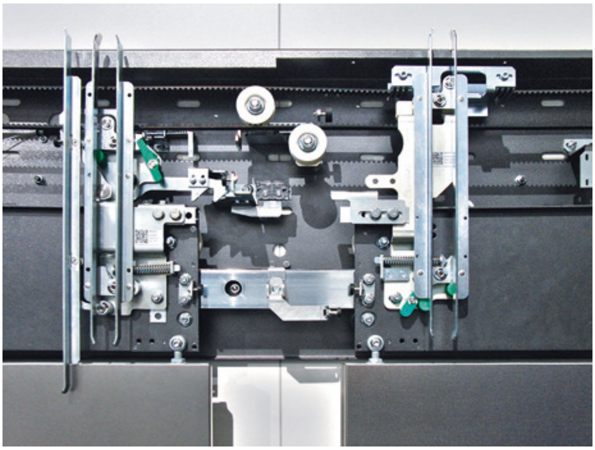

Fig. 9.6 Toothed belt door drive from Meiller. (Source: Meiller Aufzugstüren GmbH, Munich, Germany)

doors can also be fixed with dowels. This type of installation is carried out in a modernization project if the C-profiles cannot be used for the new landing doors. The car door is fixed to the floor and ceiling of the car.

The doors are available in various designs for many applications. Reinforced versions are available for use in freight lifts. In terms of design, thicker sheet metal is used as well as a stronger door machine and door rollers made of metal. In addition, the door is particularly stiffened. The door sills are reinforced accordingly so that even greater wheel loads do not cause any damage. Such door sills are found in systems where the cars are driven over by forklift trucks, for example.

EN 81-20 specifies gap dimensions that the doors must comply in order to minimise the dangers of, for example, fingers or objects getting stuck (this cannot be completely prevented as the doors always have a gap). Therefore, the door gap dimensions must be adjusted regularly during maintenance. This applies to the door gaps between the door panels in the case of centre opened doors, as well as the door gaps between the door panel and the door frame in the case of side opened doors. The circumferential door gaps between the door panels and the door frame must also be checked. The gap between the door panels or between the door panel and the frame shall not exceed 6 mm. This value may be increased to 10 mm in case of wear. Furthermore, it is defined that when the closed doors are opened manually, the gaps may be larger, but not more than 30 mm for side open doors and 45 mm for centre open doors [1].

The following options for protecting the retraction of children's hands are mentioned in point 5.3.5.2.8:

"a) Opacity of the glass…

(b) Detection of the presence of fingers …

(c) limitation of the gap between the door leaves and the frame to a maximum of 4 mm" [1]

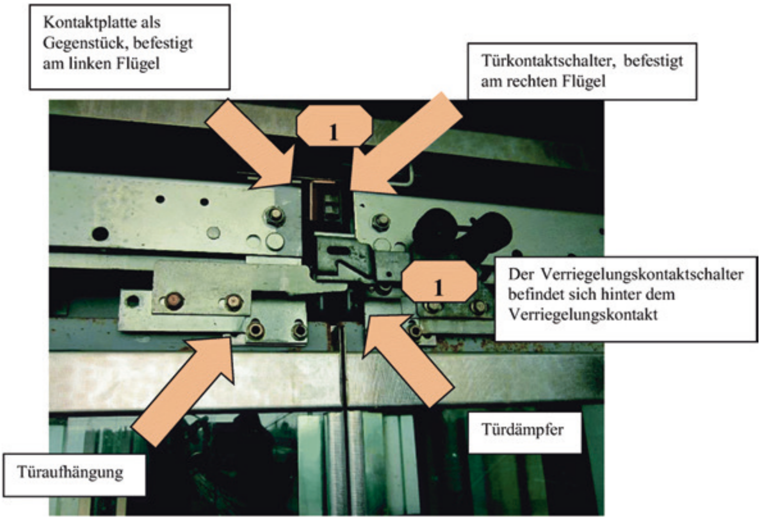

Fig. 9.7 Door mechanism of a central opening door. (Source: Author)

Figure 9.7 shows how the door gap can be adjusted. The door gap between the door panels can be adjusted by turning the door damper.

The gap can also be adjusted on the door hanger by moving the door panels in height. If small metal plates are placed underneath, the gap between the door panel and the door frame can be precisely adjusted.

With other door manufacturers, the setting options may differ.

9.4 Glass Doors

Glass doors are often used for panoramic lifts to maintain the transparency of the cars. There are different types of glass doors. A distinction is made between framed and unframed glass doors. Framed glass doors have door panel with a surrounding frame, usually made of stainless steel, which holds the large laminated safety glass pane. The base heights can also vary with this variant. The glass panels are either glued in or fastened to the door frame with screwed/riveted retaining strips on the back. Care must be taken in the event of damage of the glass, as the door's fall protection function is no longer fully guaranteed.

▶ In case of glass damage, the operator should react quickly and repair the damage. On the one hand, the statics of the door no longer correspond to the origin. This increases the risk of accidents in case of further damage. On the other hand, an already damaged door panel cause a lower threshold for vandalism.

In the case of doors with bolted/riveted retaining strips for the glass, it is possible to replace the glass in the event of damage. If there is no glass to hand, a metal sheet can also be used as a safety measure against falling.

▶ However, such temporary measures should be agreed with a improved inspection body and the door manufacturer before the measure is carried out, as the type examination for this door may expire. If the temporary measure cannot be implemented, the system must be taken out of operation. When replacing the glass, make sure that the glass is approved and has the properties specified in the lift inspection books. Attention must be paid to the marking of the glass.

Unframed door panels consist entirely of glass and are held only at the top and bottom by a stainless steel profile. With this type of door, the glass is the static supporting element. Due to a lack of protection at the outer edges, the panels are more sensitive to impact, for example from suitcases, bicycles or other objects, as shown in Fig. 9.8. Even a hard impact during the closing movement can be damaging to the edges. In order to protect the doors a little, the closing movement is adjusted so that the door panel do not hit each other. In addition, felt door dampers can also be fitted to the outer edges.

Fig. 9.8 Unfraimed glass door, centre opened. (Source: Meiller Aufzugstüren GmbH, Munich, Germany)

When planning lift systems and using glass doors, the high dead weight compared to the lighter steel doors must be taken into account. This means that the door machine must be designed much stronger in order to move the high weight of the doors with increased force. This must also be taken into account when calculating the car weight so that the associated components (drive, safety gear, ropes) are dimensioned accordingly when planning a new installation.

9.5 Folding Doors

Folding doors can be used for very small cars up to approx. 300 kg rated load without car doors. The folding doors consist of two centre open door panels which fold up in a zigzag shape when opened. Specially adapted door drives are also available for these door types. This is often the last possibility to realize a safe car closure for users. Due to the very narrow conditions in the car, the use of a self-monitoring safety light curtain is not advisable, as the probability of the safety device being activated by users in the car is very high.

9.6 Rolling Doors, Scissor Grids

Freight lifts can also be equipped with roller doors. They are mounted above the car and close the car from top to bottom. The doors roll up above the car. When using this door, care must be taken to ensure that there is a sufficiently large head room, as the structure takes up a little more space here than a telescopic door.

With scissor grating a car end can also be made. Vehicle lifts are equipped with this type of door. The scissor grilles move to the right and left of the car like a centre open door and roll up next to the car wall in each case. Here, a slightly larger space is required next to the car to accommodate the doors, i.e. the well must be wider.

9.7 Door Malfunctions and Optimizations

The doors of a lift system are generally very susceptible to faults. The human factor plays a major role at this point, because the users come into contact with them very often. These include, for example, users who are in a hurry or impatient to get into the car quickly and try to stop the door as they approach. It can also often be observed that pieces of luggage of the users knock on the doors. This can cause the door panel to move, which means that a fault is pre-programmed. When loading and unloading a freight lift with a lift truck, for example, it often happens that the load gets stuck at the edge of the door. This causes the doors to receive lateral impacts, which can cause the entire door runner system to warp. This inevitably leads to poorer door running characteristics or the doors no longer close properly (large gap formation).

The door is also an important component when it comes to calculating travel times. After all, it is not only the speed of the drive that determines the car roundtrip time, but also the door opening and closing times. In office buildings, it can often be observed that the doors already open when the passenger enters the landing in order to shorten the passenger's exit from the car by reducing the waiting time during the opening process. In addition, central opening doors can be used to shorten the door times. These open faster than side open doors.

The selection of the door sill is also decisive for a long service life of the doors. For freight lifts, where heavy goods are transported or even forklifts enter the car, a reinforced door sill with a high wheel load is recommended. This is because under such high loads, it can quickly happen that the door sills sag or bend, preventing the car from entering the landing flush with the floor. An unlevel car always means a risk of accident for the user and a cause for further disturbances. If high wheel loads are required, the sill should be made of stainless steel, as higher wheel loads can be realized here.

▶ Practical tips Troubleshooting and settings: The doors of a lift system are the most common source of faults. The causes of this can be found in user behaviour. Due to the pushing behaviour of users, the doors can be subjected to lateral shocks and thus readjusted. Furthermore, dirt in the door guides inhibits the door movements, which can also cause the doors to readjust. For this reason, care should be taken during maintenance to ensure that the door guides are regularly checked, cleaned and readjusted. With some doors it is also possible that the spacers on the lower door guides are worn. These should then be replaced regularly. Depending on the material (plastic, felt) and use, the wear limit can be reached after only a few weeks. The worn spacers cause malfunctions due to excessive play in the door sill groove. Due to the imprecise guidance, it is possible that the lateral movements of the door leaves may cause the door guides to become worn.

The facts described above show that door faults and door optimisation are very close together. A door that is optimally adjusted and maintained will generally cause few malfunctions, third-party fault is excluded. Frequently malfunctioning doors, on the other hand, can show potential for optimisation so that weak points can be eliminated.

9.8 Emergency Unlocking

To be able to open the door from the outside in an emergency, the doors require an emergency unlocking. This is designed as a triangle according to EN 81-20. The emergency unlocking is located outside the landing door in the upper area of the door reveal. There is a small hole in this area. Insert the emergency unlocking key into this hole and turn it to unlock the lock and open the landing door. Figure 9.9

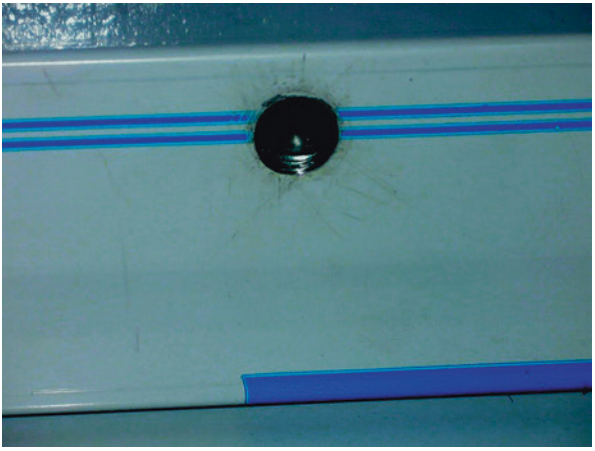

Fig. 9.9 Opening for the emergency unlocking key in the front of the door reveal. (Source: Meiller Aufzugstüren, Munich, Germany)

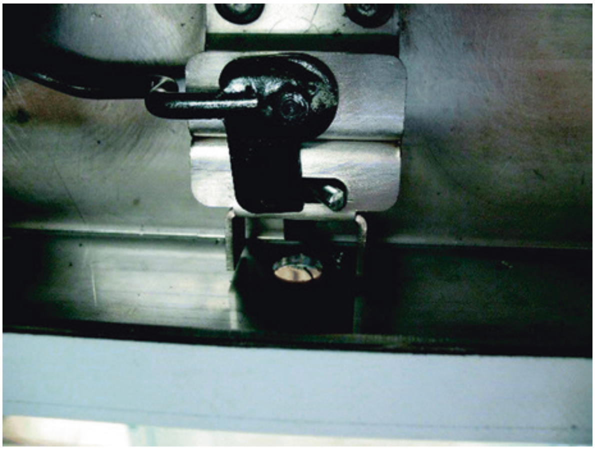

Fig. 9.10 Unlocking mechanism. (Source: Meiller Aufzugstüren GmbH, Munich, Germany)

shows the opening, which can be seen in the upper part of the door reveal. Figure 9.10 shows the unlocking mechanism. The triangle, which is inserted into the opening, moves a bracket, which in turn opens the lock and the door contact switch.

There are also door manufacturers who integrate the emergency release into the door panel. In older systems, the emergency unlocking is often found next to the door in the door frame, as shown in Fig. 9.11.

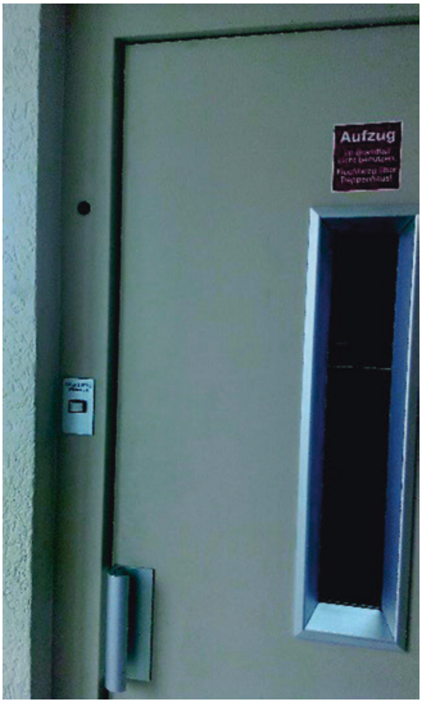

Fig. 9.11 Emergency unlocking in the door frame. (Source: Author)

9.9 Lift Systems Without Car Doors

There are older lift systems that do not have car doors. This is increasingly found in freight lifts. In order to increase safety in these systems without car doors, self-monitoring safety light curtains can be installed. These light curtains monitor the area on wall of the well. If an object or person is detected in the monitored area, the car stops immediately. In order to be able to continue the trip, the trip command must be entered again. The implementation is only permitted in Germany under the following conditions:

- The lift system is only used by instructed persons (usually by own personnel in company buildings)
- The speed of the installation shall not exceed 0,85 m/s

Since the handling is judged differently in the individual German Federal States, coordination with an improved inspection body and the authority is necessary. A risk assessment must be prepared by the employer. In other countries are different recommendations, e.g. in the Netherlands it is possible to use a lift system without a car door.

Fig. 9.12 Older car without car door and wooden floor. (Source: Author)

As an alternative, the lift system can also be converted to a simplified freight lift. In this conversion, the car operating panel is removed and the inside calls are routed outside to the landing call panels. This means that it is no longer possible to enter a travel command in the car.

The transport of persons is then strictly forbidden, and appropriate notices must be placed on the landing door and in the car. A remote alarm system is no longer required and can be removed. As a result of the conversion, the lift can be removed from monitoring through the improved inspection body and would therefore no longer count as a system requiring monitoring according to German guidelines.

If a lift installation without a car door is available and the transport of persons can be dispensed with because there are sufficient alternatives in the vicinity of the lift, a conversion to a goods lift should be aimed for. This is because, despite the instruction of persons, accidents still occur repeatedly in lifts without a car door. The danger is often underestimated when unsecured objects get caught on the passing well wall.

Figure 9.12 shows a car without a car end door.

9.10 Doors for Special Applications

There are doors for special applications. In large warehouses, for example, lift systems are used that have a rated load of up to 6 t or more and sufficiently large door openings to allow forklift trucks to enter the car. The doors used here must have a high degree of stability so that they can withstand the impact forces of the forklift trucks.

Other special requirements can be found, for example, in the lift systems in railway stations. The doors must comply with the requirements of the Railway

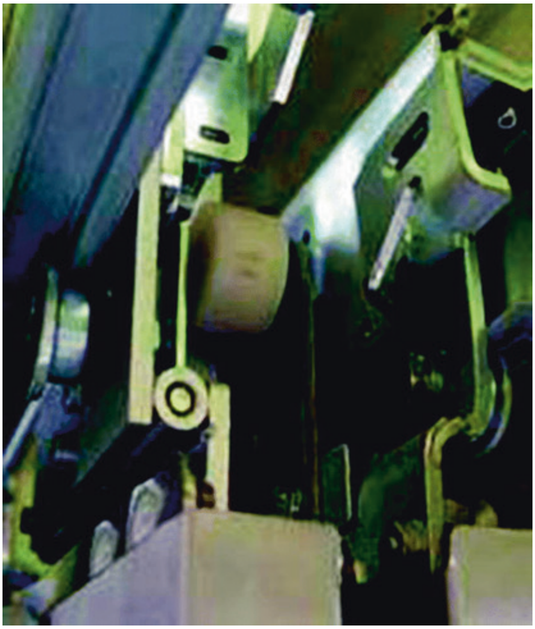

Fig. 9.13 Reinforced door guide system. (Source: Meiller Aufzugstüren GmbH, Munich, Germany)

Specific List of Technical Building Regulations for non-load-bearing structural elements that protect against falling. This is achieved, among other things, by a reinforced door runner system, as shown in Fig. 9.13 well as by reinforced door guides. Due to the bottom door guides, these doors are also less susceptible to dirt and grit, as shown in Fig. 9.14 and 9.15. Furthermore, these doors offer increased protection against vandalism. This is achieved, among other things, by reinforced counterpressure and door leaf rollers.

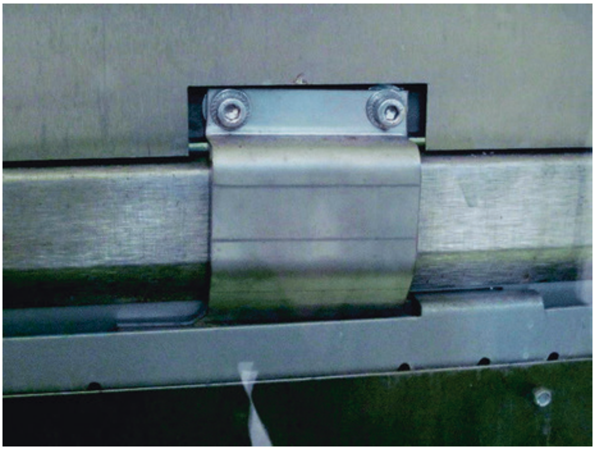

Fig. 9.14 Bottom door guide. (Source: Author)

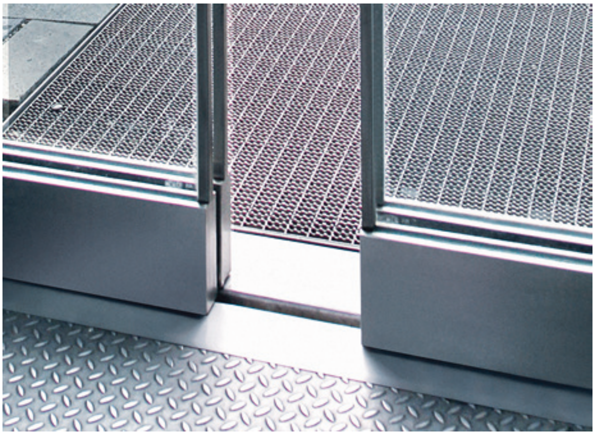

Fig. 9.15 Sill with concealed lower guide. (Source: Meiller Aufzugstüren GmbH, Munich, Germany)

9.11 Door Monitoring Devices

Door monitoring devices can be found at the entrances to the car. A simple door monitoring device consists of only one light beam, which is usually installed at the front of the car door. Opposite this is a reflector which reflects the light beam and, if interrupted, sends a signal to the door control unit to reverse. In addition to this very cost-effective solution, a receiver can also be found instead of the reflector.

▶ This type of door monitoring is susceptible to dirt. Some door interferences result from these dirty reflectors or transmitter/receiver units. For this reason, these components must generally be cleaned during maintenance work. These devices are no longer state of the art.

The transmitter/receiver unit is located approximately at knee height. The light beam must then be interrupted in order to reverse.

The use of batten luminaires offers a technically better solution. Light strips consist of a large number of LEDs arranged on a transmitter and receiver strip at a height of up to 180 cm. These light strips are mounted at the rear end of the car door. These light strips are not visible on lifts installed in closed wells. In glass lifts they are easily recognized as black rails. The only advantage of this system is that the door can be monitored over its entire height. The protection of the users is higher with these systems than with the simple systems with transmitter and receiver unit. Light strips function until just before the door is closed. According to EN 81-20 point 5.3.6.2.1.1 it is permitted to cancel the function of the light strip to the last 20 mm before closing.

Fig. 9.16 Door portal clad with artificial stone. (Source: OSMA-Aufzüge, Albert Schenk GmbH & Co, Osnabrück, Germany)

If a fire control system is installed in the lift system, the light strips are bridged when activated so that the doors can close even if the landing area is smoky. Otherwise the smoke will be detected as an obstacle by the light strips.

9.12 Door Portals

The connection of the doors to the building is possible through clad door portals. This opens up many possibilities. The connection of the door portals to the landing door can be carried out by a specialist painter with a decorative plaster. This can also be done in colour. However, it is also possible to clad the door portals with stainless steel or artificial stone.

Especially when modernising systems in existing buildings, door portals are often clad. Figure 9.16 shows a door portal that has been clad with artificial stone. The cladding can also be used to compensate for structural unevenness.

Reference

1. EN 81-20, *Safety rules for the construction and installation of lifts - Lifts for the transport of persons and goods Part 20: Passenger and goods passenger lifts*

10 Overspeed Governor

The overspeed governor is a safety component by definition of the European Lifts Directive and consists of a disc in a stand, which is located in the machine room or, in the case of lifts without machine room, in the upper part of the well, and a disc in the pit. A rope, the so-called governor rope, runs around both sheaves. At one point, the rope is attached to the safety gear on a release linkage. A switch and a weight are attached to the sheave in the pit. The switch is integrated in the safety circuit. If the rope elongates beyond a defined degree, the sheave in the shaft pit lowers and actuates the switch, which is attached below, and puts the system out of operation. This ensures that rope elongation or even a break in the governor rope can be recognized.

The overspeed governor today works in principle like a centrifugal governor. The first overspeed governors were equipped with such a centrifugal governor as shown in Fig. 10.1. In case of overspeed the disc stops and operates a switch. As the car continues to move, the fixed rope will move the linkage on the safety gear and engage. The safety brake is then released and the car comes to a stop. A switch on the overspeed governor is integrated in the safety circuit and switches off the drive.

The overspeed is defined in EN 81-20 as 115% of the nominal speed.

To prevent manipulation, the overspeed governor is sealed. The seal is examined by the improved inspection body during the periodic inspection. If the seal is damaged or missing, the lift system must be taken out of operation and the overspeed governor replaced. Figure 10.2 shows an overspeed governor and Fig. 10.3 shows an overspeed governor from 1965.

Besides to the installation of the overspeed governor in the machine room or in the head room, there is also the possibility of using travelling overspeed governors. These are mounted on the roller package of the roller guide on the safety gear frame. This system is only permissible with a backpack frame. The governor rope is not required for this type. Figure 10.4 shows a travelling overspeed governor.

D. Unger, *Lifts and Escalators*, https://doi.org/10.1007/978-3-662-67822-0_10

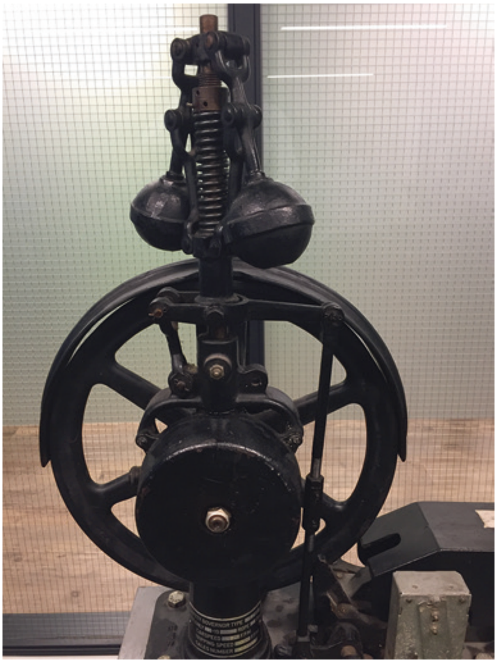

Fig. 10.1 Overspeed governor with centrifugal force control. (Source: Author)

Fig. 10.2 Speed limiter. (Source: Author)

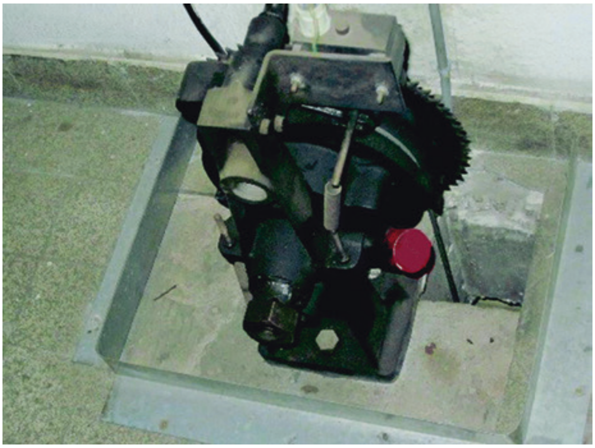

Fig. 10.3 Overspeed governor of an older system built around 1965. (Source: Author)

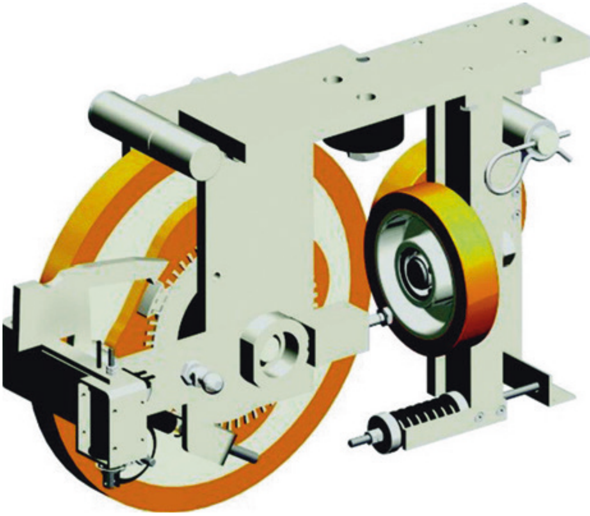

Fig. 10.4 Traveling speed limiter. (Source: Lift Technology G. Schlosser, Dachau)

11 Car Frame and Safety Gear

11.1 Car frame

The car frame is used to hold the car. At the same time the car frame is guided along the guide rails in the well. Integrated in the car frame is the safety gear that brakes the car in the event of overspeed.

A distinction is made here between a central frame and a backpack frame. With the central frame as shown in Fig. 11.1, the frame is guided on two opposite guide rails. The car sits in the frame.

With the backpack frame, see Fig. 11.2, the guide rails are on one side. Here the car frame looks like an L and holds the car like a back packer.

11.2 Safety Gear

The safety gear is directly integrated in the safety frame. It belongs to the safety devices according to the European Lifts Directive. The safety gear is triggered by the overspeed governor. If the nominal speed is exceeded by 15%, for example in downward motion, the brake is triggered and the car is braked in downward motion by actuating the safety gear. For dimensioning and design, the criteria required by the standard must be observed.

In order to protect people in the car, different types of braking devices are installed depending on the nominal speed. Instantaneous safety gears may be used up to a nominal speed of 0.63 m/s. Otherwise, progressive safety gears are used. In hydraulically operated lift systems, instantaneous safety gears may only be used if the tripping speed is not greater than 0.80 m/s.

The safety brakes must be mounted on both sides of the safety gear and adjusted in such a way that steady braking is ensured. The braking process must not cause the car to tilt more than 5%.

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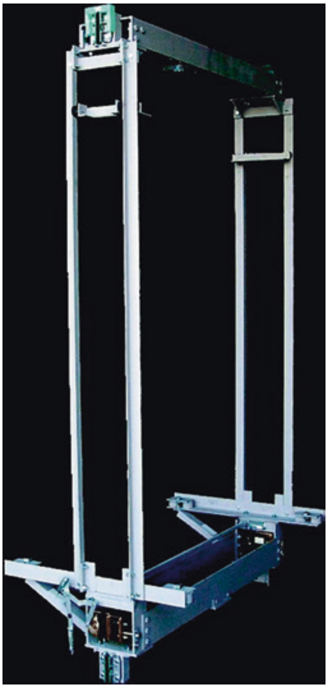

Fig. 11.1 Central frame. (Source: Lift Technology G. Schlosser, Dachau)

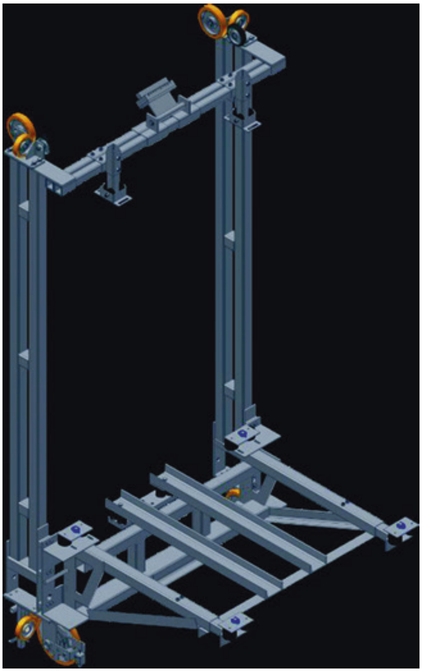

Fig. 11.2 Backpack frame. (Source: Lift Technology G. Schlosser, Dachau)

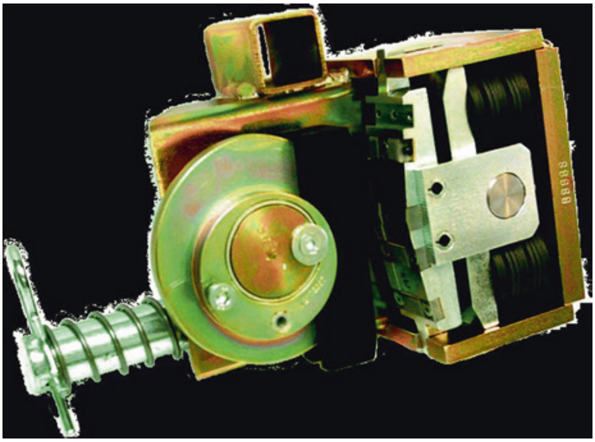

Fig. 11.3 Braking direction for downward and uncontrolled upward movement. (Source: Lift Technology G. Schlosser, Dachau)

When installing new lifts according to the currently valid standard, safety frames with safety brakes are used, which brake the car in case of overspeed in the downward travel as well as in uncontrolled overspeed in the upward travel. Figure 11.3 shows such a braking device which acts in both directions. When using such a brake, the appropriate overspeed governor must also be used. Double acting overspeed governors are used here. These work in both upward and downward travel.

In order to test the functionality of the safety gear, a catch test is carried out during the periodic inspection. During this test the overspeed is simulated and the safety brake is released. The car must come to a safe stop during this test.

After the braking process, it must be ensured that the rails are checked, as so-called catch marks are created by the braking process. Catch marks are burrs on the guide rails which are created during braking. If they are not removed, the travel characteristics suffer and damage the car guides.

Suspension Means

12

The Suspension Means of a Lift System Are Used for Vertical Transport of the Car. The Course and Length of the Suspension Means in the Well Depend On the Type of Suspension and On the Headroom.

Figure 12.1 basically shows a car suspension 1:1, the grey-shaded circle represents the traction sheave. Figure 12.2 shows a 2:1 car suspension. There are other suspension types in lift construction. Depending on the application, 4:1, 6:1 suspensions can be implemented here.

There are two types of suspension means. Those that are made entirely of steel. These are known as ropes and those which are called belts and consist of a mixture of steel ropes sheathed in a plastic material.

12.1 Ropes

A steel rope consists of several strands in several twisted layers. A strand consists of several twisted wires. This arrangement makes it possible that the rope always has approximately the same length when bending at the traction sheave or the deflection sheaves. Compared to parallel running ropes, the rope section is too short when bending around a sheave at the smallest radius, while the rope at the largest radius is too long. By manufacturing the rope with several strands, the rope can shift depending on the bending. As a result, it always has the same length.

The ropes go through various types of bending, which put the ropes under a lot of stress. In order to achieve a long service life of the ropes, the ratio of rope diameter to traction sheave diameter should be at least 40 times as high as in EN 81-20.

Furthermore one should pay attention to the bending. Several bends in opposite directions put a lot of stress on the ropes and also reduce their service life.

The ropes, or in the standard referred to as suspension means, must meet minimum requirements for number, size and strength in accordance with EN 81-20, point 5.5.1. The nominal diameter of the steel cables must be at least 8 mm. There

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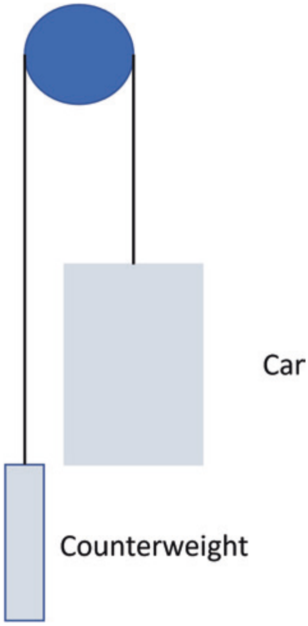


Fig. 12.1 Car suspension 1:1

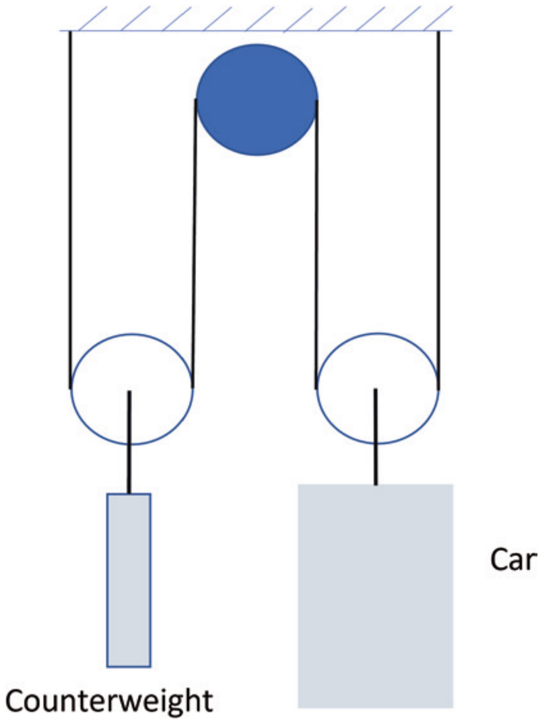


Fig. 12.2 Car suspension 2:1

must be at least two ropes. The nominal tensile strengths of the wires are specified in EN 12385-5 [1].

Steel ropes of various types are used. A distinction is made between ropes in the form of Seale, Warrington, Filler, Warrington-Seale or Standard.

The ropes are divided into nominal strength classes in accordance with EN 12385-5, and a distinction is also made between the wire surfaces in bright and galvanized as well as the type of lay. The types of lay are equal lay right and left, cross lay right and left.

You can recognize the cross lay, see Fig. 12.3 by the fact that the wires run in the opposite direction to the strand, whereas in the case of the lang lay, see Fig. 12.4 the wires run in the same direction to the strand.

Depending on the intended use, the ropes are available with different inlays. A fibre core is used to achieve a high lubricant absorption capacity, as shown in Fig. 12.5. In addition, the fibre core provides good rope deformability. With a steel core, as shown in Fig. 12.6, a lower elongation of the rope can be achieved. Figure 12.7 shows a Seale type rope and Fig. 12.8 Warrington type rope with a steel core.

Wire ropes have the advantage that damage can be detected very quickly. These are also closely observed during the inspections by the improved inspection body. The discard state of ropes is assessed by the number of wire breaks, deformation, diameter reduction or corrosion. For wire breaks, the criteria according to ISO 4344 are applied.

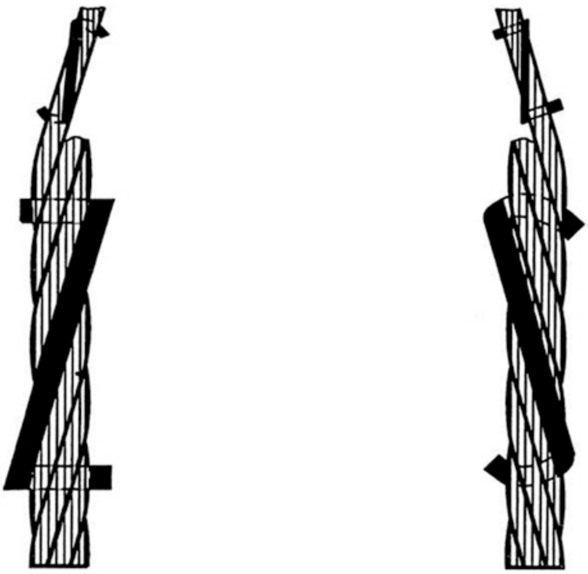


Fig. 12.3 Cross lay. (Source: Gustav Wolf, Seil- und Drahtwerk GmbH, Gütersloh, Germany)

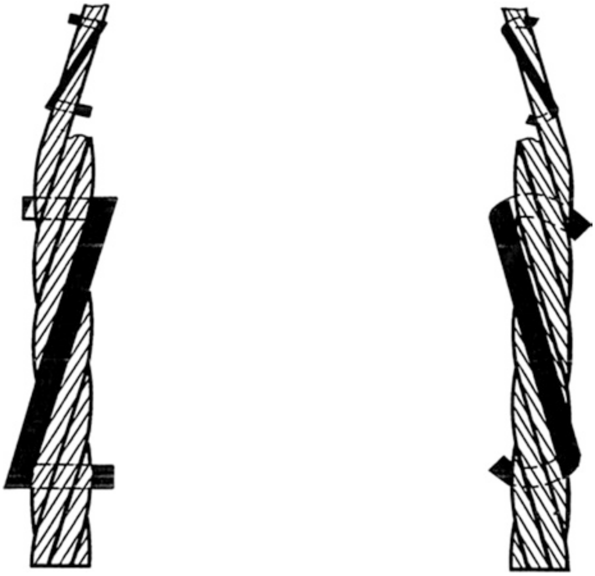


Fig. 12.4 lang lay

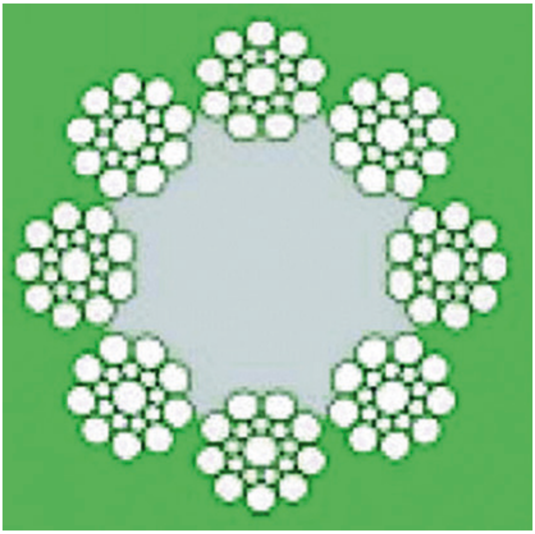


Fig. 12.5 Seale with fibre core. (Source: Gustav Wolf, Seil- und Drahtwerk GmbH, Gütersloh)

If there are more than 15 wire breaks randomly distributed over the length of a rope lay, the rope is ready for discard or should be observed within a defined period of time. If there are more than 6 wire breaks in one or two outer strands per lay length, the rope is also ready for discard or should be observed. These

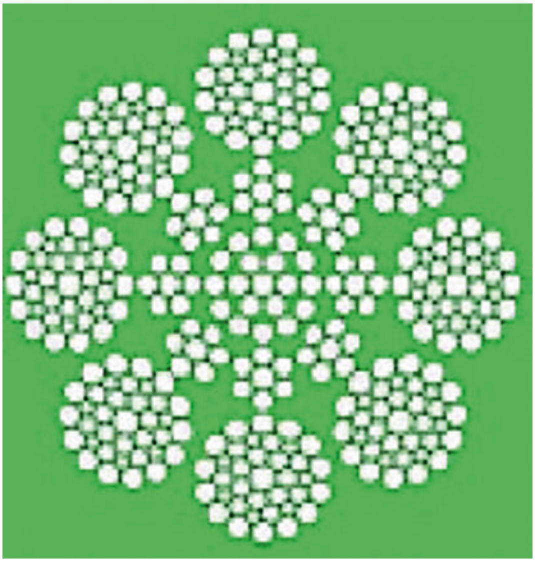


Fig. 12.6 Warrington Seale with steel core. (Source: Gustav Wolf, Seil- und Drahtwerk GmbH, Gütersloh)

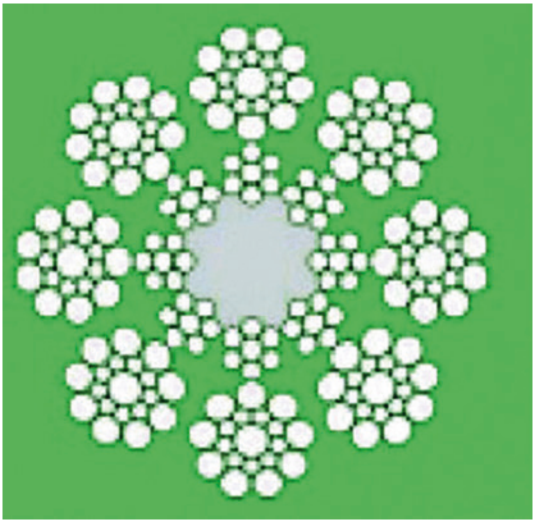
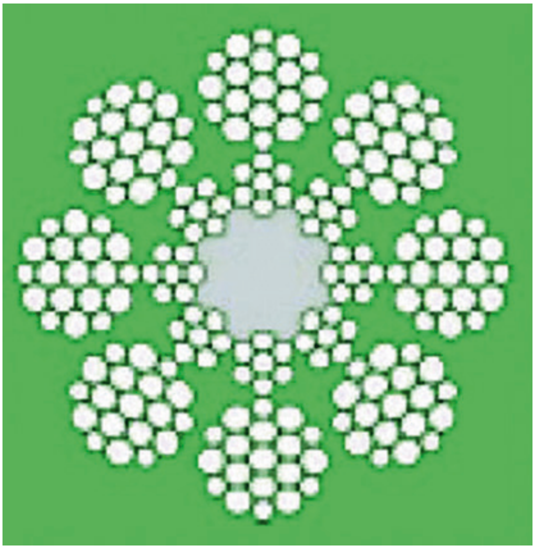


Fig. 12.7 Seale. (Source: Gustav Wolf, Seil- und Drahtwerk GmbH, Gütersloh)

values depend on the rope type and rope thickness. The rope lay length is defined as about 6 × rope diameter. If the number of wire breaks is higher, for example if in the case described above, instead of 15 wire breaks, more than 24 wire breaks are detected, the rope should be discarded immediately. If the rope diameter has decreased by more than 6%, the rope should also be replaced [2].

Fig. 12.8 Warrington with steel insert. (Source: Gustav Wolf, Seil- und Drahtwerk GmbH, Gütersloh)



▶ Here, if a rope is damaged, all the ropes are replaced so that the entire system is back in balance. This is because the ropes lengthen after installation. If the ropes are now mixed (old and new), the remaining older ropes may be subject to increased stress, as the entire load must be absorbed. In addition, damage can occur to the traction sheaves, since the load increases at the more heavily loaded grooves. After changing the rope, the ropes should be checked for uniform tension with a rope load measuring device.

Figure 12.9a show the correct method of measuring how to measure the rope diameter correctly with a caliper gauge, Fig. 12.9b the incorrect way. Always measure the largest value from one outer strand to the opposite one. If the ropes are worn out, they must be replaced. When replacing ropes, make sure that the traction sheave is checked thoroughly, if necessary, because a worn traction sheave will damage the new ropes again after a short time. Furthermore, the rope sockets should be replaced when changing ropes. When installing the new ropes, care must be taken to handle the supplied material very carefully. The rope, which is usually supplied on sheaves, must be properly unwound for installation, otherwise loops will form, as shown in Fig. 12.10 a + b. At this point the rope is no longer taut and will be damaged when passing through the traction sheave.

To fix the ropes at the ends in the well, rope terminations are used. There are different types of rope terminations. A distinction is made between.

- the sealing of the rope at the end
- of the ferrule
- the bolt crimping

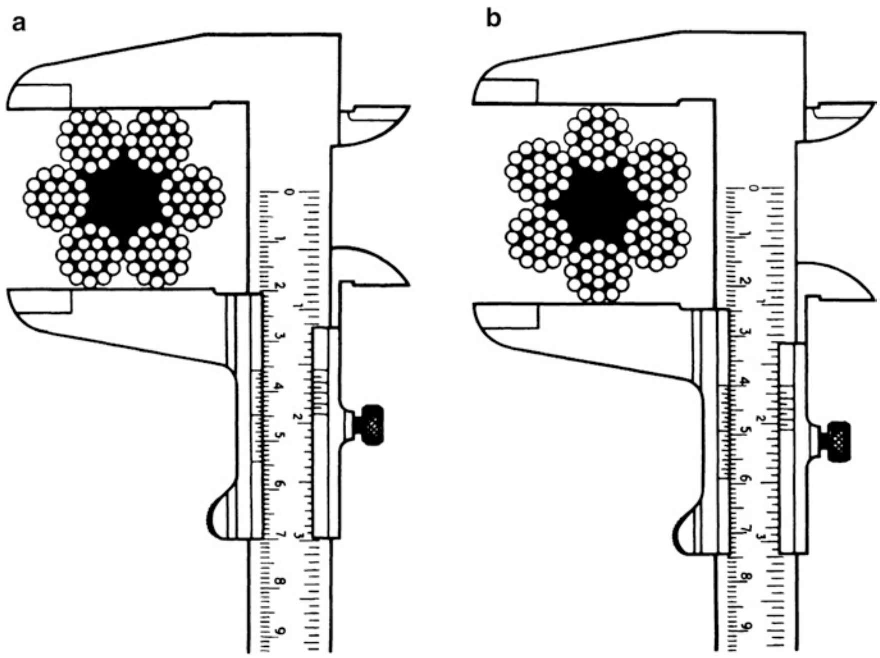


Fig. 12.9 **a** Correct measuring method **b** Incorrect measuring method. (Source: Gustav Wolf, Seil- und Drahtwerk GmbH, Gütersloh, Germany)

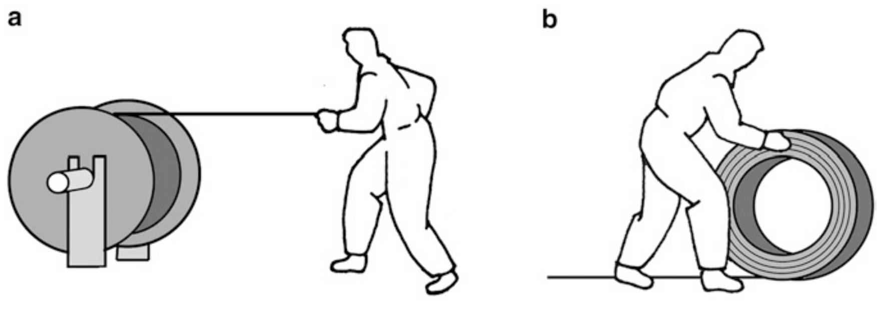


Fig. 12.10 a+b Display of the correct unrolling of ropes. (Source: Gustav Wolf, Seil- und Drahtwerk GmbH, Gütersloh, Germany)

- the wedge socket
- the rope eye with wire rope clamp

In order to achieve uniform rope tension, the rope termination must be adjusted. For this purpose, the tension force can be determined with the aid of a rope load measurement in order to detect any deviations. Unevenly adjusted ropes can lead

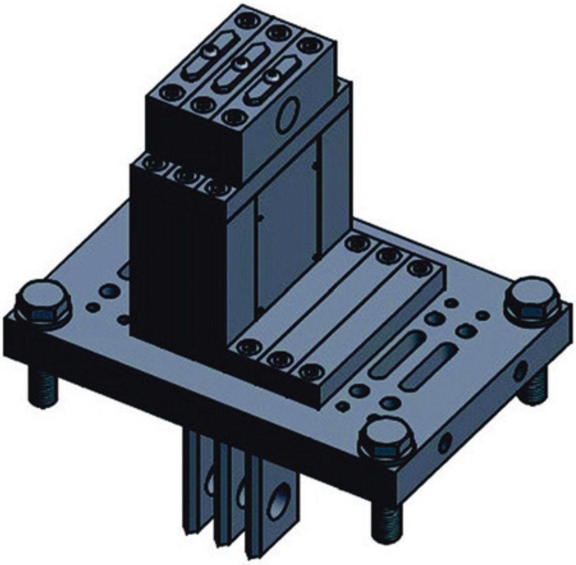


Fig. 12.11 Rope Harmonizer. (Source: Henning GmbH, Schwelm)

to skewed pulling of the car as well as to an uneven load distribution. This reduces the service life of the ropes. However, in order to keep the ropes always in an even load distribution, there is a system which uses hydraulic pistons to keep the rope loads always at a constant rope tension. This is achieved by providing two hydraulic pistons for each rope and connecting them to each other via a base plate. Thus, the same pressure prevails in each piston. The system was developed by the Henning company and can be seen in Fig. 12.11. [3]

When determining the rope length, the information from the lift inspection book must be taken. If this information is not available, the rope length can be determined in another way. The rope length can be roughly determined using the following example of a 2:1 suspension as shown in Fig. 12.12 (car at the lowest landing, values are approximate):

	(1) Height × 2 (2:1)
+	(2) End connections approx. 1 m
+	(3) Car width
+	(4) Crossing distance approx. 1 m × 2 (2:1)
+	(5) Length in engine room (MR)—traction sheave approx. 2 m
+	(6) Length in MR—traction sheave/deflection pulley approx. 2 m
+	(7) Length in MR—pulley approx. 1.5 m
+	(8) Length of pulley to counterweight approx. 1 m

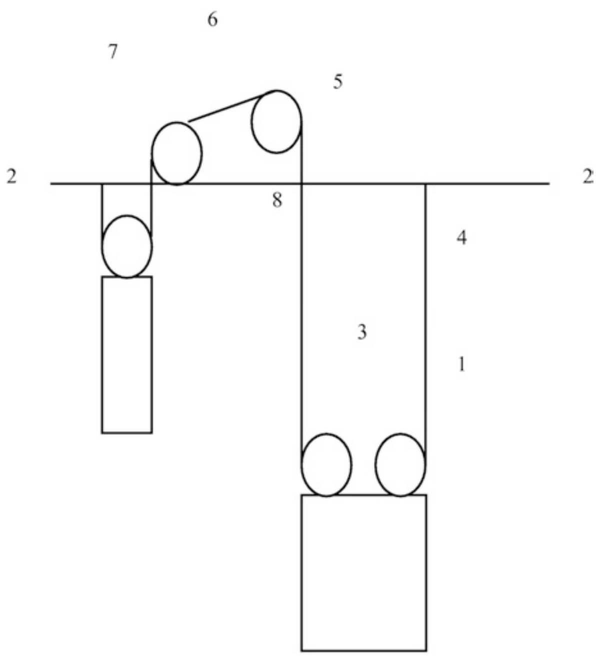


Fig. 12.12 Example for determining the rope length

12.2 Belts

As an alternative to steel ropes, there are lift systems that have belts as a means of suspension. Currently, these are offered by the companies Otis and Schindler. The belts of the Otis company consist of small steel ropes covered with a polyurethane layer. Figure 12.13 show such a belt from Otis.

These belts are environmentally friendly because they can be operated without lubricants. They have a lower weight compared to steel ropes, so drive shafts with a diameter of only 100 mm can be used, as smaller bend radius is possible.

In terms of durability, these belts have a longer service life than steel ropes. In case of fire, the polyurethane sheathing resists temperatures up to 250 °C. Only then does it begin to melt down and can still withstand an evacuation trip with the help of the steel cores still present [4].

When inspecting these belts, as with the steel ropes, they must not show any external damage and should always be checked for cleanliness during maintenance. In Otis lift systems, the belts are monitored by a belt monitoring device which permanently measures the resistance of the inner steel cables of the belt, see Fig. 12.14. If the resistance value changes, the system is shut down, as the belt monitoring device is integrated into the safety circuit of the lift system [5].

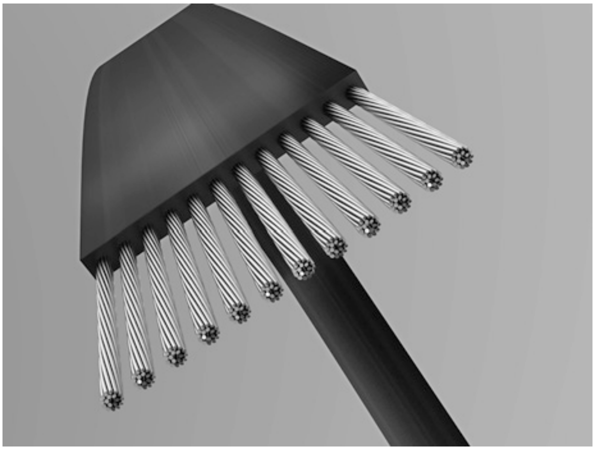


Fig. 12.13 Cross-section through a belt. (Source: OTIS GmbH & Co OHG, Deutschland)

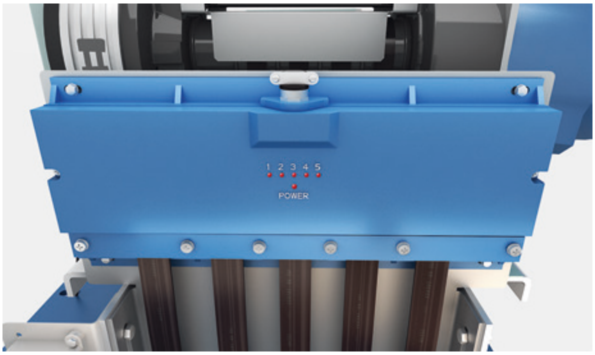


Fig. 12.14 Belt monitoring device. (Source: OTIS GmbH & Co OHG, Deutschland)

The principle of how the belts are suspended is the same as for the steel ropes. The wedge sockets used have been specially designed to accommodate the belts.

References

1. EN 81-20, *Safety rules for the construction and installation of lifts—Lifts for the transport of persons and goods Part 20: Passenger and goods passenger lifts*
2. Gustav Wolf, elevator ropes, edition 09/11
3. Product brochure Wire Rope Harmonizer, Henning GmbH, edition 08.10.2013
4. Otis product brochure PU belts, edition 47-6796-00 (05.02)
5. Otis Gen2 flex product brochure, April 2007 edition

13 Brakes

The brakes are located directly on the drive. They serve to decelerate the car safely in an emergency. In EN 81-20, point 5.9.2.2 Braking device, the nature and functions require, among other things, that the brakes brake automatically when the voltage drops. All mechanical parts of the brakes must be doubled and one brake must be able to bring the car safely to a standstill in the event of failure [1].

The following types of brakes are distinguished:

- Double-cheek brakes
- Disk brakes
- Emergency brakes

13.1 Double-cheek brakes

The brakes are located on the sides of the drive. The braking force is transmitted to the drum via a lever mechanism. The brake shoes are manufactured on the basis of synthetic resins or rubber. In older systems the brakes were made of asbestos. To release the brakes there is a lever above the drive, as shown in Fig. 13.1. This allows the car to be lowered in an emergency by opening the brakes. Figure 13.2 shows a drive with a double-cheek brake.

When adjusting the brakes, ensure that there is a sufficiently large gap between the drum and the brake shoes. Any changes to the drum due to heat must be taken into account. The brake must also be pretensioned. The respective settings can be found in the manufacturer's operating instructions. The disadvantage of this brake is the noise it generates, as the brake is audible when it is applied.

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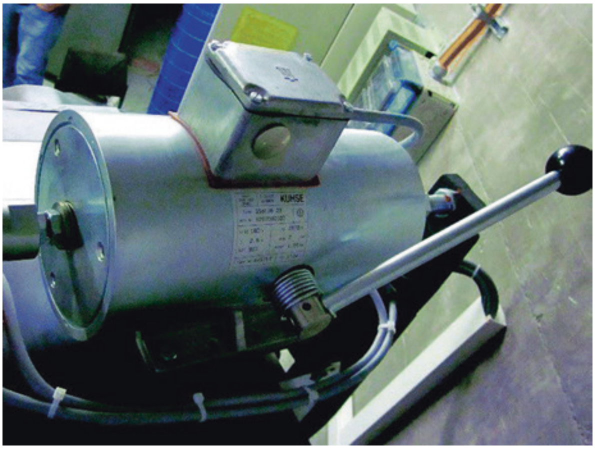
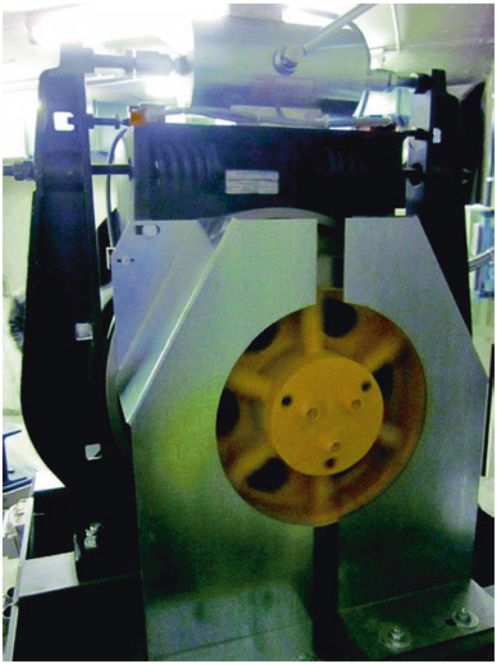


Fig. 13.1 Venting device with lever. (Source: Author)

Fig. 13.2 Drive with double shoe brake and venting device (box above). (Source: Author)



13.2 Disc Brakes

A disc brake for a lift drive works according to the same principle as for a passenger car. With this type of brakes the stroke can be kept very small, which also leads to more favourable noise characteristics.

In high-speed lifts, for example, with a speed of 7 m/s, such disc brakes are used. Due to the high speeds, this type of brake is required because the large motors with large armature shafts mean that the drive cannot be brought to a standstill by frequency control alone.

With the synchronous motors used today, a so-called working brake is no longer necessary. In low-speed lift systems, frequency control allows the car to be controlled to a standstill without the aid of the brakes. During operation, the brake serves merely as a holding brake. It must, however, be fully functional in an emergency and meet the deceleration conditions required by the standard at nominal speeds.

13.3 Emergency Braking Systems

Emergency braking systems are used for retrofitting in traction lift systems. The protection against uncontrolled upward travel required by the standard can be achieved with an emergency braking system. It is also possible to install an emergency braking system in the form of a disc brake on the traction sheave.

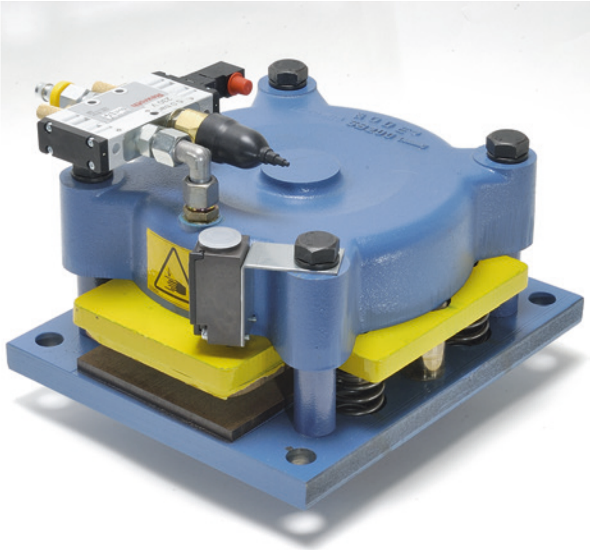


Fig. 13.3 Rope brakes as an emergency braking system. (Source: Bode Components GmbH, Düsseldorf)

Fig. 13.4 Rope brake installed under the well head ceiling. (Source: Bode Components GmbH, Düsseldorf)

Other emergency braking systems are designed as rope brakes. In this brake, the ropes run between two brake shoes. They can be installed in the machine room as shown in Fig. 13.3 or below the well head ceiling as shown in Fig. 13.4. The ropes are not damaged in this process, as the brake linings have a special coating.

Reference

1. EN 81-20, *Safety rules for the construction and installation of lifts—Lifts for the transport of persons and goods Part 20: Passenger and goods passenger lifts*

Interaction of the Lift Components 14

The individual lift components are now described in the chapters described above. However, how do they work together in a lift system. What happens, for example, when a button is pressed when using the lift system and which components must fulfil which functions.

14.1 Function of the lift when used by the user

When a user comes to a lift system, he first presses the button on the landing call panel to call the car. The call command is sent to the controller. From the lift positioning system, the control system is informed at which landing the car is currently located and calculates whether the drive must move the car up or down in order to process the landing call. The controller sends a command to the door controller to close the doors. After the doors are closed, the hook bolt has locked the door and at the same time the safety switch has been closed, so that the safety circuit connected to the control unit is now closed. Now the drive can be set in motion and the car moves out of the unlocking zone towards the destination landing. The drive accelerates the car outside the unlocking zone up to the nominal speed. During travel, the car is monitored by the overspeed governor. At 115% of the rated speed, the overspeed governor would now become stuck and the safety brake would engage at the safety gear frame, bringing the car to a standstill along the route specified in EN 81–20. If the car does not reach the calculated travel distance in the well during the start of travel, then the run-time monitoring is activated and interrupts the power supply to the drive so that the lift is put out of service.

After the car has almost reached its travel through the well to the destination landing, the control system will slow down the drive via the frequency inverter and move the car to the landing at an increasingly reduced speed down to 0 m/s. When exactly the landing is reached, the control system get this information from the lift positioning system, which knows the exact position of the car. When the landing

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is reached, the car is back in the unlocking zone and, if the door is flush, the door machine receives the command from the controller to open the door. After the door has opened, users can enter the car and enter a destination stop by selecting a stop in the car panel. The controller stores the travel command and gives the door machine the command to close the door. During the closing process the safety light curtain monitor the door area. If an obstacle enters the door area during the closing process, the closing process stops and the door opens (reverses). The door controller receives this information from the door monitoring system, evaluates the data and immediately passes the commands to the door machine for execution. After the door has closed, the controller will again give a command to the motor to move the car in the desired direction of travel, provided the safety circuit has been closed again.

14.2 Function of the Lift When Used by Service Personnel

When the lift is driven by service personnel, the service technician must first go up to the car roof, as this is where the inspection control is located. To get to the car roof, the car must be sent away from the landing and the landing door must be opened with the triangular opening. Opening the interlock contact with the triangle opens the safety circuit and the lift system comes to a stop. Now the service technician can climb onto the car roof and close the landing door behind him, provided the company-specific safety rules are observed.

If the service technician has activated the inspection control on the car roof, he can move the car with the help of the inspection control. To do this, he must press two buttons on the inspection control simultaneously. One button for the travel command and one button for the travel direction (up or down). When the lift is moved with the inspection control, all commands that were stored in the control are deleted and only the service technician can now control the lift. While the inspection control is activated, no landing calls can be entered and the doors remain closed. The travel speed is reduced and must not exceed 0.63 m/s. This ensures that the service technician can safely drive through the well. The safety devices such as the speed limiter or the safety brake are still active and respond in an emergency. When the service technician has finished his work, he leaves the car roof and returns to normal operating mode. Afterwards the lift system is active again and can work as described in Sect. 14.1.

15 Remote Alarm and Rescue Service

Here you will learn about the function of emergency call devices and about rescue measures from lift systems. According to the German Industrial Safety Regulation, a two-way communication system must be installed in a lift system so that emergency calls can be responded to. The emergency call device is activated by pressing the emergency call button in the car operating panel, as shown in Fig. 15.1. The emergency call device dials a pre-programmed phone number via a telephone connection, as shown in Fig. 15.2. This call number must establish the connection to a permanently manned location (24/7) that can receive this emergency call. To ensure the safety of this connection, the telephone connection must be provided with an auxiliary power source. There are no regulations about the implementation, but there are different possibilities of realization. The most common connection is via a landline telephone connection with any network provider. When connecting an emergency call device to an extension line, it must be ensured that outgoing emergency calls reach their destination. This is realized by a priority circuit in the telecommunication system. As an alternative to the fixed network connection, an emergency call device can also be used which establishes a connection to the control center via GSM. Before deciding whether GSM should be used as a transmission path, the operator should first have it checked whether sufficient network coverage is available at the facility location.

The emergency call should be answered by a 24-h control centre. The staff in this control centre should be professionally trained in dealing with trapped persons. Many users suffer from claustrophobia during long stays in closed and confined spaces. For this reason, the control center staff try to calm the trapped persons and keep them permanently informed about the current status of the rescue operation by calling back to the car. The trapped person can talk to the control centre via an intercom unit installed in the car. Last but not least, additional costs can be avoided, as many trapped persons alarm the fire brigades via mobile phone in panic. In Germany the costs for this rescue operation are to be borne by the owner. Last but not least, there are additional costs if the fire brigade opens the

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Fig. 15.1 Emergency call button in the car. (source: ©2023 Amphitech, SAS. All rights reserved)

Fig. 15.2 Emergency call dialer. (source: GS electronic Gebr. Schönweitz GmbH, Rheine, Germany)

doors with heavy equipment and damages the doors as a result. In order to minimise the damage when the fire brigades are deployed, specific instructions can be given to the local fire brigades. These instructions include training in how to rescue trapped persons and how to shut down a lift system.

When the emergency call comes in, the 24-h control centre must be able to identify the location of the lift and the factory number. This is particularly important if there are several lift systems in a building. Using an alarm plan stored in the control center, the person who received the emergency call can immediately initiate rescue measures. However, the technical requirements must be met. For example, the data protocol of the emergency call device must be compatible with the control centre so that the necessary data can be transmitted. There are various systems for selecting the emergency call device. On the one hand there are open protocols. This means that the systems of the control centre can “understand” the protocols of the emergency call devices. If this is not the case, the systems of the control centre can be adapted by software extensions. There are also emergency call systems with closed protocols. Here the emergency call device is compatible with only one control centre. In this case, a change of the control centre is only possible by replacing the emergency call device.

In principle, any instructed person can carry out the rescue of persons. The rescue measures are largely carried out by the lift service companies. These companies have their own control center and service technicians who can carry out the rescue operations. Furthermore, rescue measures can be carried out by security companies that specialize in rescuing trapped persons in lifts. In an emergency, the fire brigades can also rescue trapped persons, but this should not be organised as a rule, as the fire brigades should be left to their original tasks. In case of panic, the trapped persons often call the fire brigades if they get the impression that the rescue company will not arrive in time. In larger building complexes the rescue of persons is also arranged by janitors. These must be specially trained for the rescue. It has proven to be useful to have this training carried out by a improved inspection body. There, special training programs on this topic are offered. But the manufacturers of lift systems also conduct these training courses.

The emergency call devices can be supplemented with additional components to take over further tasks. For example, it is possible to have these additional modules perform some tests on lift systems that the person in charge must carry out regularly. In Germany there are some national guidelines who recommend some regular checks. These additional modules check the car light for function, the stopping accuracy of the car at the landing or the functions of the doors. However, even with these systems, it is not possible to completely do without a person present on site, as not all tasks can be queried electronically. For example, checking the landing doors at the landing to see if they open when the car is not behind them cannot be performed electronically. For this test, an attempt must be made to open the landing door using muscle power. This is to check whether the door interlock is working properly.

Other data from the lift system can also be sent, such as the transmission of fault messages and operating states. These messages can then be used in a monitoring software and can provide important information about the installed lift systems for the operator and the technical service provider in the form of fault statistics for availability calculations. This data can also be used to control maintenance operations.

Emergency Plan
In Germany it is required to have an emergency plan at the lift system on site. "An emergency plan must be drawn up for each lift installation and made available to the emergency services. The emergency plan must contain the following information:

- Location of the lift system,
- responsible employer,
- Persons who have access to all facilities of the installation,
- Persons who can carry out the release of entrapped persons,
- Contact details of people who can provide first aid (for example, emergency doctor or fire brigade),
- information on the expected start date of an exemption, and
- the emergency rescue instructions for the lift installation" [1].

During the test prior to put the lift into servcie, the improved inspection body also checks whether the emergency plan is available and the contents of the emergency rescue instructions are plausible. It is also permissible for the improved inspection body to query the control centre about the content of the emergency plan.

Reference

1. Ordinance on Industrial Safety and Health of 3 February 2015 (BGBl. I p. 49), last amended by Article 147 of the Act of 29 March 2017 (BGBl. I p. 626)

16 Maintenance/quality Measurement on Lifts

In this chapter you will learn the differences between some maintenance contract types. In addition, you will get an overview of maintenance contents and quality measurements on lift systems.

16.1 General information

The maintenance of a lift system is decisive for its service life. An unmaintained lift system will always cause faults and reduce system availability. In addition, components will be damaged due to lack of maintenance and the capital good "lift" will lose value.

In Germany with the introduction of the German Ordinance on Industrial Safety and Health (BetrSichV), attention was focused on DIN EN 13015 "Maintenance of lifts and escalators". This standard specifies how maintenance instructions are to be drawn up. A specialist maintenance company can be certified in accordance to EN 13015. This certificate can only be obtained in Germany, if DIN ISO 9001 certification has already been completed. The documentation procedure increases transparency for the owner, as it creates a system history and it is possible for everyone to see at any time what work has been carried out on the lift system (similar to a service booklet for cars).

Section 10 of the BetrSichV stipulates that the employer must carry out all necessary maintenance measures on the plant on the basis of the risk assessment. The performance of the risk assessment is described under §3 and must be checked regularly according to §3 article 7. The state of the art must be taken into account. To ensure this, the lift system should be serviced regularly. The maintenance cycle must be determined. The annual maintenance cycle depends on many factors.

However, there is no generally valid formula for determining the annual maintenance cycle. There are rough classifications by the individual manufacturers

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as to the intervals at which maintenance should be carried out according to their experience.

The following criteria can be used as examples:

Number of trips of the system (frequency). The following number of trips can occur for the different types of buildings:

Residential building	approx. 250,000 trips p.a
Office building	approx. 370,000 trips p.a
Hospital/public building	approx. 450,000 trips p.a
Railway stations (highly frequented)	approx. 520,000 trips p.a

- Environment (residential area, industrial area, schools, so called focal point)
- Type of building (public building, office building, residential building)
- According to the age of the plant
- According to the probability of failure (the probability of failure of a system is similar to a bathtub curve. After a system has been placed on the market, the running-in phase begins. In this phase, faults can occur even more frequently, as the operating behaviour of the system can still change due to parameters that are not optimally set. After the running-in phase and proper use, these faults decrease and then increase again to the end of the service life (reaching the wear limits). When the wear limits of the components are reached, a complete or partial modernization can be considered).

Quantitatively, the number of maintenance operations is therefore difficult to determine. As a rule, one should trust the experience of the manufacturer and observe the situation in the building. A number of maintenance operations determined at the beginning of the service life does not have to be maintained until the end of the service life. Here, one should be flexible and adapt the maintenance cycles to the ever changing conditions of use of a building. In an office building, for example, the environmental conditions can change considerably over the years due to changes in use, so that the cycles must be adapted to ensure high availability of the system. It is therefore quite possible that maintenance cycles may increase from 4 maintenance operations per year to 8 or more maintenance operations per year.

There are therefore no upper limits (more maintenance), but in the experience of the author, at least 4 maintenance operations per year should be carried out on an lift system. A lot can happen within a period of 3 months, so with this minimum number of maintenance the owner is on the safe side.

In addition to the number of maintenance operations to be carried out, the maintenance expenditure on an lift system must also be considered. After all, many maintenance operations per year with an insufficient maintenance scope or a maintenance scope that does not correspond to the use of the lift system can also be harmful to the lift system.

It is possible to carry out the complete scope of maintenance during each service by carrying out all the planned maintenance steps according to the manufacturer's instructions. It is also possible to vary the maintenance contents according to requirements and, for example, only check some components for a defined number of maintenance tasks. In this way, several small maintenance steps per year can be mixed with a few larger ones. From the author's point of view, however, the safety components should always be checked and maintained and the well pit should be cleaned during the smaller maintenance operations.

When agreeing with the customer on the frequency and content of maintenance, there are various options that must always be agreed individually between the owner and the maintenance company. As a rule, the maintenance contents specified by the manufacturers are taken as a basis when a maintenance contract is concluded. Some owners have their own specifications for the maintenance scope and maintenance cycles. However, these specifications should not contradict the necessary maintenance contents of the manufacturer or the warranty conditions.

16.2 Maintenance Plan

Table 16.1 shows an extract of an exemplary maintenance plan (not complete and assigned to a system type) [1].

16.3 Maintenance Types

16.3.1 General

Before work begins, the operating books of the facilities must be reviewed and the entries contained therein evaluated. Since all events such as fault clearance, repairs, maintenance and Improved inspection body inspections are recorded in the operating books, current events can be taken into account. If errors occur during the activities, this history can be used to check whether this error has already occurred once or whether it is an individual case or a new event. Recurring errors can indicate defective or incorrectly set components. Further indications can be obtained by evaluating the error memory, which is available as a menu item in the microprocessor control in modern lift systems. See Sect. 16.7 for more information, and the safety measures mentioned in Sect. 16.5 should also be taken into account during maintenance.

The manufacturer's instructions must be strictly adhered to when servicing lift systems. The manufacturer's specifications can be found in the system documentation. This documentation contains both general and system-specific maintenance steps that must be carried out during maintenance work. Failure to observe them may result in components wearing out more quickly or even being destroyed. A possible warranty claim may even expire.

Tab. 16.1 Exemplary maintenance plan

Activities
Inspection of the brakes
Checking the traction sheave
Checking the ropes
Checking the deflection rollers
Checking the floor marking
Testing the traction sheave
Testing the oil-resistant paint in the engine room
Testing the hydraulic unit
Checking the siphon and piping
Testing the emergency release valve
Checking the oil level in the unit
Checking oil for contaminants
Inspection of car floor, walls
Testing the car door
Inspection of the door guides
Check that the car is flush
Checking the operating elements
Testing the emergency lighting
Overhead cable test
Checking the signage
Testing of the electrical protection devices
Testing of the touchdown devices
Inspection of the safety gear
Test of the speed limitation device
Testing of locking devices
Checking the external control
Testing the remote alarm system

If the maintenance services are not outsourced to the manufacturer, it is more important that all manufacturer specifications are adhered to.

16.3.2 Partial Maintenance

Partial maintenance is carried out if a defined number of maintenance operations per year is agreed between the client and owner/contractor. This can be a minimum of 4 maintenance operations in accordance with the specifications in Sect. 16.1, with no maximum limit. In the case of partial maintenance, no repairs are generally carried out at flat rates. These are remunerated separately and are not part of the scope of services of a partial maintenance. Optionally, further services such as flat-rate troubleshooting or personal rescue can be agreed.

16.3.3 Full Maintenance

A full maintenance usually includes the services of a partial maintenance plus the elimination of faults 24/7 and the replacement of wear parts. The definition of which wearing parts are replaced depends on the content of the contract or the agreements between the client and the owner/contractor. There is no standard for the content of the contract. Usually the most common wear parts such as lamps, brake pads, operating materials, guides, seals are replaced. Depending on the level of remuneration, components from the control system or drives can also be replaced. In many cases, the full maintenance contract also includes the connection of the remote alarm and the rescue of persons, so that the customer receives an all-round carefree package.

16.3.4 Condition-Based Maintenance

Condition-based maintenance can be carried out on systems that are connected to a monitoring system. All system states of the lift are forwarded to the monitoring system. The wear limits of the components as well as other characteristic data such as temperature of the drive, oil level, number of trips, operating hours are monitored. With such a system, maintenance can be carried out to a different extent and in different cycles. Rigid maintenance cycles are no longer necessary, but the maintenance dates can be adapted to the conditions recorded on site. By monitoring the components, wear limits can be exhausted and the wear reserve can be completely exhausted. This prevents the premature and unnecessary replacement of components. Fault statistics can also be set up using the data recorded and, for example, lift availability can be calculated. An optimized use of resources by service technicians through adapted maintenance contents is also possible. Unfortunately, however, even in such a scenario one reaches the limits, as no mechanical wear and tear can be measured. This requires a sensor system that can also measure mechanical changes in components. More information on this can be found in Sect. 16.4.

16.3.5 DIN EN 13015

DIN EN 13015 “Maintenance of lifts and escalators” is a supplementary standard. In Germany any lift maintenance company can pass through certification according to this standard if it has already been certified according to DIN EN ISO 9001. In addition to specifying the type of documentation to be kept (obligation to keep an operating log), this standard also requires regular training of employees. Furthermore, it is stipulated that all identified defects are recorded in a defined process and that they are eliminated in time.

The standard also stipulates that all parties involved (operators as well as maintenance personnel) are informed about their obligations.

16.4 Quality Measurements

There are different methods to check the quality of a lift installation with regard to the ride characteristics. Usually these are electronic measuring methods. Until the development and introduction of electronic measuring methods, simple means were used, for example, to test the travel characteristics of a lift system.

A simple test that can still be performed today is to ride in a car with a coin standing in the middle of the car. You place a coin with the short side in the middle of the car floor and travel from the top stop to the bottom stop. If the coin does not move, i.e. does not roll away or fall over, then this is a sign that the lift system has good running characteristics. This means that the guide rails are perpendicular in the well, the rail joints are exactly on top of each other and the car sits optimally between the guide rails, and the drive, in conjunction with frequency control, exhibits excellent travel characteristics in both acceleration and deceleration.

Today we have various electronic measuring methods at our disposal. For example, the ride quality of a lift system can be measured with an electronic acceleration sensor as shown in Fig. 16.1. The measurement corresponds to ISO 18738

Fig. 16.1 Electronic acceleration sensor. (Source: Henning GmbH & Co. KG, Schwelm, Germany)

"Measurement of lift ride quality". For this measurement, the electronic acceleration sensor is placed in the middle of the car floor. Afterwards a lift command is given. Ideally, the car should travel from the lowest floor to the highest. The ride quality is measured by recording the accelerations in the axes x, y and z. In addition, the door movements are recorded and the jolting and shaking movements on the car and on the rail guides are measured. The measured values are displayed and recorded as curves and can be followed directly on the laptop via a tailored software even during the measurement. After the measurement the recorded curves can be analysed and evaluated. During this evaluation, it is possible to determine the quality of the lift system. If a reference measurement was carried out at the beginning of the service life, the problem areas can be identified by comparing the currently recorded curves with the reference measurement. If this measurement is repeated regularly, changes in the system over time can be detected.

A further quality measurement on the lift installation is the measurement of the rope tension. Good rope tension ensures a long service life of the ropes, since unevenly tensioned ropes can lead to skewed pull of the car. A lift installation with unevenly tensioned ropes consumes a little more energy if this causes the car to pull at an angle. If the rope loads vary due to insufficiently evenly tensioned ropes, the more heavily loaded ropes will wear out more quickly. Wire or strand breaks will start earlier than normal. With damaged ropes, there is also the risk that the traction sheave will also suffer damage. Figure 16.2 shows a rope tension measuring system with the corresponding evaluation unit.

For this measurement of the rope tension, rope clamps are attached to each rope. The rope tension can be determined using a strain gauge inside the rope clamps. The measuring device carried along evaluates the results and can also

Fig. 16.2 Measuring device for measuring the rope tension. Rope clamps and measuring unit. (Source: Henning GmbH & Co. KG, Schwelm, Germany)

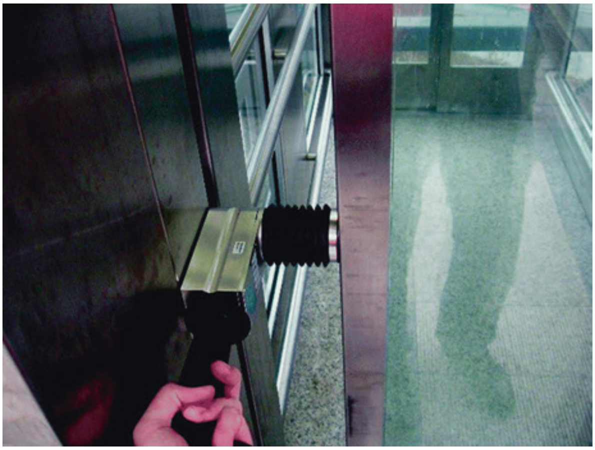

Fig. 16.3 Electronic door closing force measurement. (Source: author)

display them in a diagram. The results can be saved and printed out by means of a software. Changes to the ropes can thus be continuously documented over time.

Measuring the closing force of the doors is another way to measure the quality of maintenance on a component. The permissible door forces are specified in EN 81-20 and must be checked regularly. There are several ways to determine the closing force on doors. On the one hand, it can be determined using the Swiss measuring hammer. This is a mechanical measuring tool in the form of a hammer that is held in the door during the closing process of the landing door. The force can be read off a ring on a scale which moves when the door leaf hits the measuring club. Another possibility is electronic measurement. A device similar to the Swiss measuring hammer with an electronic unit and an evaluation unit. This measurement also determines the forces when the door hits the measuring instrument. The evaluation unit can display the recorded forces in a diagram and is even able to take the kinetic energy into account and calculate it out. Figure 16.3 shows the electronic measuring method for door closing force measurement.

If possible, maintenance companies should always use electronic measuring methods. These measuring methods have one thing in common: you can document the results in writing and thus have a record of the tests carried out. These can be repeated at any time so that a history with comparative data can be built up.

16.5 Safety Measures During Maintenance

A number of safety measures and rules must be observed during the maintenance of lift systems. In Germany, there are some national guidelines from the employers' liability insurance association, which provides information on how service technicians should behave during maintenance. In general, maintenance should only be started in the well head and continued during downward travel. During the downward movement, passing parts such as the counterweight or brackets for guide rails can be better identified. Injuries that can be caused by crushing the passing counterweight, for example, are thus avoided. The acting persons should be trained in safety. This instruction must be repeated annually and should deal with the work equipment, working materials or accident prevention measures to be used [2].

If the lift installation is a stand-alone workstation, organisational and technical measures must be taken to ensure the safety of the service technician. The technical measures should include emergency call facilities in the pit and on the car roof so that service technicians can make an emergency call in the event of a trap via this facility. If no technical measures are available, organisational measures must be taken. These include, for example, carrying out maintenance with a second man who can help in an emergency [2].

Personal protective equipment must be worn during maintenance work and all tools must be kept in proper condition. When working on electrical systems, ensure that this work is only carried out by a qualified electrician, a qualified electrician trained for this system for specified activities or a person trained in electrical engineering. In particular, the 5 safety rules of the german employers' liability insurance association in electrical engineering must be observed:

- Unlock,
- Secure against restarting,
- Determine that there is no voltage,
- Ground and short circuit,
- Barricade adjacent, live parts

No inspections shall be carried out during the travel. When operating the inspection control, ensure that it is held correctly in the hand (the symbols must not be upside down) to avoid confusion of the direction arrows.

Users must be made aware of the impending maintenance by signs on the landing doors. If necessary, the landing doors must be locked.

For documentation, service technicians today have smartphones with additional functions, handhelds or laptops at their disposal. This is where the maintenance lists are called up and processed. The work can be logged in and out via the device. It is also possible to select and order spare parts via these devices.

During the stay in the well it must be ensured that no telephone calls are made during the trips, at best during the entire work in the well. This leads to inattention and increases the risk of accidents. If absolutely necessary calls have to be made, the travel should be interrupted.

As far as maintenance is concerned, the development will continue in the direction of travel. Starting with evaluations of current system statuses and indications of which components are at the wear limit, through to the independent ordering of spare parts for the system. Furthermore, exact driving characteristics and main areas of use can be determined. It is possible to evaluate which stops are approached most frequently, the number of trips of the system per day, per week, per year or which power consumption individual components have, in order to be able to carry out a diagnosis in case of an increased abnormal power consumption and to replace the component or part before it fails. In this way the failure can be reduced to a minimum. Targeted and plant-specific maintenance visits are possible. By networking the system with the maintenance company, communication is also possible in both directions. For example, the system reports a malfunction to the maintenance company before the owner recognizethe fault. In return, the maintenance company can directly communicate the information about the received fault and the expected service visit to the operator or the tenants of a building. It is also possible to send information directly to the system, which can, for example, be shown on a display in the car or at the stops.

16.6 Cleaning

A lift system must be cleaned regularly. Especially in public areas, the car is often dirty. In the case of lift cars with stainless steel walls, however, the manufacturer's care instructions must be observed. Incorrect cleaning will destroy the surface of the stainless steel. Excessive use of water in the car must be avoided. This means that blasting the car with a high-pressure cleaner is not recommended, as this can damage the electronics in the car (car panel, lighting).

The wellpit should also be cleaned regularly. Here, too, it should be noted that excessive cleaning with high-pressure cleaners should be avoided to prevent water damage to electronic components in the pit.

When cleaning work is carried out in the well in order to clean it from the inside, it is necessary for two people to ride on the car roof. The occupational safety measures and the information on the maximum load-bearing capacity of the car roof must be observed.

16.7 Error Messages/error Codes

Whenever maintenance is carried out, the service technician should inform himself about the condition of the system before starting work. In addition to inspecting the operating log of the system, he also has the possibility of reading the error memory of modern lift systems. The current events can be displayed. From a safety point of view, this is generally recommended in order to take into account currently pending errors or status messages during maintenance/fault clearance. Errors that have recently occurred in the past should also be taken into account. Frequently recurring errors indicate a general problem that can be solved by detailed investigations. This is because only a trained service technician, as a skilled person, can correctly interpret the knowledge gained.

A conversation with the owner is also very helpful. If the system is properly logged in at the start of maintenance, current statuses or malfunctions of the system can be queried. This can also be used to find out whether the system has been used improperly. The service technician can take this information into account during maintenance.

The errors that occur in a system are stored in the error memory. Depending on the manufacturer of the control system, up to 100 entries can be stored without any problems. Using a laptop or USB stick, these errors can also be stored on an external medium. In case of extensive error analyses, the information can be passed on for further investigation. The error codes can also be read directly on the control system. For this purpose there is a display in the control unit which shows the error as a numerical code, as plain text or in a combination of numerical code and plain text.

In larger buildings, technical staff sometimes also carry out the initial analysis. After an instruction it is then possible to read out these plain text displays and thus carry out an initial analysis. This often allows minor faults to be rectified without the need to commission the maintenance company.

> Note: Since most of the plain text displays are located directly in the control cabinet, it is essential that the persons reading these errors are appointed as qualified electricians for specified activities, since live parts can always be touched when working in the control cabinet.

The meaning of the individual errors can be found in the operating and maintenance instructions. There you will find tables which explain the individual error codes. Here are some errors that may occur and their meaning (the list is not complete and may differ from that of the manufacturer).

Runtime error	If the car has not travelled the calculated distance, this error is displayed. Causes here can be the missing motor start or slipping ropes
Safety circuit	This error is displayed when components that are integrated in the safety circuit respond. Door openings while driving also fall into this category
Excessive temperature	The drive is too hot. Either insufficient ventilation or, in the case of hydraulic power packs, too little hydraulic oil in the power pack
Overload	Lift cannot move from the starting position because the car is overloaded. If there are obviously fewer people in the car than the payload allows, this may also be due to an incorrectly adjusted load weighing device

Literature

1. DIN EN 13015:2001+A1:2008, Maintenance of lifts and escalators—Rules for maintenance instructions
2. DGUV-Information 209-053, Berufsgenossenschaftliche Informationen für Sicherheit und Gesundheit bei der Arbeit (employers' liability insurance association), Tätigkeiten an Aufzugsanlagen, February 2017

Documentation of Lift Systems

17

Chapter 17 deals with the subject of documentation of lift systems. The complete documentation of a lift system is indispensable for an owner. It contains all the technical data of the lift system as well as the records of the recurring inspections of the Approved Inspection Authorities. It also contains the operating instructions with manufacturer's data.

The following documents are also important for the operator:

- Lift inspection book *contains parts of the documentation*
- Risk assessment
- Determination of inspection periods *checked by Approved Inspection Authorities*
- Emergency plan

17.1 Lift Inspection Book

The lift inspection book essentially contains the following documents:

- Description of the lift system
- Technical specifications
- Rope calculations
- Calculations of the guide rails
- Declaration of EU-conformity
- Type examination certificates of the safety components according to EU regulations
- Circuit diagrams of the lift control
- Plant drawings

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The logs of the recurring main and intermediate inspections from the Approved Inspection Authorities according to national German rules are also collected there. Thus the owner has a chronological list of the lift conditions of the past years. If changes are made to the system, these must be documented in the lift inspection logbook. According to national German rules, in some cases, changes to a lift system must be accepted by a Approved Inspection Authorities. In this case, the owner receives a certificate confirming the inspection carried out.

17.2 Operating Instructions with manufacturer's Instructions

The operating instructions contain information for the owner of a lift system as well as for the maintenance company. It contains information to be observed during maintenance work or inspections or special care, lubrication and adjustment instructions for parts or components. Spare parts lists for the most important components and wearing parts may also be included there.

18 Lift Systems During Life Time

This chapter describes the obligations of the owner of a lift installation during life time. This chapter contains procedures, which are only valid in Germany. But these requirements could also apply in other countries, because the owner must ensure safe operation of the lift system and keep the system up to the state of the art.

18.1 Risk Assessment

A risk assessment must be carried out by the employer. A risk assessment is used to determine which hazards can arise when using the lift system. On the basis of this risk assessment, further measures can be derived which the employer must take to increase the safety of the system. This is important for owner who are also employers, since most owners also use the lift systems as work equipment and must therefore comply with their duty of care for their employees.

However, a risk assessment also records hazards that may occur for users. A lift system built in accordance with a harmonized standard can, under certain circumstances, contain additional hazards. For example, a lift installation in a glass well attached to a building can become a danger for trapped users in the summer months due to high temperatures. In this case, the risk assessment may indicate that sufficient cooling must be provided within the well and that a shading system must also be installed.

18.2 Controls of the Owner

With the introduction of the Ordinance on Industrial Safety and Health (BetrSichV) in Germany, the owner has been assigned certain obligations. Thus, he has to maintain and monitor the plant in accordance with the state of the art and

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to carry out necessary repair or maintenance work without delay. These obligations are also described in national regulations like TRBS 3121 “Operation of lift systems”. Furthermore, the owner must appoint one or more persons who have the necessary reliability:

- to supervise the lift installation
- carry out regular checks
- to release trapped persons

These persons must carry out the following checks at appropriate intervals, usually weekly (this list is not exhaustive) [1]:

- the car cannot start up while a landing door is open
- a landing door cannot be opened while the car is outside the unlocking zone of this door
- the car cannot start up while the car door is open
- the accesses to the lift well, to the drive unit and to the associated switching devices can be walked on freely and safely and no objects foreign to the lift are stored in the machine room
- the stopping accuracy usual for the system is still available at the individual stops
- the emergency call equipment is functioning (unless the emergency call system contains an automatic self-check) and the instructions for releasing persons are legible and up-to-date at the main access point
- the emergency brake switch or the door open switch is effective
- for cars without car doors, the well wall on the access sides of the car is not damaged
- the car lighting is functional
- the intended use or the proper operation of the lift system is carried out in accordance with the manufacturer's specifications

These controls should be recorded and retained as part of legally compliant documentation. Through the regular checks, even obvious defects in the system can be detected and eliminated by the assigned maintenance company.

If the owner wants to fulfil his obligations according to the BetrSichV, he should also check the commissioned services of his maintenance company randomly. Even if his maintenance company is a specialist company that is certified according to EN 13015 or works according to these rules, it does not release him from this control obligation. In this case it is not necessary to inspect the complete lift system and check every activity carried out. It is sufficient if only a few points are checked randomly. This can be done, for example, if the service technician properly sign out from the owner after maintenance. Then the operator can convince himself of the work. Enclosed is a checklist that can be helpful in this respect. Further points can also be added.

Checklist Maintenance/performance Evaluation

Checkpoints	Yes	No
Has the agreed maintenance plan been properly completed?		
Has the maintenance been entered in the operating log?		
Are there any other entries from the past (repair, malfunctions, personal liberation)?		
If the lift system is to be used safely in accordance with Lift Directive, Annex 1, No. 4.6		
Do the door gaps run evenly from top to bottom?		
Were the door gaps observed for glass doors? Door gaps between the door leaves (an adult's little finger should not fit in)		
Have the bottom door guides been cleaned?		
Is the engine room swept clean?		
Has the well pit been swept? ***Only carry out this check in the presence of the service technician, i.e. he opens the landing door, secures it and switches on the well light!*** ***Attention: Danger of falling!*** This is a point on which there is always disagreement between the owner and the lift company. This is because the standard maintenance contracts only stipulate the removal of operation-related impurities. However, a maintenance company can demand that a service technician does not leave the pit without clearing it of fire loads such as newspapers, paper etc. that may be in the pit		
Is the hydraulic unit excessively contaminated with oil? (This indicates a leaking hydraulic block)		
Is the oil-resistant paint in the engine room damaged? (only valid for hydraulic systems. Can also be determined during the weekly operator checks)		
Is the oil-resistant coating in the well pit damaged? ***Only carry out this check in the presence of the service technician, i.e. he opens the landing door, secures it and switches on the well light!*** ***Attention: Danger of falling!***		

18.3 Electrical Safety Test

Lift systems are stationary electrical systems which must be tested for electrical safety in accordance with VDE 0105-100 (German standard). In this case, the protection against electric shock is verified by measuring the tripping residual currents of the fault circuit breakers (RCD) and the miniature circuit breakers. These tests are to be carried out within the specified periods for the protection of the users.

This test is to be documented with an electrotechnical measurement protocol. Since this is a recurring test, it is important that an initial test according to VDE 0100-600 is available. This must be carried out before the product is placed on the market.

Fig. 18.1 Fluff formation in the well. (Source: Author)

18.4 Fire Protection

Fire protection is an important issue that does not leave the lift system unaffected. It has already dealt with the topic of how an external signal, for example from a fire alarm control panel, can be used to move the car to a defined landing (fire evacuation control).

Fire protection in a lift system can also mean, regular inspection of the lift well to check the degree of soiling. Figure 18.1 shows a part of a lift well where lint has formed. The removal of operational contamination as mentioned in the maintenance documentation does not refer to the cleaning of well walls. Since the lift well acts as a chimney through the permanent opening in the well head/machine room, dirt also accumulates on the well walls, which can lead to lint formation. The removal of this dirt is usually not a service provided by the maintenance companies, which is done with normal maintenance. This is an additional service. The soiling of the well is observed by Inspection authority body during the recurring inspection. If the degree of soiling has risen considerably, so that there is a fire load, this will be noted as a defect in the inspection report. Depending on the influence of the environment, it may well be that the well must be subjected to a complete well cleaning every 3–5 years.

Reference

1. Technical rules for operational safety, TRBS 3121 Operation of lift systems, GMBl. No. 77 of 20.11.2009, p. 1602

19 Traffic Calculation

Traffic calculation is a mathematical method to determine the necessary number of lifts in buildings, the size of the cars and the speed of the lifts. This chapter will give you a brief insight into this complex calculation method.

These calculations are usually made when constructing new buildings, usually for large buildings or high-rise buildings. In the case of high-rise buildings, especially office buildings, it is of enormous importance to transport people arriving at the start of work quickly to the desired stops. At this point we speak of the building filling time. With these calculation models it is possible to vary all available times, such as travel time or door closing times, in order to determine the optimal solution for the building. Door opening and closing times can be adjusted in such a way that the car already moves into the landing with open doors. This reduces the time it takes for users to get in and out of the car.

There are several methods to perform a traffic calculation. Usually, calculation programs are used that have been specially developed for this purpose. Lift companies need these calculations to determine the optimal solution for lift systems in high-rise buildings (high-rise lifts). However, there are also other methods to perform a traffic calculation.

The following information is essentially required:

- Number of persons staying/working in the building
- Floor height
- Number of stops
- Door opening time, door closing time
- Speed of the drives (assumption)

This data can be used to determine the number of lift systems required in a building, what size (rated load) they should have and how fast they should travel (rated speed).

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Different types of transport are considered here:

- Filling operation (usually in the morning hours)
- Intermediate floor operation from the main stop
- Mezzanine floor operation within the building
- Emptying operation (usually in the evening hours)

There are other types of consideration and scenarios that are not discussed in detail here. In addition, there are calculations for larger building complexes that take into account the use of escalators as well as stairs and several entrances.

Definitions of terms:

19.1 Five-Minute Interval:

Number of passengers that can be transported to the topmost stops within a maximum of 5 min.

19.2 Interval:

Theoretically the longest time that a person has to wait until the next car arrives at the main landing. As a guideline value for comfortable operation, 30 s are defined here.

19.3 Number of Theoretical Stops in a Building:

To determine these values, tables are available which show the theoretically possible stops depending on the car size (number of persons) and the total number of stops in a building. The values in these tables were determined on the basis of tests, investigations and calculations.

19.4 Car Filling Time:

To determine the car filling time, it is assumed that the car is always filled to 100%. (In practice, the cars are only filled to approx. 60–70%). For example, such a value contains the times needed for users to get on and off the car at the main landing. It varies with the size of the car and the possible number of people that can be transported.

19.5 Door Times:

The door times include one opening and one closing process. These times depend on the door type.

19.6 Dwell Time:

The time it takes for passengers to get on and off per stop.

If several systems/groups of systems are taken into account and if other factors such as mezzanine floor traffic at different times or the inclusion of parking decks are taken into account, the calculation becomes much more extensive. In shopping centres, where escalators are in use, the calculation gets additional more extensive.

If such calculations are required, the lift company should be consulted. However, there are also consultants who can perform such calculations. It is not always guaranteed that you will get the 100% solution, but with such calculation methods you can get an approximately optimal solution for your building.

There are different philosophies to calculate the traffic of such a system. In the author's opinion, they all come to the same solution in the end. The different calculation methods can be found in the following writings:

- ISO 8100-32, *Lifts for the transportation of persons and goods – Part 32: Planning and selection of passenger lifts to be installed in office, hotel and residential buildings*
- Elevator traffic handbook from Gina Barney
- The vertical transportation handbook from Georg Strakosch

20 Accidents at Lift Systems

In this section you will find some advice on how to behave when using lifts to avoid accidents.

Accidents at lift systems happened frequently. Most accidents are minor in nature, such as cuts or crush injuries.

In this section you will find some advice on how to behave when using lifts to avoid accidents.

Accidents at lift systems happened frequently. Most accidents are minor in nature, such as cuts or crush injuries. These accidents are not reported to the authorities and are not published in the press. It is not known how many of these accidents occur. Unfortunately, however, there are also serious accidents, some even end fatally. In Germany the number of accidents is regularly collected and investigated by the DAfA (German Committee for Lifts) or the VDMA. Unfortunately, considerable research work is sometimes necessary here. Knowledge of such accidents is of great importance, as some conclusions can be drawn from the course of events, which in turn can serve as a basis for adapting occupational safety guidelines or even a product standard. The victims of these accidents can be both users and maintenance personnel.

As a service technician, the following rules should be observed in any case (this list is not exhaustive):

- The manufacturer's instructions regarding safety and handling must always be observed.
- It must always be ensured that personal protective equipment is used. This includes a safety helmet or bump cap, safety shoes, safety goggles, possibly ear protection, cut-resistant gloves, electrical-tested tools and calibrated and tested measuring instruments. A non-slip plastic wedge or similar should be used to keep the landing doors open when entering and leaving the well.

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- Furthermore, operating instructions (if available) should be observed.
- In Germany, information on these topics can be found in the information leaflets of the professional associations.

The following rules should be observed by all users (this list is not exhaustive):

- The lift is to be used only for its intended purpose. This includes avoiding overloading the car beyond the rated load.
- Excessive impacts against the doors must be avoided. This will cause the doors to move and therefore there is a risk that the doors may jam or not close properly. This increases the risk of jamming. It is also possible that the doors do not close completely and the car gets stuck during the ride.
- Do not jump in the car.
- Do not attempt to open the landing doors with objects or tools. Even if you have the emergency release key, only qualified personnel or instructed persons are allowed to open the landing door.

21 Modernization of Lift Systems

In this chapter, a modernization is described using an example and which directives and standards have to be taken into account. There are several possibilities and starting points for modernizing lift systems. Many lift owners only make visual changes. These visual changes usually involve only re-lining the car or modernizing the landing doors.

However, it is also possible to carry out a modernisation based on safety aspects. This includes, for example, the replacement of an old lift control system that no longer corresponds to the state of the art in terms of function and operation. It is also possible to simply replace the drive with a new drive with frequency control. In this case, aspects of energy consumption play a role. In addition, a new drive can also increase driving comfort.

The following example is intended to illustrate which aspects have to be considered in a modernisation and which effects small causes can have.

We assume that the car of a lift system is to be relined. For this purpose the walls are to be covered with a new stainless steel decor. As an assumption, the car should have a rated load of 630 kg.

A lift car with a size of 1100 mm × 1400 mm has a weight of approximately 900 kg. An additional lining with stainless steel weighs about 250 kg to 300 kg. This increases the car weight to approx. 1200 kg.

Due to the weight increase of the car, all other relevant components must be checked. Here it must be checked whether the limit values and basic data still correspond. Therefore the following components should be checked or recalculated:

- Safety gear
- Guide rails
- Buffer
- Supporting means
- Engine
- Roller carrier

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- Hydraulic jack
- Control block
- Pressure lines
- Line break valve

Assuming that it is a traction lift with 4 landings, with the machine room above, it is possible to ignore the hydraulic components such as hydraulic jack, control block, pressure lines and line break valve.

Inspection of the Safety Gear

Safety gears are used up to a certain limit value in case of a release. This limit value depends on the car weight and the rated load. If the car weight is increased, this limit value can be exceeded.

For this reason, the existing safety gear must be recalculated with the changed car weight. If the limit value is exceeded, a new safety gear must be installed for the next higher limit value. When installing a new safety gear, it must be ensured that a protective device is provided for overspeed in the up and down device.

Checking the Overspeed Governor

In addition, the single-acting overspeed governor in the engine room must be replaced by a double-acting one.

Checking the Guide Rails

The guide rails are mounted on the wall of the well. The additional weight of the car changes the buckling stress in case of a release. This means that rails that are too small cannot withstand the additional loads without damage in the event of a fall. Insufficient guide rails must therefore be replaced.

Checking the Counterweight

The counterweight only needs to be adjusted by the additional car weight.

Checking the Buffers

An increase in car weight can cause the buffer to be replaced, as the buffer must cushion the car downwards. The weight of the car plays a major role here.

Inspection of the Suspension Means and the Power Unit/roller Carrier

Therefore, if the car weight is increased by 300 kg, the counterweight must also be increased by 300 kg. This means that the drive and drive shaft are loaded by an additional 600 kg. The drive shaft must be able to withstand the load and the drive motor must have the necessary power to move the additional weight. In addition, the load-bearing equipment must be checked to ensure that it is not under-dimensioned. If the drive motor is to be replaced, it is recommended that the ropes and the traction sheave be replaced.

Checking the Control System

It is not absolutely necessary to check the controller. If it is still state of the art, it does not need to be replaced. However, if the check should reveal that the drive needs to be replaced by a drive with a higher connected load, the control unit should be checked.

An owner who is dependent on technical advice cannot estimate the effects of his desire for a new car lining. However, a reputable lift company will always carry out the above-mentioned investigations.

A cost-effective alternative to the example just described is to replace the entire car. In this case, it is possible to keep the car weight constant or even reduce it in the best case by using suitable materials. When a new car is installed, a new car door is also required, including the required electrical equipment on the car roof.

In addition, it is recommended to replace the safety gear if it no longer corresponds to the state of the art, as older systems in particular have no protection against uncontrolled upward movement. This would also increase the safety of the lift system. Alternatively, it is also possible to install a rope brake in the machine room or below the well head ceiling.

Irrespective of which components are replaced and adapted to the state of the art, the following three points of a modernisation should be considered:

Modernisation should always be.

- Hearing *(through modern and quiet components)*
- Feeling *(through a smooth driving behaviour)*
- Vision *(by embellishing the car, doors)*

22 Planning of Lift Systems

In this chapter you will learn some aspects that need to be considered when planning a lift system.

Before starting to plan and dimension the lift system, fundamental questions must first be clarified.

- What should be transported?
  - persons, ... with wheelchairs, ... with walkers, ... with bicycles, ... with baby carriages, ... with shopping carts. How many people must be accommodated in a car?
  - loads, ... as pallets, ... as roll containers, ... with forklift operation. What volume and weight will the loads have?
- In which building should the system be installed?
  - Residential building? What is the height of the building or at what height are the stops located? In Germany, from a height of 13 m upwards, a stretcher must be considered according to the high-rise building guidelines, which must be carried by the car. At this point, a 13-passenger lift with a car size of $1{,}100 \times 1{,}300$ mm would be used. The installation of a firefighters' lift according to EN 81–72 is also required.
  - Office building? The same questions have to be asked here as well. In addition, it may be necessary to install a lift in accordance with EN 81–73 if this is required in a fire protection concept.
  - Hospital? At this point EN 81–70 must be considered because of the users as well as of a firefighters lift according to EN 81–72 and possibly EN 81–73. Furthermore, it's necessary to think to an interface to an emergency power supply, so that in case of a power failure the lift can either be operated permanently or only a further operation to the next floor is necessary.
  - School, Public Building? Here, vandalism safety must also be considered. In this case, EN 81–71 is also applied.

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  - Hotels, Pubs, Restaurants? Small goods lifts can be used to transport food and smaller loads. In this case EN 81–30 will be applied. These would be lift systems according to the Machinery Directive (2006/42/EC), which have different procedures to put the lift onto the market.
- What are the environmental conditions of the building/installation? At this point the question arises whether weather conditions have an influence on the installation. Should the system be installed in an area prone to flooding, near a river or lake? If so, there are questions about the material to be used for the car, such as stainless steel in V2A or V4A. Are there any requirements regarding water management laws that would influence the use of a hydraulic lift?
- Who is the user group?
  - Strangers? For strangers, especially in public buildings, you should consider the following additional standards, as they could all be used (EN 81-70, -71, -72, -73).
  - Employees? In an office building, the lift control system can be combined with various interfaces. From the card reader for the assignment of a lift system for systems with destination control or with the encryption of the system, so that defined stops can only be approached with a key.
- How should the lift behave in case of fire? As described above, it may be necessary to consider the additional standard EN 81–73. If a fire protection concept has been drawn up for the building, it must be clarified to which landing the lift should travel when a signal is received from the fire alarm control panel or from a smoke detector. If only one floor has been defined, this is called a static fire landing. If an alternative floor has been defined, it is called a dynamic fire landing.
- How should the lift behave in case of power failure? The lift system can travel to the nearest landing. For this application it is sufficient to install only one battery pack. However, if the lift system has to make a complete trip to the ground floor or even continuous operation is necessary, a backup power supply is required (diesel emergency power generator).
- Which interfaces to other disciplines were defined? If information has to be forwarded from or to a monitoring system or the building control system or a fire alarm center, this has to be taken into account in the lift control system.
- How should the landing closure be designed? Should wall perimeter frames be used or should a complete door portal be produced. Who should take over this service? Usually the lift manufacturer can take care of this, but it should be clear in advance so that these services are included in the offer. The material must also be defined. Should stainless steel be used or only pre-painted sheet metal for the final coating by the customer?
- Is well smoke extraction required? There are construction projects that require a permanent closure of the well smoke extraction system required by the state building regulations. For this purpose lamellas or windows are used, which can be opened for ventilation or in case of fire. Such a system must be integrated into the lift control system. The functions should also be clear here in advance.

Tab. 22.1 Standard well dimensions

Rated load/kg	Car width/mm	Car depth/mm	Well width/mm	Well depth/mm
630	1100	1400	1500–1700	1700–1900
800	1350	1400	1700–1900	1700–1900
1000	1100	2100	1500–1700	2300–2500
1600	1400	2400	2000–2300	2500–2800

Now that the above questions have been answered, the dimensioning of the car can be started. In a new building, there is usually more freedom when it comes to dimensioning the car and the well. In the case of a replacement installation, the existing well dimensions must be taken into account.

The standard car sizes with the corresponding rated load and well dimensions can be taken from Table 22.1. These assignments are based on the specifications in EN 81-20, Chapter 5.4. The system can be dimensioned on the basis of the size of the car and the drive to be used, electric traction or hydraulic lift. The type of drive determines the arrangement of the components in the well. In the case of an electric traction lift, the counterweight is placed next to or behind the car, in the case of a hydraulic lift the hoist must be placed. When the components are fixed, a well construction plan can be created as shown in Fig. 22.1.

Figure 22.2 shows the dimensions in the well. The well height is defined as follows:

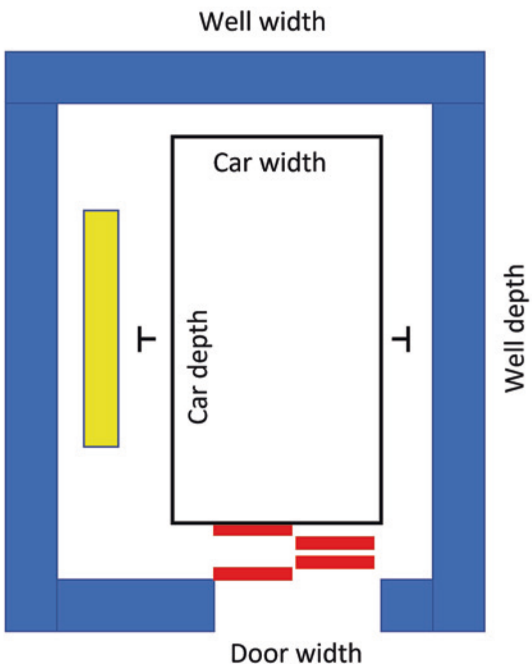

Fig. 22.1 Well construction plan

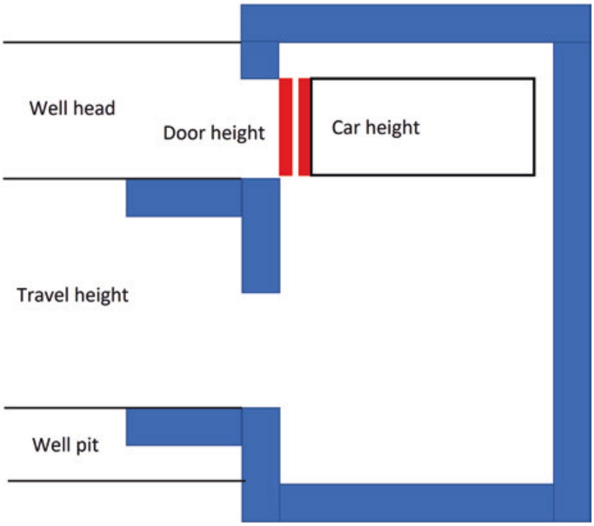

Fig. 22.2 Well cross section

Travel (FH):	The travel is the measure from upper edge of finished floor of the lowest landing to upper edge of finished floor of the highest floor
Well pit (SG):	The shaft pit dimension is the dimension of the upper edge of finished floor lowest landing to the bottom of the shaft pit
Well head (SK):	The well head dimension is the dimension of from the upper edge of finished floor uppermost landing to the lower edge of the well head cover
Door height (TH):	The door height is the dimension of the shaft and car doors

Fig. 22.3a, b shows two sections of a plant drawing, which represent a well cross section.

Now that the system has been dimensioned, the lift manufacturer can start ordering or producing the components. However, this does not yet clarify all questions. There are still other points that need to be coordinated. The following non-concluding questions arise:

- Who connects the equipotential bonding in the pit? The guide rails must be connected to the potential equalization of the building. This question has to be clarified, as not every installation company provides this service. Therefore the tendering agency should make sure that this performance is taken into account. This means that an electrical company can provide this service.
- Who orders the telephone connection for the remote alarm device? Normally, the owner of the lift system must provide a telephone connection in the machine room. Which provider he chooses here is at his decission. Often, the future owner is not yet known because the building was constructed by a

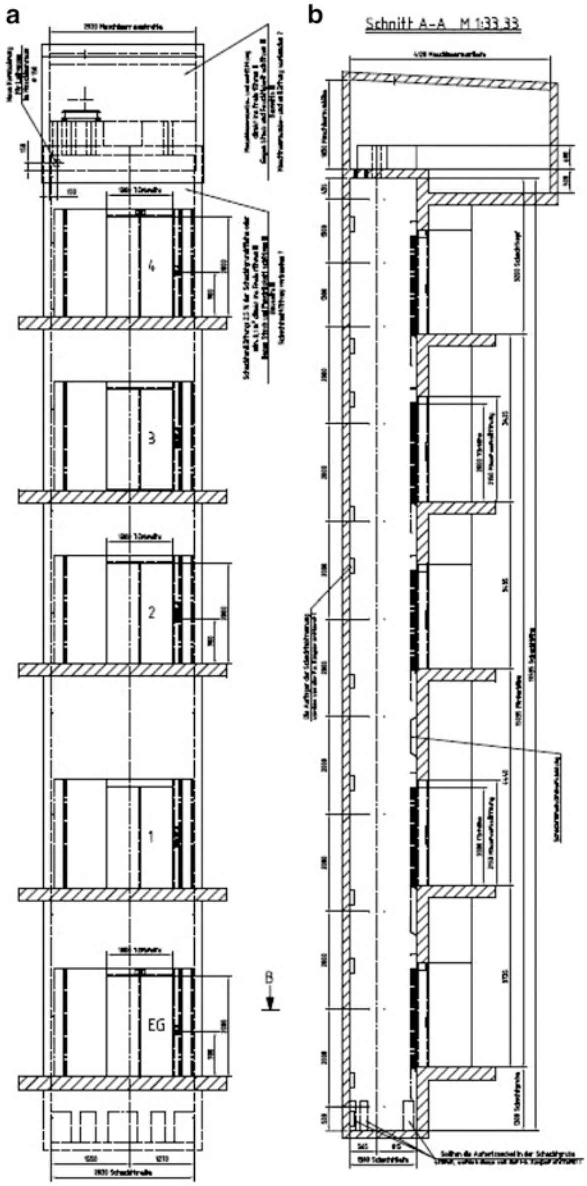

Fig. 22.3 (**a**) Well cross section of a lift system on the corridor side and (**b**) well height section of a lift system on the side. (source: author)

general contractor. In this case, an interim solution must be chosen. It's possible to use a remote alarm device with GSM. This can be a temporary solution until a fixed telephone connection is installed. It is also possible to use this as a permanent solution. In general, when using the GSM solution, one must ensure that there is sufficient network coverage at the location of the system.

- Who provides the power supply for the lift system? Prior to putting the lift into service the lift must be operated with original power according to German rules, i.e. acceptance with construction power is not permitted. In addition, the power supply from the sub-distribution board to the main switch of the lift system must also be checked.
- Which assembly technique is used? Is the lift system assembled with or without scaffolding. An assembly with scaffolding provides for a wooden platform on each landing. In addition, barriers are required at the landings to provide fall protection. This service must be assigned either to the lift manufacturer or the contractor. In the case of a scaffold-free installation, the platforms on the landings are not required, only the fall protection devices.
- Where should the emergency call be activated? This question should be clarified in time prior to putting the lift into service. According to EN 81–28, the owner is required to connect the emergency call to a permanently manned location. This service can be provided by the lift manufacturer. He has an emergency call control center and can answer the emergency call 24/7 and initiate suitable measures to free entrapped persons. In exceptional cases, e.g. in hospitals, the emergency call can also be connected to the doorman, provided that this position is occupied 24/7 by at least two persons.
- Who takes over the liberation of persons? The rescue of entrapped persons from the car is a separate service. It can be done but it does not have to be done by the same company that answers the emergency call. Usually the lift manufacturer can also provide this service. It should be determined in time before putting the lift into service. When selecting suitable contractors, care should be taken to ensure that the specifications of EN 81–28 are observed. EN 81–28 stipulates that the time between the sending of an emergency call and the arrival of a rescuer should not exceed 60 min. When selecting the location of the rescuer it's better to choose the geographically correct company. A buffer for traffic jams, storms or heavy snowfall in winter should be taken into account. National rules could define shorter times.
- Who commissions the notified body to put the lift system onto the market according to EU law? Usually this is a service of the lift manufacturer and this service should be included in his offer. However, it's important to make sure that this point has not been forgotten. It is possible, that national regulation require additional test procedures.
- Do substitute measures have to be created during the construction phase? When installing a replacement system in an existing building, it is often essential that the lift be available to residents at defined times. This delays the installation time and may have to be compensated by installation in 2 or 3-shift operation.
- Are additional disciplines required? If other disciplines are required, these services should also be considered at an early stage. These include, for example, chiselling work or core drilling. If the car bottom has been lowered to install a

tile covering provided by the customer, this service must be ordered and completed in good time for acceptance of the lift system.
- Where can the material be stored? A material location should be determined before delivery. This question is somewhat easier to answer in the case of a new building, but problems can arise when constructing in existing buildings. Material storage outside the building or even outside the premises can be expensive.
- What are the transport routes in the building? If floors need special protection, these precautions must be taken at an early stage so that there are no delays in the construction process.
- Is a crane needed? If a crane is needed to bring materials into the well, it must be registered with the authorities and approved in good time.

If you can influence the timing of the order, it is always advisable to first contact the lift manufacturer before hiring the building contractor. The lift manufacturer provides the shaft floor plans, which can be taken into account by the contractor in his drawings.

Once the lift system has been commissioned, no further changes should be made to the building, especially to the building cross sections. For example, changes of the upper edge of the floor can affect the installation of the landing doors on the floor. This is the case if the door cut-out is no longer sufficient when the upper edge of the floor is raised. As a result, the door cut-out must be extended. Likewise, it is not advisable to change the height of the building in the case of a planned hydraulic lift system. This is because once the jack is already in production, it cannot be changed.

When the construction work begins, it is recommended to inform yourself regularly about the progress of the construction work, so that you can take countermeasures at an early stage in case of deviations.

Building Management System

23

This chapter gives you a brief insight into the possibility of implementing a lift system in the building management system.

Lift systems can be permanently monitored with the aid of the building control system. There are various ways of realizing this. They range from the simple monitoring of fault messages to the online display of travel movements in the well. The messages can be displayed on a screen and the data can be further processed using software. It is also possible to send fault messages by email or SMS to one or more recipients.

Since there are many manufacturers and systems on the market, no specific system can be described here. The solutions are offered by manufacturers of lift controls especially for their product as well as by complete providers of facility management solutions where several disciplines can be integrated.

The main difficulty is that such solutions require a suitable interface. An owner of many plants of different disciplines must create a common platform in order to be able to connect all plants via a defined interface. This is the only way to ensure that all signals can be processed. If, for example, EN 627 "Rules for data acquisition and remote monitoring of lifts, escalators and moving walks" is observed, the codes defined in this standard can be transmitted and further processed. In this way, a basis can also be created for other disciplines.

The performance of such monitoring systems ranges from the simple transmission of fault messages to the control of lifts. Shutting down systems or entering a command remotely are possible with such systems. Particularly in lift systems with large travel heights, such a system serves as a support, for example, for passenger rescue. The rescue organization can be informed directly of the location of the car.

Such systems are also useful for statistical purposes. Availabilities can be displayed with exact information about the time when the respective lift was out of operation. The lift utilization can also be displayed. It is thus possible to evaluate which stops are reached most frequently and at what times the systems are used.

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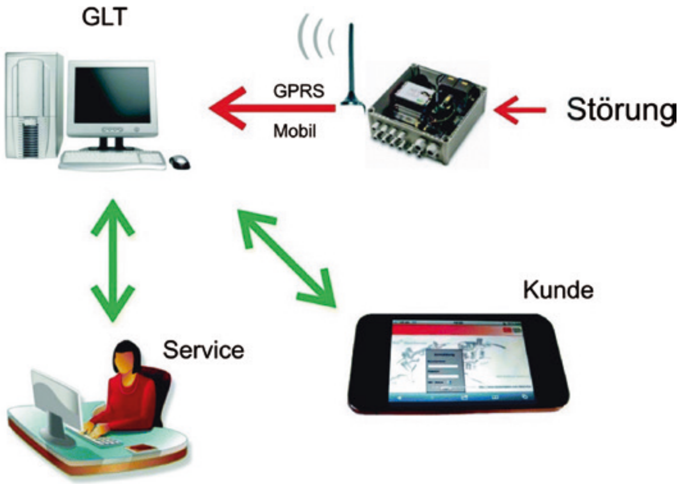

Fig. 23.1 Transmission paths of fault messages. (source: author)

For the transmission one should have a dedicated line. Only then the real-time displays are possible. Furthermore, there is the possibility of setting up online access for defined user groups, which makes it possible to observe events from any location via the Internet.

If no dedicated lines are available on site, GPRS modules can also be used. Here, for example, a SMS is sent when a fault occurs. This can be sent to a master computer, which makes the fault available in a monitoring software. Persons from the service centre, service technicians or the customer can access this data via online access. The following Fig. 23.1 basically shows the transmission paths of such fault messages.

With regard to the topic of condition-based maintenance, many scenarios are possible in the future. For example, wear limits can be determined (remaining service life of components). The data is transmitted to the service control center and evaluated. If the wear limits are reached, the system can even order the components independently or support the ordering process. This ensures that a new component is available before failure and can be replaced in time. This is just one example of many other possibilities that are possible in the future from the author's point of view.

24 Environmental Considerations

This chapter deals with the energy consumption of lift systems as well as the consideration of the lift system in connection with its environment. Energy savings or the reduction of life-cycle costs are becoming increasingly important.

24.1 Energy consumption of a lift system

The energy efficiency of lift systems is playing an increasingly important role. Although the energy consumption of a lift system only accounts for approx. 5% to 10% of the total energy consumption of a building, efforts are being made to develop products that contribute to energy saving. Developments in recent years have therefore shown that more and more drives and systems have been developed that consume less energy. Electric drives have become smaller and more efficient. With a modern drive in combination with a suitable frequency control, large savings can be achieved compared to conventional drives, which only have two speeds without frequency control. When using hydraulic power units with frequency control, energy savings of up to 30% can be achieved compared to a conventional drive without frequency control.

The advantage of these savings is also due to the advanced control technology. The disadvantage of this modern control technology, however, is that compared to conventional relay controls, these have a stand-by consumption that should not be underestimated. The stand-by consumption includes not only the energy consumption of the actual control system, but also the energy consumption of the peripherals. These include the door drive, which is permanently in operation, and the car lighting.

In a study conducted by the Swiss Agency for Energy Efficiency (S.A.F.E) in 2005, performance measurements were carried out on various types of lifts and systems. This involved taking performance measurements during travel. Performance measurements of stand-by operation and auxiliary equipment were

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also carried out. It was found that the stand-by consumption ranges from 30 to 80% of the total energy lift consumption. However, it should be taken into account that the proportion of stand-by consumption in systems with a high number of trips is relative to systems with a low number of trips [1]. Even though the study is already several years old, the core statement is still true today.

Further savings can be achieved in the area of car lighting. Due to architectural considerations, many lift systems have a power consumption of up to 300 W and more for lighting. By switching off the lighting during downtime, energy can be saved here in 24-h operation. This is permitted in EN 81-20 as soon as the landing doors remain closed at the landing. In the case of glass lifts, complete shutdown is less sensible, as most users assume that the system is out of operation when the car is dark. In this case, however, a partial shutdown can be used for a certain saving effect.

Alternatively, the use of LED lighting is an interesting solution. Due to their longevity and very low energy consumption, these lights are being used more and more.

The energy consumption of a lift system can be calculated using the following formula [1]:

$$E_{F,a} = \frac{Z_F \times \ k_1 \times k_2 \times h_{max} \times P_m}{v \times 3600}$$

EF,a	Energy requirement for car movement (trips), in kWh per year
ZF	Number of trips per year
k1	Average load factor (technology factor)
k2	Lifting height factor, average/max. lifting height, = 1 if 2-storey, otherwise 0.5
hmax	Maximum lifting height, between bottom and top stop, in m
Pm	Engine power, in KW
v	Travel speed

Classification of lift systems into energy efficiency classes as for white goods is not permitted for lift systems. At present, it is being clarified what such a classification may look like.

24.2 The Ecological Footprint of a Lift System

If building owners want to carry out building certification, the ecological footprint of all disciplines must be determined. Building certification is used to check the extent to which a building meets the requirements of sustainable construction. The following measures are considered:

- Efficient use of energy, water and other resources
- Protection of the health of the building users and improvement of the productivity of the employees
- Reduction of waste, pollution and environmental degradation

There are various evaluation criteria for the certification of buildings:

- LEED (Leadership in Energy and Environmental Design) from USA
- DGNB (German Sustainable Building Council) from Germany
- BREEAM (Building Research Establishment Environmental Assessment Method) from Great Britain

In order to determine the ecological footprint, so-called EPDs are required. EPD stands for Environmental Product Declaration. To calculate the individual EPD's, so-called PCR, Product Category Rules are required. These rules can be used to calculate one EPD per trade. A PCR for lifts can also be used as an aid to determining an EPD.

A PCR describes the life cycle of a product. It determines the consumption of resources during the manufacture of a product over the life cycle from cradle to grave. The preliminary products or the extraction of raw materials are also taken into account.

The use of PCR's will become increasingly important in the future as more and more buildings have to take into account the aspect of sustainability and the reduction of energy consumption. According to the EPBD (European Performance of Buildings Directive) all new buildings in Europe used by public authorities as owners must comply with this directive. A study carried out in 2018 and 2019 examined the possibility of integrating lift systems into the Eco-Design Directive. The study showed that although lifts could be integrated in this Directive, it was considered more appropriate to group them in the EPBD. The decision on whether this classification should be made does not have to be taken by the European Commission during the creation of this manuscript.

Although the energy consumption of a lift system is low in comparison to the total energy consumption of a building, the industry is trying to follow the trend and further develop energy-efficient products.

Reference

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25 Decommissioning of Lift Systems

In this section you will find some hints for the decommissioning of lift systems. There are situations in which lift systems must be taken out of service. For example, in office buildings that may be empty for several months or even years, lifts are taken out of service to save on maintenance costs and energy consumption. Often the mistake is made that the systems are just shut down and left to their own devices. This is not recommended, because the owner is violating his duty of care.

A lift system that is temporarily not in use should remain in operation if the period is manageable. Care should be taken to ensure that the lift installation does not stop on just one floor, but should be moved temporarily so that the ropes are not subjected to one-sided and abnormal loads. Furthermore, owner checks must be carried out, since nobody can rule out the possibility of the lift being used by unauthorized persons. The remote alarm system with the connection to a control centre must remain in operation. In addition, maintenance is recommended, since even when the well is not in use, it continues to act as a chimney and the system comes into contact with dust. If these impurities are not removed, malfunctions and increased wear and tear of the components may occur.

If a building is empty for a longer period of time, it is advisable to shut down the system properly. To do this, the car is moved to the lowest landing and supported on a scaffold. The ropes are laid down to relieve them and the power supply is disconnected. This definitely prevents unauthorized persons from still being able to use the system. Nevertheless, a regular check should be carried out according to the general condition. It is advisable to check whether the landing doors can be opened or whether the landing doors are permanently closed from the inside. If necessary, this should also be documented.

For hydraulic lift systems it is recommended to remove the oil and then clean the unit. This ensures that the lift is not switched on and used again. All other points should be carried out as described above.

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Historical Facts About Escalators

26

The first escalators, built at the end of the nineteenth century, were basically nothing more than conveyor belts with sloping wooden panels. In 1859, Nathan Ames patented a triangular staircase. In 1892, the American Jesse Reno patented a moving walkway with an endless platform.

However, George A. Wheeler, also an American, is considered the real inventor of the escalator with his patent registered in 1892. This escalator had a handrail that ran with the escalator. Otis later acquired these patents and further developed the escalator.

Due to its design, the escalator quickly gained acceptance in department stores, as it can transport many people within a short time without long waiting times [1].

Reference

1. Lifts and escalators; technology, planning, design, Oliver Bachmann, Verlag Moderne Industrie, 1992

D. Unger, *Lifts and Escalators*, https://doi.org/10.1007/978-3-662-67822-0_26

27 Codes and Standards for Escalators

In this chapter you will find an overview of some directives and standards that are important in the context of escalators. Escalators are subject to different sets of rules than lift systems.

27.1 EN 115-1—Safety Rules for the Construction and Installation of Escalators and Moving Walks

EN 115-1 applies to all new escalators and moving walks. However, escalators that have not been installed under this standard can also be included here. The following descriptions apply to both escalators and moving walks, even if the chapters only refer to escalators.

- The escalator must be fully clad. Balustrades must therefore be provided on both sides.
- Sufficiently dimensioned storage spaces must be available at the entrances and exits of escalators. These are defined as being at least the width of the handrail spacing plus 80 mm with a depth of 2.50 m or twice the width of the handrail spacing plus 80 mm with a depth of 2.00 m.
- Escalator lighting at the entrances and exits must be at least 50 lx, measured on the ground.
- The engine rooms may only be entered by competent persons and must therefore be secured for unauthorised persons. They must be adequately dimensioned in terms of size. The components such as the control system must be set up so that they are accessible so that maintenance personnel can carry out all necessary work. It is important that there is free movement in front of the switchboards or the control unit within the width of the control unit and a depth of 0.80 m.

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- The handrails must run in the same direction as the step band, the speed between the step band and the handrail may only differ by a maximum of + 2%. The construction of the handrails must avoid crushing.
- The steps may only have a maximum height of 0.24 m. The maximum width of the steps shall not exceed 1,10 m and they shall not be less than 0,58 m.
- Combs must be available at the entrances and exits. The combs must have comb segments which do not permanently deform on contact with an object, i.e. return to their original state or break off.
- Escalators may have a maximum angle of inclination of 30°. At a rise of up to 6 m and a rated speed not exceeding 0.5 m/s the escalator may have an angle of inclination of up to 35°.
- The travel speeds of escalators are limited. At an angle of inclination of up to 30° it may be a maximum of 0.75 m/s, up to 35° a maximum of 0.5 m/s. In general, the speed is limited to a maximum of 0.75 m/s according to the standard.
- A braking system must bring the escalator to a safe stop if the mains or control voltage fails. Stopping must also be guaranteed in the event of overspeed. This monitoring device must respond at 1.2 times the rated speed [1].

27.2 EN 115-2 Safety of Escalators and Moving Walks - Rules for Increasing the Safety of Existing Escalators and Moving Walks

This standard deals with escalators and moving walks already in operation. It divides the hazards into different categories and defines corrective actions to bring escalator safety up to the state of the art so that users can use this product safely.

It also divides the risks into low, medium and high risks and indicates corrective measures.

Structure of an Escalator
Figure 27.1

27.3 EN 115-5—Safety of Escalators and Moving Walks—Part 5: Replacement of Existing Escalators/moving Walks in Existing Buildings

This standard is a new standard and currently under development and shall only be used when escalators/moving walks are replaced in existing buildings where structural constraints in an existing building makes the installation of an escalator acc. to EN 115–1 impossible. The following hazards are dealt with in this standard:

- Free height
- Reduced standing area in machinery spaces
- Escalators with more than 35°inclination and 6 m rise
- Reduced horizontal step at lower landing

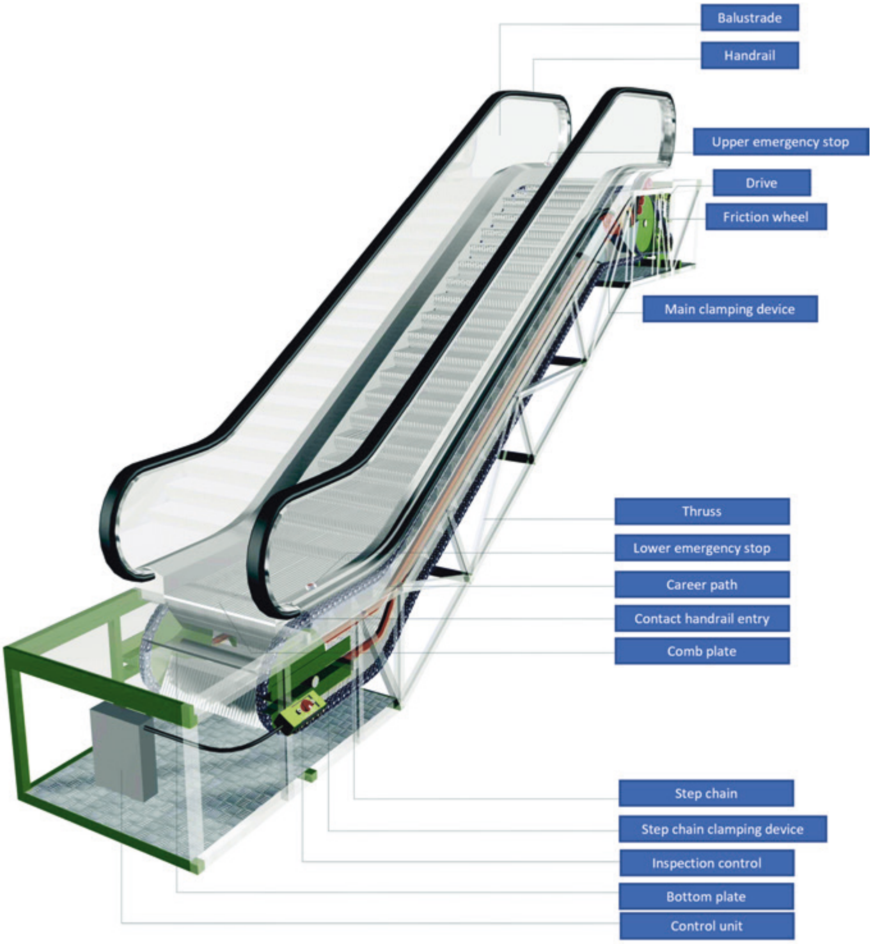

Fig. 27.1 Design of an escalator. (Source: Schindler Deutschland AG & Co. KG, Germany)

The publication of this standard is expected in 2024/2025.

Reference

1. EN 115–1, *Safety of escalators and moving walks - Part 1, Construction and installation*

Escalator Components

28

Chapter 28 deals with the individual escalator components. The individual components of an escalator, like the lift system, make up a functioning escalator. Roughly speaking, an escalator consists of the return station in the lower section, also known as the lower landing, the driving station in the upper section, also known as the upper landing, the truss with the step band, the balustrade and the control system. Figure 28.1 shows a section of the driving station.

28.1 Truss

The truss or also called supporting structure consists of a welded sectional steel construction. The truss serves to accommodate all the components used and forms the housing. It is divided into three parts, the lower section for the return station, the upper section for the driving station and the central section, which is aligned according to the inclination of the escalator.

The truss is designed to absorb the forces and vibrations of the escalator. Support points are created in the building so that the truss with dampers is placed there. This prevents vibrations from being transmitted to the building. The truss can be manufactured in one piece for the complete travel height or in several parts. This is referred to as a multi-part escalator. A multi-part escalator is used when there are no suitable transport facilities in the building and it is not possible to install a complete escalator in one piece.

For outdoor escalators, usually known as escalators in Public Transportation, the truss is additionally galvanized.

D. Unger, *Lifts and Escalators*, https://doi.org/10.1007/978-3-662-67822-0_28

Fig. 28.1 Escalator tower (blue) with handrail drive wheel (red) (Source: Schindler Deutschland AG & Co. KG, Germany)

28.2 Step Band System

The step band system is built into the escalator truss and consists essentially of the step guide system, the step chain and the individual steps (pallets for moving walks). To make it easier to distinguish the moving step band from the fixed comb plate, lighting of the step band is provided at the upper and lower landing points, as shown in Fig. 28.2. Often comb segments with yellow markings are also used. This makes it easier to distinguish the moving part from the fixed part.

Outdoor escalatots for public transportation are equipped with step band heating. These are located near the upper and lower landing to prevent the formation of ice on the steps during the winter months. Depending on the length of the escalator, heaters in the form of heating ribs are also installed in the middle of the step band.

28.2.1 Guiding of Steps

The guiding of steps guides the steps through the escalator. It consists of rails that run laterally inside the truss. They are curved at the top and bottom. The rollers attached to the steps are located in these rails. The steps run at the top under

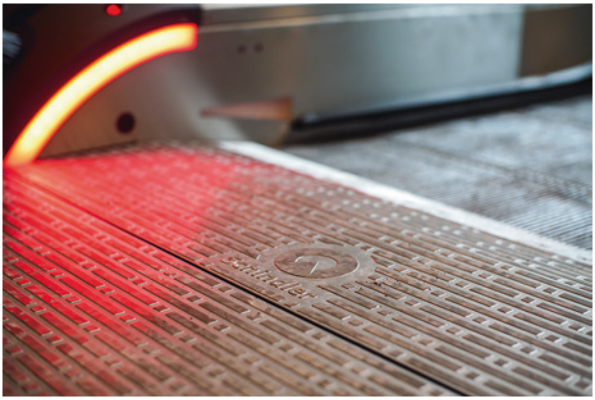

Fig. 28.2 **Lighting of the** Step band. (Source: Schindler Deutschland AG & Co. KG, Germany)

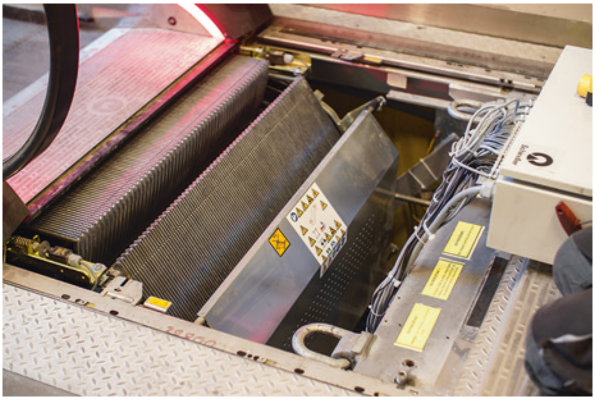

Fig. 28.3 Change of steps within the return station. (Source: Schindler Deutschland AG & Co. KG, Germany)

the comb plates into the interior of the escalator. In the driving station there are curved rails that bring the steps to the underside of the escalator and carry them to the return station where they reappear underneath the comb plates (endless loop). Figure 28.3 shows the change of steps within the return station.

28.2.2 Step Chain

The step chain is located inside the step band system and is arranged around the inside of the escalator. It transports the steps. The step chain is driven by the main drive chain, which is directly connected to the drive. In escalators for public transportation, the step chain is stronger. Care must be taken to ensure sufficient

Fig. 28.4 Step in installed condition. (source: author)

lubrication of the step chain. This should be observed during maintenance. The frequency of lubrication depends on environmental influences and the operating hours. Please refer to the manufacturer's instructions to find out which lubricant may be used. Figure 28.4 shows a step chain in installed condition.

However, there are also systems that automatically lubricate the step chain. Here, lubricating cartridges are retrofitted above the step chain. The step chain is lubricated via a scraper that touches the step chain. This ensures consistent lubrication and has the advantage of preventing excessive lubrication from dirtying the escalator, as over-lubrication causes excess lubricant to fall off the chain and contaminate the escalator interior. The lubrication cartridges make lubrication independent of maintenance cycles. The lubrication cartridges are available in different sizes and can be set to require a pre-defined time (3, 4 or 6 months) before they are used up.

28.2.3 Steps/pallets

The characteristics of the steps described in this chapter also apply to pallets installed in moving walks. The steps are made of die-cast aluminium or steel. Each escalator manufacturer has steps specially designed for its escalators which cannot be installed in other escalators from other manufacturers due to their design.

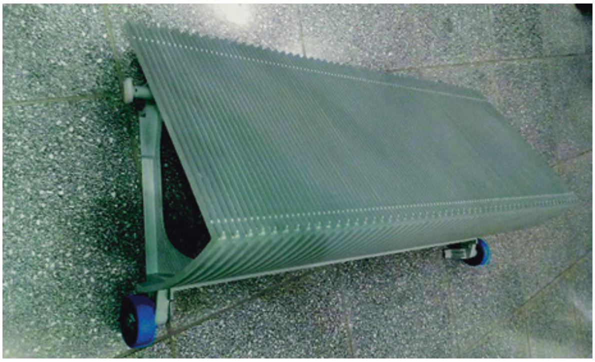

Fig. 28.5 Escalator step. (source: author)

The forces and strengths of these steps are regulated in EN 115-1. On the escalator steps, as shown in Fig. 28.5, there are rollers at the front which are suspended in running rails in the step band system. The rear side is hooked into a bar connected to the step chain. The steps are guided laterally.

The steps are dismantled in the return station. First of all, the maintenance step must be removed. The maintenance steps have split axes that can be moved. The maintenance step is moved to the return station using the inspection control. In the return station there is an opening in the rail system from which the maintenance step can be removed. After dismantling the maintenance step, the remaining steps can removed. When mounting the steps, the reverse order must be observed. To maintain an even distance from the balustrade, there are sliding blocks or other devices on the sides above the return station to bring the steps into the correct position. For this purpose, the step band must be moved after installation so that the installed step can pass the sliding blocks or the device and thus come into the correct position.

▶ When installing the steps, special attention must be paid to the correct position of the steps. The installation equipment can only compensate for small deviations. If the step is far outside the installation area, the step may get caught on the balustrade when the step band is moved and be damaged.

There are step grooves on the steps. These step grooves have a height of 10 mm to 11 mm. The step grooves form the surface of the step tread for the users. Due to wear, these step grooves may be worn down to 10 mm (minimum dimension of EN 115-1). If this dimension is reached, the step must be replaced. It is not uncommon for the grooves to be ground down by external influences such as lost screws or stones. The reason for this is that these objects get stuck on the comb segments and grind the surrounding steps at this point. It is not always certain that the clamping force of the object to trigger the comb plate contact is sufficient to shut down the escalator. It is also not ensured that the foreign objects are transported over the comb plates to the landing point.

▶ It is imperative that the information on the comb settings given in the manufacturer's maintenance instructions be observed. The depth of engagement of the combs in the steps should prevent foreign bodies from getting stuck between the teeth and the steps. The objects should be transported over the comb plates. The risk of entrapment can be minimized by correct settings.

When replacing the steps, make sure that the correct steps are used. Due to the different types of escalators produced by the manufacturers, it is possible that the steps are very similar and only differ in a few points. It is not possible to exchange the steps of different escalator types or manufacturers. In addition, no mechanical modifications must be made to the steps, otherwise the step would lose its approval.

The above mentioned maintenance step can also accommodate lubrication cartridges. Lubricating cartridges are small containers filled with the appropriate lubricant, as already mentioned in Sect. 28.2.2. The flow rate can be adjusted by a setting at the top of the cartridge and a propellant charge transfers this lubricant to the brushes, which then lubricate the sliding blocks. This allows permanent lubrication for several months.

The lubrication cartridges can also be attached to other parts of the escalator, for example to provide permanent lubrication of the chains. This can be provided on escalators that do not have a central lubrication unit. Figure 28.6 shows a lubrication cartridge fitted to the bottom of the step.

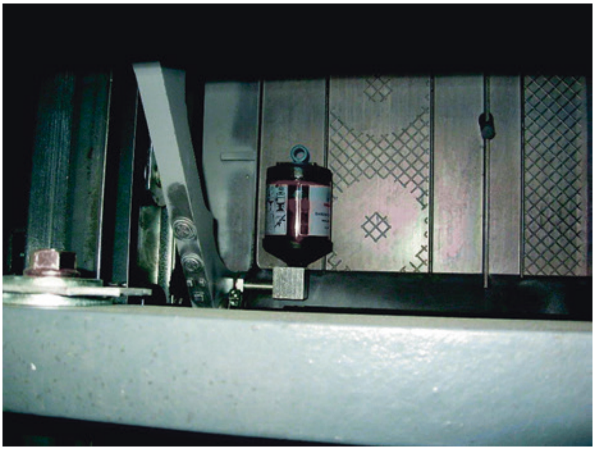

Fig. 28.6 Lubrication cartridge. (source: author)

Fig. 28.7 Steps with marking. (source: author)

In order to be able to see the steps better, steps with a yellow marking can also be used, as shown in Fig. 28.7.

28.3 Return Station

The return station is located at the bottom of the escalator, Fig. 28.8 shows a return station. At this point the step band changes direction. The return station is accessible for maintenance purposes. By lifting cover plate, service personnel can enter the return station via a descent device. In the return station there is a power socket and a maintenance lamp to illuminate the working area well. Furthermore, the control unit can also be located there, which can be lifted out of the return station for inspection purposes. The inspection control is connected to this control unit to move the escalator. When the inspection control is connected, all operations outside the escalator are bypassed, i.e. the escalator is controlled only via the inspection control. Figure 28.9 shows an inspection control system.

The return station is a part of the lower landing point as shown in Fig. 28.10. If steps need to be removed for maintenance or repair purposes, they are removed in the return station. To do this, a safety plate must first be removed. This safety plate is located directly in front of the step band and prevents service technicians from coming into contact with the circulating step band while in the return station.

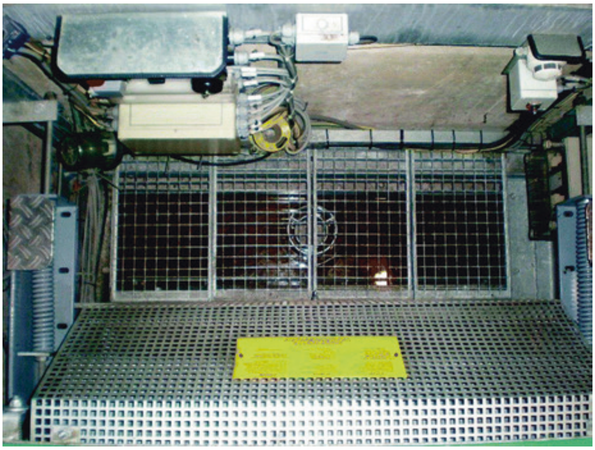

Fig. 28.8 Reversing station. (source: author)

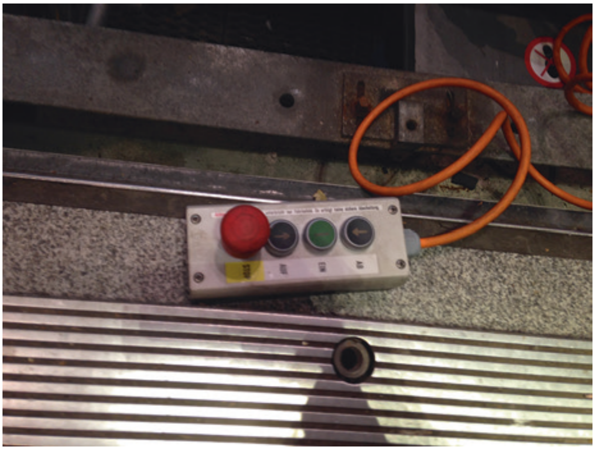

Fig. 28.9 Inspection control with connection cable. (source: Dr. Christoph Wetzel, BGHW Mannheim, Germany)

28.4 Drive Station

The drive station is located in the upper part of the escalator. Just like the return station, the step band changes direction there. The drive station, as the name suggests, is where the drive is located. The drive station can be opened for maintenance in the same way as the return station. There are exceptions here too, so that you will also find escalators where the drive is located in the middle of the step

Fig. 28.10 View of lower landing site with reversing station. (source: author)

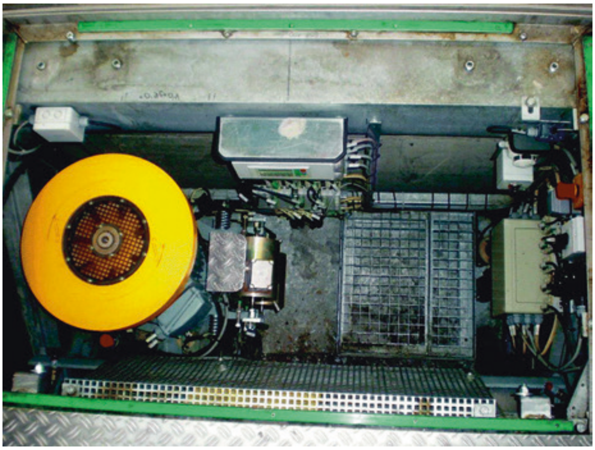

Fig. 28.11 Drive station, left in the picture the drive with the handwheel (yellow). (source: author)

band. These escalators require a larger opening of the step band for maintenance purposes. In the drive station there is also the possibility to connect the inspection control. This allows the escalator to be controlled from both sides. This is also necessary from a safety point of view. Some national regulation requires to travel alone at the escalator. For this reason, from halfway up the escalator, the service personnel must change the inspection control and thus operate the escalator from the other station. Figure 28.11 shows a drive station.

28.5 Balustrade

Balustrade is the term used to describe the side panels of the escalator. It serves as a fall protection for the users. The balustrade can be made of various materials. The most commonly used are stainless steel sheets, no less plastic-coated sheets. The invisible part of the handrail and the drive technology of the handrail are located under the lower inner decking. The balustrade sheets are divided into individual sections that can be removed individually. This allows access to the inside of the side escalator for cleaning or maintenance.

At the entry and exit points of the escalator there are emergency stop switches on the balustrades in the lower section and a control unit to switch the escalator on and off.

For effects, escalators are also equipped with balustrade lighting. In this case the interior panel is made of laminated safety glass. The lighting consists of fluorescent lamps, which are hidden behind this glass balustrade and illuminate the entire area. If the lamps are changed, the glass interior panels must be removed. Due to the weight of this glass modules this work requires the presence of two service technicians. LED lights are used on modern escalators. Due to their properties, these have a longer service life and lower energy consumption.

28.5.1 Skirt Deflectors

On the step band, left and right, directly above the steps are the Skirt deflectors, also called brushes. These deflectors serve as protection against the entry of shoes or other objects into the side area of the steps. Shoe pulling in is a common cause of escalator accidents. Most commonly affected are rubber boots or shoes with a rubber sole. The friction of the shoes against the balustrade generates heat which softens the shoe at the point of contact and causes the shoe to be pulled in.

The brushes consist of individual brush pieces. The brushes are bent for the upper and lower area. Figure 28.12 shows a part of a step band with the brushes.

28.6 Handrail

The handrail runs all the way around the top of the balustrade. Its purpose is to allow users to hold on to it while driving. The handrail is attached endlessly in the escalator and runs with the step in the same direction and speed. According to EN 115-1, the speed of the handrail may not deviate by more than + 2%.

Handrails consist of several layers of fabric in which a rubberised steel insert is incorporated. Rubber is used as the surface, which forms the end of the handrail. The upper side of the handrail is called the back, the lower part the lips.

There are two types of handrail, the flat handrail as shown in Fig. 28.13 and the wedge handrail, as shown in Fig. 28.14. This wedge prevents the handrail

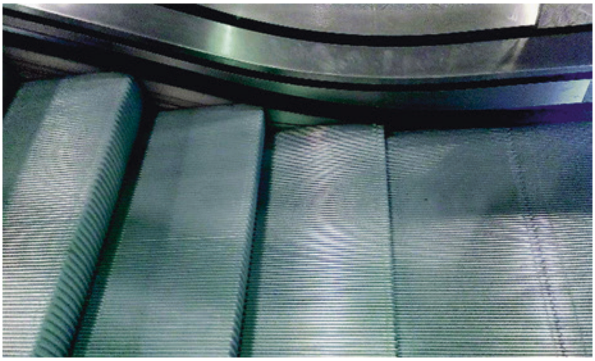

Fig. 28.12 Step band with lateral deflectors (brushes). (source: author)

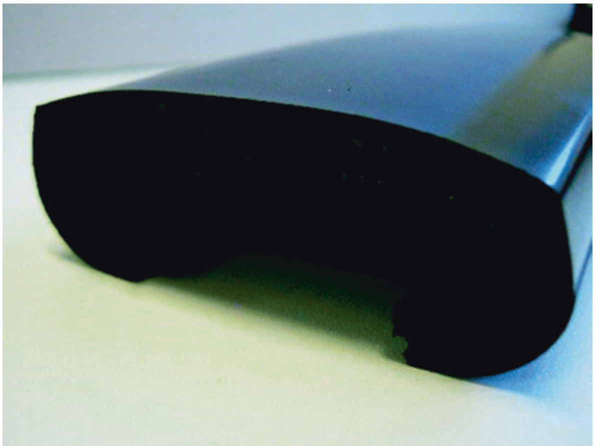

Fig. 28.13 Flat handrail. (source: Boettcher Systems, Gelsdorf, Germany)

from slipping off the handrail guide rail and is mainly used in escalators for public transport.

The handrails are produced in different widths (depending on the manufacturer). Table 28.1 shows the different handrail widths.

Figures 28.15 and 28.16 show technical drawings with the dimensions of a wedge and a flat handrail.

The handrail is driven by the handrail drive. The handrail drive is in turn driven by the main drive, i.e. there is no separate drive for the handrail. A handrail tensioning station is located in the escalator to tension the handrail. The handrail tensioning station allows the handrail tensioning degree and speed to be adjusted by changing the tension.

Fig. 28.14 Wedge handrail. (Source: Boettcher Systems, Gelsdorf, Germany)

Tab. 28.1 Examples of handrail widths from some manufacturers (this list is not exhaustive)

Manufacturer	Handrail width/mm
Otis, Thyssen	75
Kone, Thyssen	80
Schindler, Fujitec	82
Kone, Thyssen	89

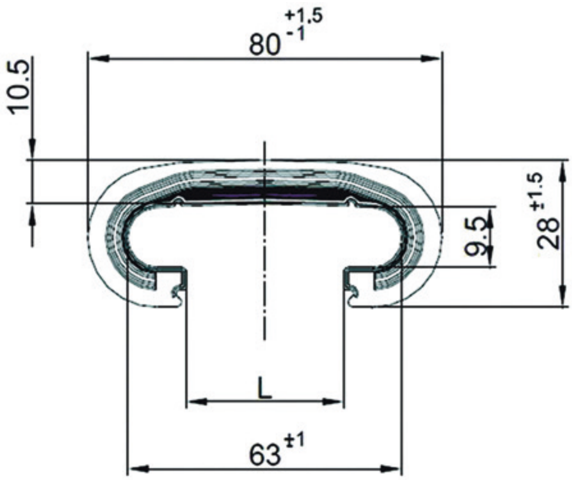

Fig. 28.15 Drawing of a flat handrail, 80 mm wide. (Source: Boettcher Systems, Gelsdorf, Germany)

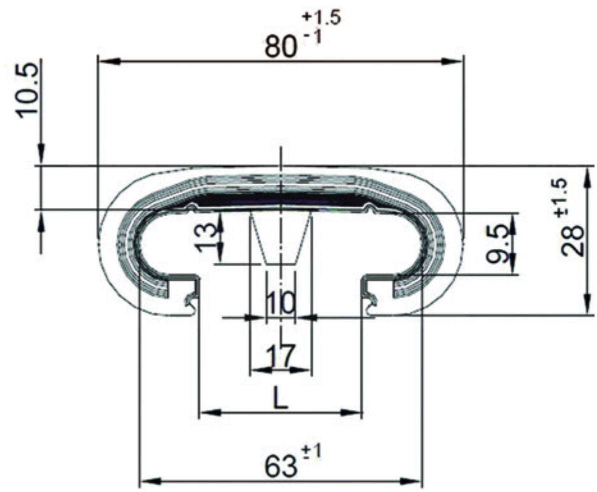

Fig. 28.16 Drawing of a wedge handrail, 80 mm wide. (Source: Boettcher Systems, Gelsdorf, Germany)

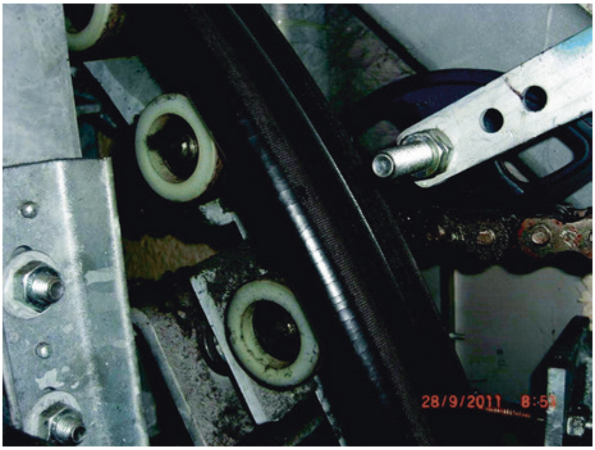

Fig. 28.17 Handrail guide behind the lower inner decking (source: author)

▶ If handrails are too tight, they can be damaged. This is also partly visible by the fact that grinding marks appear on the top of the handrails. These marks are caused by the pressure rollers of the tensioning station.

Figure 28.17 shows a section of the handrail guide inside the escalator.

Due to its shape, the wedge handrail is increasingly used in escalators for public transport, as it does not slip easily compared to the flat handrail. This is a good

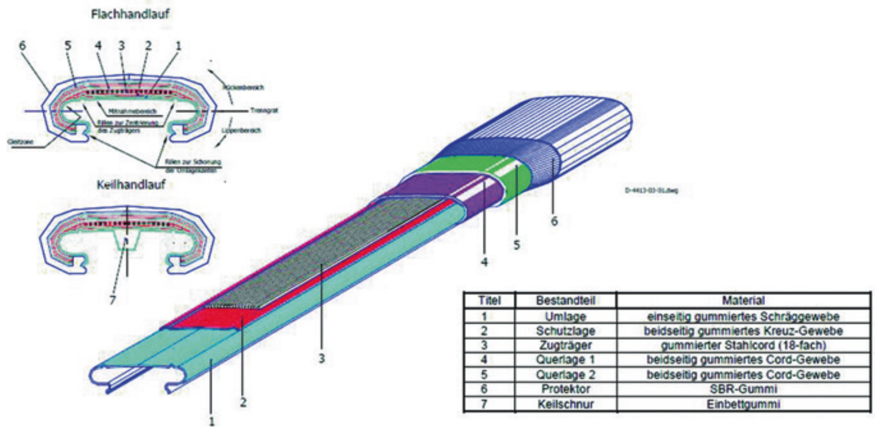

Fig. 28.18 Construction of a TechGrip handrail by Boettcher. (Source: Boettcher Systems, Gelsdorf, Germany)

solution, especially for escalators in public areas where vandalism is common. Figure 28.18 shows the basic structure of a handrail.

As already described, handrails are endlessly located in the escalator. If a handrail needs to be replaced, it can be obtained from the manufacturer in different variations. It is also possible to purchase it as an endless version. This means that the handrail is manufactured to the ordered length and vulcanized in the factory. Here, the length of the handrail must be known exactly. The assembly on site at the escalator is much more complex with this version, because the complete balustrade plates have to be removed. However, there is no need to vulcanise the handrail on site.

Another possibility is to cover the handrail open on one side and prepared for vulcanization as shown in Fig. 28.19. In this version, the handrail can be inserted on one side of the escalator until it is fully retracted. The complete removal of the balustrade is not necessary. In this type of assembly, the non-prepared end of the handrail (which has already been inserted into the escalator) must be adjusted in length to the opposite end piece and vulcanised together, one above the other. The counterpart must be cut out of the handrail as shown in Fig. 28.20 to fit the shape of the prepared end. During vulcanization, both ends are placed in the vulcanization mould, which works on the principle of a sandwich toaster. There are two pieces of metal that are heated and the two ends fuse together.

The third possibility is the vulcanization of handrails where both ends have already been prepared. The handrail is inserted into the escalator as described above. Figures 28.21 and 28.22 show a vulcanization mould.

The above mentioned installation work requires a lot of experience and skill. For this reason, these activities are only carried out at the specialist companies by employees who either perform vulcanisation as their main occupation or for the most part. Great care must be taken during this work, as a poorly vulcanised handrail can reopen at the vulcanisation point and the handrail can tear.

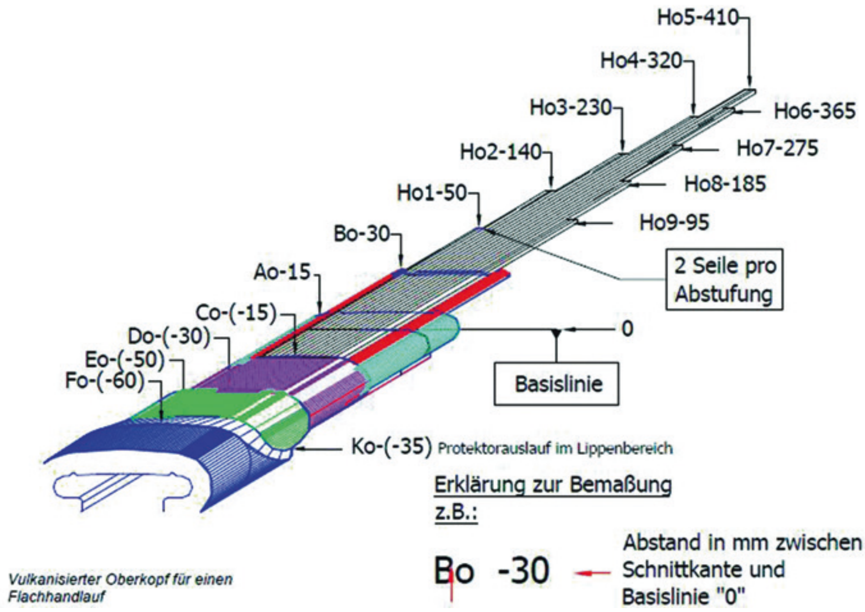

Fig. 28.19 Prepared handrail for vulcanization, counterpart to Fig. 19.20. (Source: Boettcher Systems, Gelsdorf, Germany)

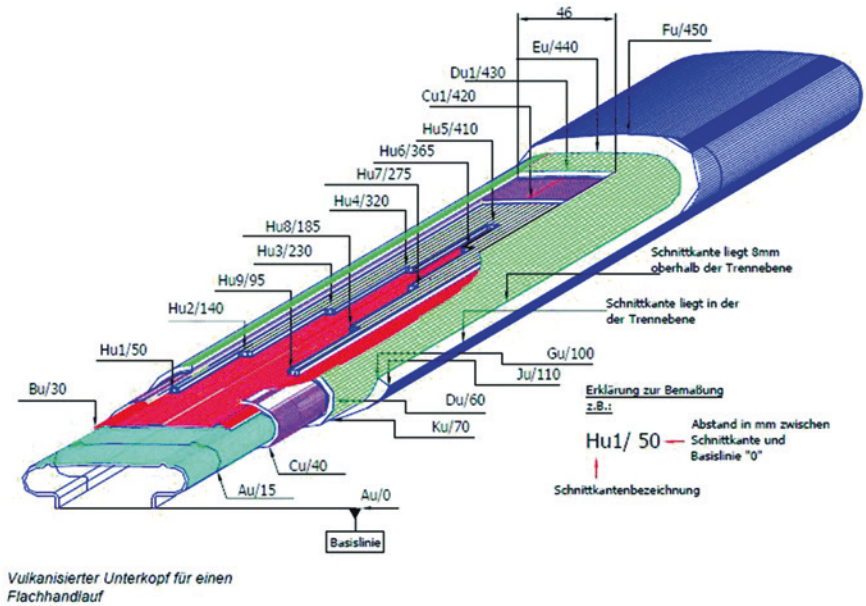

Fig. 28.20 Handrail prepared for vulcanization. (source: Boettcher Systems, Gelsdorf, Germany)

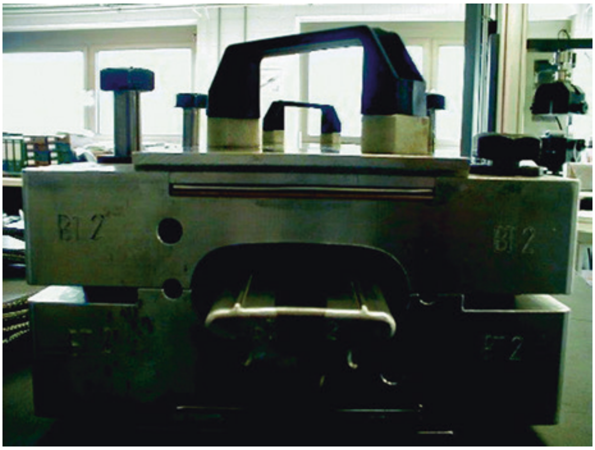

Fig. 28.21 Vulcanisation mould. (Source: Boettcher Systems, Gelsdorf, Germany)

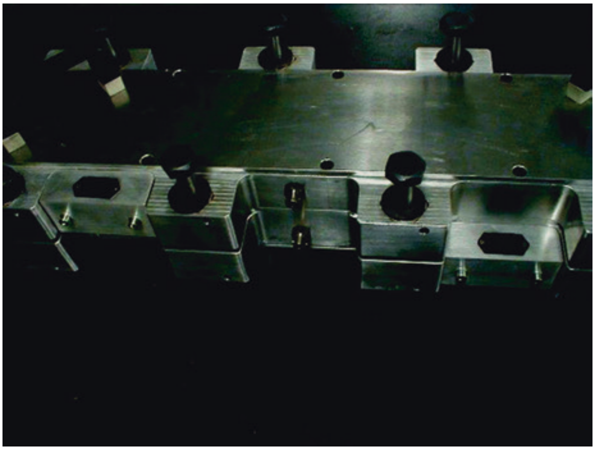

Fig. 28.22 Vulcanisation mould. (Source: Boettcher Systems, Gelsdorf, Germany)

Handrails are replaced every 4–7 years, depending on wear and tear. However, wilful destruction can greatly reduce the service life of handrails. If the handrail is cut into, the strong pull of the handrail can cause a small damage within only a few weeks, leading to the complete tearing of the handrail and thus to the failure of the escalator. It is therefore important that such damage is detected early and repaired quickly. With vulcanization, a damaged area can be repaired without having to completely replace the handrail. The damage can be detected during weekly operator checks, for example.

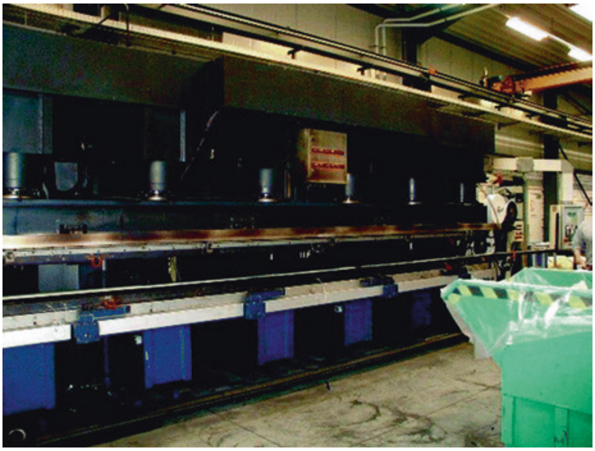

Fig. 28.23 Production facility. (source: Boettcher Systems, Gelsdorf, Germany)

Handrails are built up by several layers of fabric. The rubberized steel inlay is worked into the interior. After all layers have been built up, the raw handrail is put into a mould and shaped under pressure and high temperature.

Figure 28.23 shows a part of the production facility of a handrail at Boettcher Systems in Grafschaft-Gelsdorf, Germany. Since the handrails are exposed to high loads, they are subjected to a test, whereby various alternating bends are performed here. These tests are a part of quality assurance. Figure 28.24 shows a test facility.

28.7 Drive

A motor with a gearbox together form the drive. The drive consists of a three-phase motor with a helical gear unit. Depending on the delivery head, drives with outputs of up to 15 KW or more are in use. The drive is usually located in the drive station, which is located in the upper part of the escalator.

The main drive shaft is attached to the drive, which drives the step band via a gear wheel. Alternatively, instead of a chain, there is also a belt (depending on the manufacturer). Furthermore with this drive the handrail is driven via the handrail drive chain.

Normally there is only one drive in the escalator. For high rises, two drives are also used, as shown in Fig. 28.25.

The drive is mounted on a rail so that the chain tension can be adjusted. With the drives, it is important to ensure that the gear oil is regularly checked for filling level. The oil change intervals can be found in the manufacturer's instructions. The type of oil to be used is also specified there.

Fig. 28.24 Test facility for handrails. (Source: Boettcher Systems, Gelsdorf, Germany)

A handwheel is located at the top end of the actuator. This can be used for fine adjustment of the step band during maintenance or repair work.

28.8 Comb Plate with Comb Segments

The comb plate with the comb segments (combs), as shown in Fig. 28.26, is located at the beginning as well as at the end of the step band at the landing points and is attached in a movable manner. When the steps below the comb segments enter, the steps disappear inside the escalator and then change direction at the return station. The comb segments have the task of catching larger objects and thus protecting the escalator from major damage. The comb segments are arranged so that the grooves of the steps/pallets move into the spaces between the comb segments, the teeth.

▶ The dimension from the upper edge of the groove to the lower edge of the comb segment is described in EN 115-1 and must always be checked and, if necessary, adjusted during maintenance. If this dimension is observed, the risk of objects being drawn in is minimised.

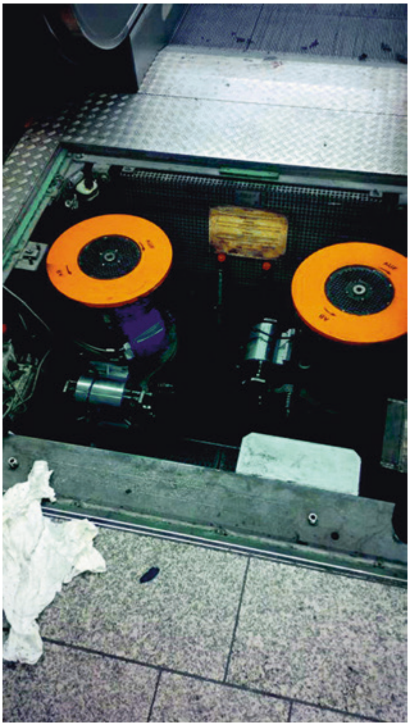

Fig. 28.25 Drive unit consisting of two motors. (source: author)

Fig. 28.26 Comb plate with comb segments at the lower landing station. (source: author)

The comb segments are available in three different versions. Firstly for the middle area of the comb plate, as well as for the left and right side with a built-in edge.

▶ When replacing the comb segments, make sure that the manufacturer's instructions are followed. They may contain information on the torques for fastening the comb segments (manufacturer-dependent). During maintenance, the bearing surfaces must be regularly checked for corrosion and cleaned if necessary. The manufacturer's instructions must also be observed here.

The teeth of the combs are designed in such a way that they either break off or bend when a foreign body hits them and then return to their original position.

The comb plates are movably arranged, i.e. if objects get wedged on the comb segments, the comb plate moves in horizontal direction if the object can build up sufficiently large forces. When a sufficiently large force is applied, the displacement actuates the horizontal comb plate switch, which brings the escalator to a standstill. If the comb plate moves in a vertical direction, the vertical comb plate switch is moved, which also stops the escalator.

In some cases, there is information in the manufacturer's instructions about the settings of the release forces (manufacturer-dependent). There are no normative specifications here.

Figure 28.27 shows the possibilities for attaching the comb segments to the comb plate. The comb segments are attached to the comb plate with screws. The comb plate is prepared with recesses so that the segments can be inserted directly into it. Once the escalator has been shut down by the horizontal or vertical comb plate switch, it can only be put back into operation by a competent person, as these faults are interlocked faults. In the case of a locked fault, the escalator cannot be put back into operation by a control column, which is installed in front of the escalator, but must be put back into operation by unlocking the fault in the control. Locked faults are used to protect the escalator. The competent person can interpret the information on the control system and decide what the next steps should be. This ensures that there are no misinterpretations and consequential damage to the escalator can be excluded.

28.9 Safety Circuit

Like a lift system, an escalator also has a safety circuit. Monitoring switches are installed in this safety circuit which, in the event of a fault, put the escalator out of operation.

28.9.1 Comb Plate Shut-Off (Horizontal, Vertical)

The comb plate shut-off can be done in horizontal or vertical direction. The purpose of this shut-off device is to protect the steps from damage caused by the inclusion of a foreign body. If, for example, a screw becomes jammed, either the comb segment is pushed upwards and the vertical shut-off is activated. If the comb

Fig. 28.27 Possibility of attaching the combs to the comb plate. (Source: author)

segment is pushed back, the horizontal cut-off is activated. When this function is activated, the escalator stops automatically and the system is locked. This ensures that if an attempt is made to restart the escalator from the control column without correcting the fault, it will not be possible to start the escalator.

This switch-off prevents objects from grinding off the complete step band at the inclusion point. This is because by grinding the step grooves below the required tolerance height, the step is no longer usable and must be replaced with such a damage pattern. The prerequisite for this, however, is that the force generated by this object during jamming is greater than the release force.

▶ The triggering force of the comb plate switches is partly specified in the operating instructions of the escalator manufacturers. There the maximum permissible force is specified which must not be exceeded. The settings of the tripping forces must be checked during regular maintenance.

There are now also repair procedures for escalator steps. This means that the complete step does not have to be replaced every time there is damage, but can be repaired. There are two known methods for this on the market. Welding a new groove onto a removed step and repairing a groove with plastic. Both methods generally require the steps to have the strength specified in EN115-1 after repair. Furthermore, the step must not have deformed after the repair. These procedures cannot be carried out on the steps indefinitely. According to the author's experience, the steps are usually only reconditioned/repaired once.

28.9.2 Step Break Contact

The step break contact monitors the steps inside the escalator. It is present in both the return and drive stations. In the event of a step break, the contact is activated by the lowering of the step and puts the escalator out of service. Here too, the system is locked and can only be put back into operation by a competent person. The step break contact is also triggered if the steps are deformed or tilted.

28.9.3 Handrail Insertion Contact

The handrail insertion contact is located at the entry and exit point at the bottom of the balustrade. This contact is located at the point where the handrail enters the interior of the escalator. The contact is triggered if the handrail is torn or if there are objects on the handrail or if they are jammed in the entry area. Figure 28.28 shows a handrail entry point.

28.9.4 Handrail Chain Contact

The handrail chain contact monitors the tension of the handrail chain. If the tension is insufficient or if it tears, this contact triggers. The escalator is then put out of service and locked. The fault can only be reset by qualified personnel.

Fig. 28.28 Handrail insertion at the landing site below the balustrade. (source: author)

28.9.5 Broken Chain Contact

The broken chain contact monitors the tension of the drive chain. If there is no tension or the chain is missing after a break, this contact triggers and puts the escalator out of service. This interlocked fault can only be rectified by qualified personnel.

28.9.6 Cover Contact

The cover contact is located below the cover plate covering the return or drive station (upper and lower landing point). This contact opens the safety circuit when the cover plate is opened and shuts down the escalator. This device prevents the step band from moving when entering the return/drive station and is intended to protect service personnel from injury.

28.9.7 Speed Monitoring

The speed monitor monitors the speed of the drive. If the speed is exceeded, the drive is put out of operation. Furthermore the starting of the drive is monitored. This is realized by an initiator, which is mounted below the flywheel. Depending on the manufacturer, the speed can also be monitored in a different way.

28.10 Control Unit

The control unit is located in the return station and regulates the operation of the escalator. The safety circuit is also connected here. It is also possible to locate the control unit outside the escalator in a separate machine room or niche. In any case, it must be ensured that only qualified personnel have access to the control unit.

The control unit consists of a main circuit with 230 V/400 V AC and a control circuit with 24 V/48 V DC. In older escalators the control circuit consists of a relay circuit. More modern escalator controls have a PLC (programmable logic controller) or microprocessor. Figure 28.29 shows an escalator control cabinet.

The communication between the periphery and the controller is done via bus systems. To start the escalator, the control system in modern escalators is equipped with a frequency converter. If a machine room is available, this is located directly next to the control cabinet. In escalators without a machine room, the frequency converter is located in the return station. The starting procedure on older escalators is realized with a star-delta connection or a soft start device.

The escalator can optionally be equipped with a standby circuit. This means that in the event of an unlocked fault on the escalator or if the emergency stop is activated, the escalator will return to stand-by after a defined time.

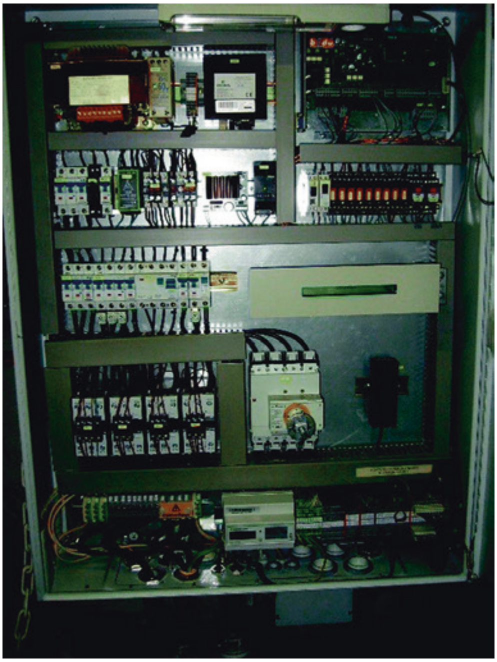

Fig. 28.29 Control cabinet of an escalator installed in the engine room. (source: author)

This means that light curtains or light sensors are used to check whether there are any people on the escalator. The light sensors are located above the step band inside the lower inner decking. If no person is detected on the escalator within a pre-defined time and the escalator is not locked, the escalator will resume moving the step band if a person enters the escalator after the set time has elapsed. This is to prevent the escalator from moving if there are people on the step band.

28.11 Brakes

The escalator is fitted with a service brake on the drive, which must stop the escalator if an emergency stop is activated or if the safety circuit is activated. The brake can be designed as a band brake or as a disc brake with a dual circuit system. The brakes must be checked for proper condition and adjustment during each maintenance operation. The air gap is important, because if the air gap is set too large, the brake is not fully effective.

For the recurring tests on escalators, the German VdTÜV bulletin states that the braking system must be checked for effectiveness. This test must be carried out every two years with a test load. As a rule, weights are placed on the step band to obtain the necessary mass. Alternatively, the brake can also be tested using the envelope curve method.

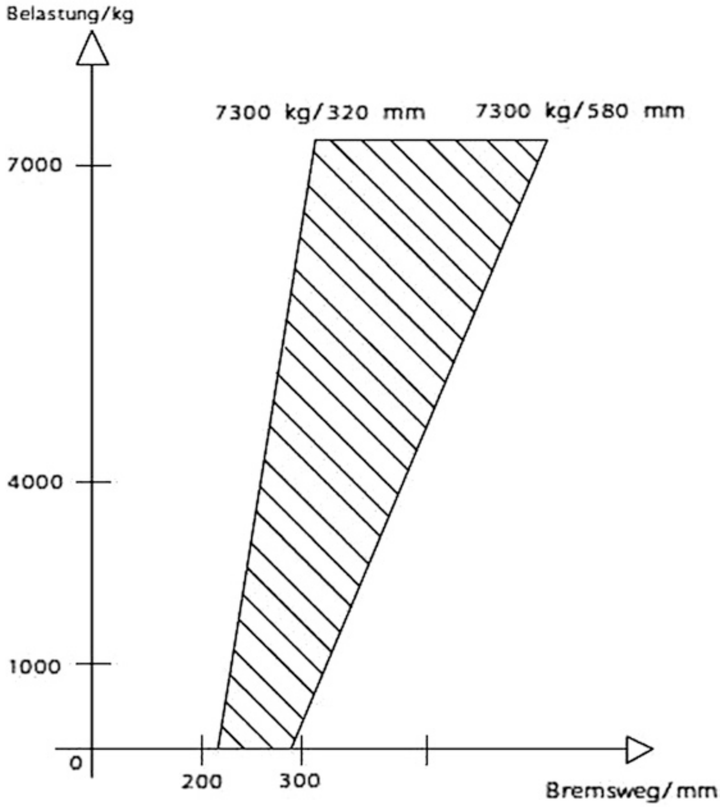

Fig. 28.30 Envelope curve

In the envelope curve method, combinations of load and braking distance are shown. A defined load value is assigned a defined braking range within which the escalator must come to a stop.

Usually the braking distance is adjusted when the vehicle is running empty. In this case, the stopping distance for empty runs must be set between 220 and 280 mm according to the diagram (envelope curve) in Fig. 28.30. For a load of 7300 kg, the stopping distance must be adjusted between 320 and 580 mm. The envelope curve is determined by the manufacturer and must be recorded for each escalator.

Key:

Belastung = load

Bremsweg = stopping distance

Some escalator types have a safety brake in addition to the service brake. However, this is sometimes only available as an option or if other regulations require it. The safety brake is activated, for example, in the event of a step or chain breakage or power failure.

28.12 Chains

The chains in an escalator play an important role. There are different types of chains that are present in an escalator. The chains in an escalator include the main drive chain, the step band chain and the handrail drive chain. Figure 28.31 shows a step band chain.

Tensioning devices are provided at various points on the escalator to tension the chains. Figure 28.32 shows an example of how the individual chains interact in an escalator. The details may vary between manufacturers and shows only the principle.

Sufficient lubrication is important for the chains. With low-maintenance chains, lubrication can be carried out at longer intervals. During maintenance, lubrication is carried out by the service technician. It is applied by hand or, as described

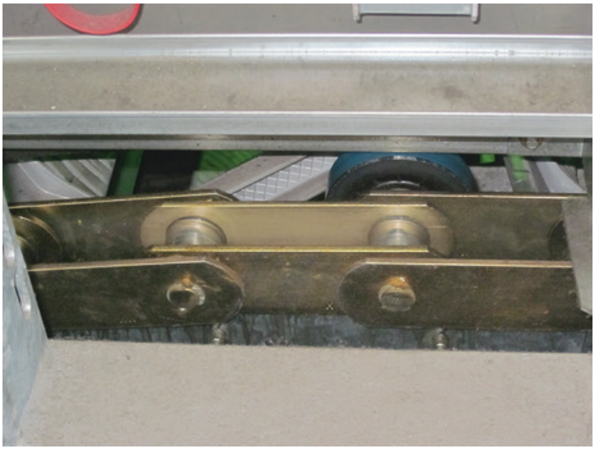

Fig. 28.31 Step band chain. (source: author)

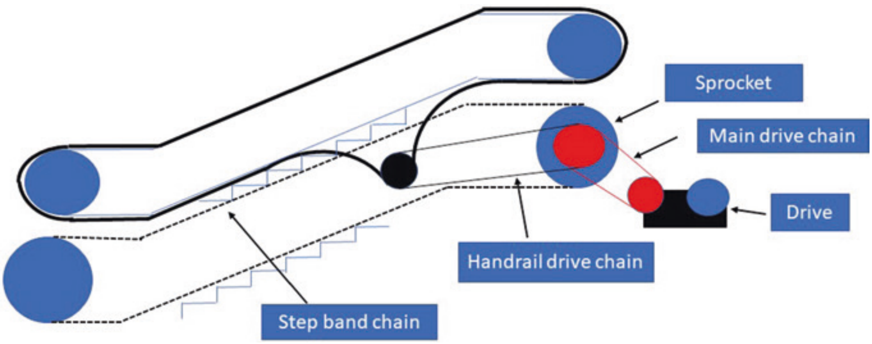

Fig. 28.32 Representation of the chains, in principle. (Source: Author)

in Sect. 28.2.2, by means of a grease cartridge which then lubricates the chains evenly over several months.

Below are some examples of chains:

Main drive chain:	The main drive chain connects the main drive with the main drive wheel
Step band chain:	The step band chain connects the main drive wheel with the step band
Handrail drive chain:	The handrail drive chain connects the main drive wheel with the handrail drive wheel

Escalators for public transport often have a central lubrication system. The central lubrication is located in the drive station and automatically lubricates the drive, handrail drive and step band drive chain. At regular intervals, preferably during maintenance, this unit must be checked and filled as necessary.

28.13 Display Units

At the landing point below the balustrade in the base area there are control elements. The controls allow the escalator to be switched on or off using a key switch. The direction of travel can also be selected on the control element. There is also an emergency stop button and a plain text display for information. Depending on the manufacturer, this plain text display is also only available as an option. Instead of the control on the balustrade, a control column can also be mounted next to the escalator.

The direction indicator shows the direction of travel of the escalator. This can be displayed either as a green arrow or a red one-way street symbol (red circle with white bars). When the user sees the green arrow, he or she can use the escalator as it is operating in his or her direction of travel. If the user sees the one-way street symbol, the escalator is moving in the opposite direction, the escalator cannot be used at that point. Instead of the green arrow, the release can also be

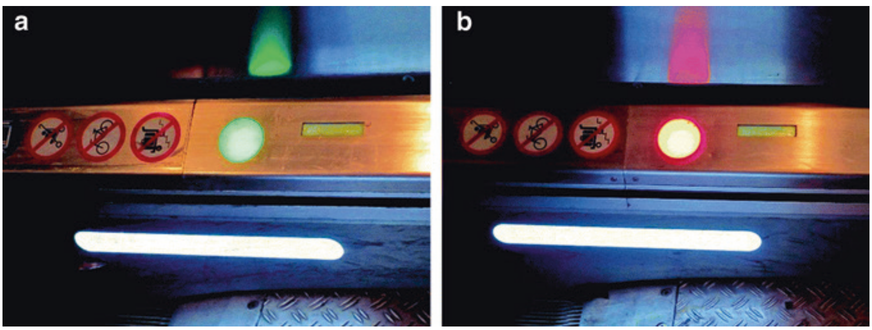

Fig. 28.33 **a** and **b** Direction indicator in green, escalator can be used in the direction of travel. Red light, escalator cannot be used as it runs in the opposite direction. (source: author)

Fig. 28.34 Direction indicators attached as stickers to the balustrades. (source: author)

indicated by a green light. A red light can be used instead of the one-way street symbol. Figure 28.33a, b shows the direction indicators using green and red lights.

Figure 28.34 shows an example of how the direction indicators are implemented on escalators in other countries. In this example the symbols are glued to the balustrades.

29 Escalator Types and Their Mode of Operation

The different types of escalators are discussed here. There are two types of escalator, the department store escalator and the escalator for public transport. Escalators are available with an inclination of 30° up to 35°. There are also moving walks.

29.1 Department Store Escalator

The department store escalator is used inside buildings. In department stores or inside the buildings of shopping centres or sometimes in railway stations, its characteristics mean that it can only be used in this area. They are characterised by the fact that the supporting structure (truss) is not galvanised and the individual components such as steps and handrail are made less robust (compared to escalators for public transportation). The flat handrail is often used for this type of escalator. The department store escalators are only operated during department store opening hours. Here, operating times average 12 to 14 h on weekdays.

29.2 Escalator for Public Transport

Due to its characteristics, the escalator for public transport is used outside of buildings in outdoor areas. The construction and characteristics of the components used are suitable for outdoor use. Here you can see differences in the steps, these are more robustly constructed and have stronger rollers. The rollers on the steps are outside. Furthermore, the escalator is less sensitive to soiling and the resulting consequences. A wedge handrail is used as a handrail, because the wedge makes it more difficult for the handrail to slip due to external influences. Furthermore, components such as balustrade plates or comb segments are reinforced. The escalator truss is galvanized to make it more resistant to moisture. The electrical equipment is protected against the ingress of water and usually has an IP65 degree of

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protection. Escalators for public transport are used in railway or subway stations, mainly outdoors. The operating times are much longer than for department store escalators. At busy railway stations, operating times of 24/7/365 are not unusual.

29.3 Moving Walks

In contrast to escalators, moving walks are not equipped with steps, but with pallets. Escalators are used to bridge large ground-level distances. These are usually without inclination, but they can also have an inclination of up to 6°. All other properties are the same as those of escalators. Moving walks are also subject to the rules of EN 115-1. Moving walks are often used in shopping centres or airports to make it easier for users to walk long distances.

In shopping centres, moving walks are installed that can be used with shopping trolleys. For this purpose, special shopping trolleys are to be used, with which one can travel on the moving walk. The rollers of the trolleys are matched to the pallets of the moving walks and fit into the grooves of the pallets, thus holding the trolley securely and preventing it from rolling away. Figure 29.1 shows a moving walk.

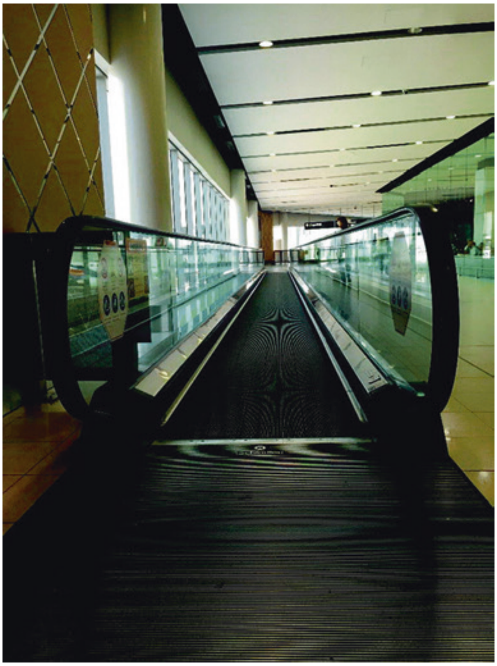

Fig. 29.1 Moving walks. (source: author)

29.4 Operating Modes

Escalators can be operated in different modes. However, this must be specified when ordering the escalator. This means that without these functions the escalator cannot be operated in any other mode.

A distinction is made between the following operating modes:

Continuous operation	The escalator is permanently in operation at its nominal speed
Intermittent operation	With no load, the escalator is in creep speed and only when a person enters the escalator does the escalator accelerate to nominal speed. Movements of persons are detected by light curtains or sensors in the base plate.► The time within which the escalator changes to slow speed is adjustable
Alternating operation	The escalator operates in both directions (up and down). The direction of travel is determined by the person who first enters the escalator. After a defined period of time with no passenger movement (empty travel) on the step band, the step band switches off again automatically

Intelligent sensors can detect lateral movements to the escalator and only switch the escalator on when a person is actually moving towards the escalator for use.

Documentation of Escalators

30

This chapter briefly discusses the description of escalator documentation. The topic of documentation has already been covered in detail in chapter 17. The contents of the documentation for a lift system do not differ significantly from those for an escalator.

The complete documentation of an escalator is also indispensable for the operator.

The most important documents are:

- Description of the plant
- Technical data
- Calculation of the step chain
- Calculation of the drive chain
- Structural analysis for the thruss
- Test report of the steps
- braking distance calculations with envelope curve
- Circuit diagram of the escalator
- Plant drawings
- Operating instructions with manufacturer's data
- Risk assessment
- Test protocols

30.1 Operating Instructions

The operating instructions contain information for the escalator operator as well as the maintenance company. It contains instructions on how to handle the system or special care, lubrication and adjustment instructions for parts or components.

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30.2 Risk Assessment

According to some national rules, e.g. in Germany, an escalator is a work equipment. For this reason, the employer must also prepare a risk assessment for his employees for the use of the escalator.

31 Escalator During Lifetime

Chapter 31 provides guidance on the operation of escalators. The German DGUV Information 208–028 (formerly BGI 5069, Part 1) “Escalators and Moving walks” from the German Social Accident Insurance Institution regulates the safe operation of escalators. This document lists accident prevention regulations for users and service personnel.

Here are a few points from this writing:

- Escalators and moving walks must be adequately lit during the time they are in operation.
- Bulky and heavy goods may not be transported on escalators and moving walks.
- Storage spaces in front of the entrances and exits of escalators and moving walks must be kept free. They must not be constricted, for example by fixtures or deposited objects.
- Handrails of escalators and moving walks must be tensioned in such a way that they cannot leave their guides when used as intended.
- If defects are found on escalators and moving walks which impair the safety of users, the escalators and moving walks must be taken out of service until the defects are rectified. [1].

31.1 Verification

Furthermore, DGUV Information 208–028 (formerly BGI 5069, Part 1) contains guidelines on tests that escalator operators should follow. Here are some points:

- Escalators and moving walks must be inspected by an expert before first use and after any significant modifications.
- Periodic inspections by experts shall be carried out at least at annual intervals.

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- Escalators and moving walkways must be inspected by a competent person for proper condition as required, but at least every quarter.
- The results of the tests are to be entered in a test book [1].

31.2 Operator Checks

According to DGUV Information 208–028 (former BGI 5069, Part 1) escalators should be checked for proper condition before being switched on. The operator checks are documented and serve the operator as proof of proper testing. This also allows damage to the escalator to be detected at an early stage and countermeasures to be taken.

As with the elevator system, the operator should carry out random checks on the maintenance of the escalator. The following checklist can be helpful in this respect.

Checklist Maintenance/performance Evaluation

Checkpoints	Yes	No
Has the agreed maintenance plan been properly completed?		
Has the maintenance been entered in the operating log?		
Are there any other entries from the past (repair, faults)?		
Is there any noise when operating the escalator?		
Are the teeth on the combs damaged/missing?		
Is the engine room swept clean, if available?		
Has the reversal station been swept? ***Only carry out this check in the presence of the service technician, i.e. he opens the reversing station, secures it and switches on the pit light!*** ***Note: Danger of falling!***		
Has the drive station been swept? ***Only carry out this check in the presence of the service technician, i.e. he opens the reversing station, secures it and switches on the pit light!*** ***Note: Danger of falling!***		

31.3 Fire Protection

Fire safety is a particularly important issue for escalators. The reversing and drive stations of the escalators are cleaned of operational impurities during regular maintenance. These impurities are partly caused by the escalator itself, such as the abrasion of components, or by contamination from the escalator environment, such as dust, especially in outdoor installations. However, these impurities cannot be completely removed by sweeping the reversing stations, as the movements of the step belt transport these impurities from the reversing stations into the interior

Fig. 31.1 Fluff formation in the step band system. (source: author)

Fig. 31.2 Pictograms on the balustrade. (source: author)

of the escalator and attach themselves to the components. Lint or dust can settle on the lubricated components in particular. This lint formation is observed during the periodic inspection by an expert. There is a risk of fire if the lint is too thick. Therefore escalators must be cleaned regularly. This cleaning is required over a period of approximately 3–5 years (depending on the environment and operating time) and is not normally a defined service under a maintenance contract and must be ordered separately. Figure 31.1 shows the interior of an escalator where an escalator interior cleaning must be performed.

31.4 Labelling

Escalators must be labelled. Pictograms are used to draw attention to hazards and behaviour. The pictograms are attached to the side of the balustrade at the top and bottom landing. Figure 31.2 shows the currently valid pictograms according to ISO 3864-1 and ISO 3864-3.

Reference

1. DGUV Information 208–028 Escalators and moving walks - Safe operation

32 Pictures of Damage

Here you will find some hints for the detection of damages. Regular operator inspections of escalators allow any damage that occurs to be detected in good time and countermeasures taken. There are some fault patterns that can be easily detected even by non-experts.

For example, porous handrails can be recognized by the handrail arches when looking closely. In Fig. 32.1 small cracks can be seen next to each other. These cracks indicate a porous handrail. Porous handrails do not represent damage yet, but they should be observed. If the cracks become larger, they should be repaired.

Damage caused by vandalism, for example by scratching the handrail with a knife or a sharp object as shown in Figs. 32.2 and 32.3, will cause severe damage to the handrail. These areas should be repaired quickly after detection in order to avoid consequential damage caused by the handrail tension increasing the crack. The repair can be carried out by inserting a small piece of new handrail at the damaged area.

Another type of error is the absence of a tooth on the comb segment. The German DGUV Information 208–028 (formerly BGI 5069, Part 1) defines that the comb segment must be replaced if two adjacent teeth are missing. It is advisable to replace the comb segment already when one tooth is missing and not to wait until the second adjacent tooth has broken off. This minimizes the risk of tooth retraction. Figure 32.4 shows a comb segment with one broken tooth and one bent tooth.

If broken off parts on steps or broken-off webs are visible, then the step should be replaced, as falling users can injure themselves at these damaged areas (danger of cuts), as shown in Fig. 32.5.

Figure 32.6 shows defective inserts on an escalator step. These inserts are made of plastic and are located around one step. The yellow colour makes it easier to identify the steps and makes them easier to use for the user. These inserts are an alternative to yellow markings on the steps, which are only applied to the steps using paint. The disadvantage is that if the insert is defective, the escalator must be switched off.

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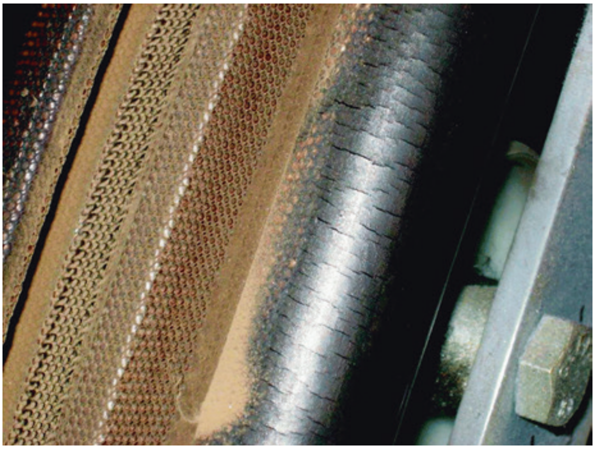


Fig. 32.1 Slight crack formation on a handrail. (Source: Author)

Fig. 32.2 Vandalism damage to a handrail. (Source: Author)

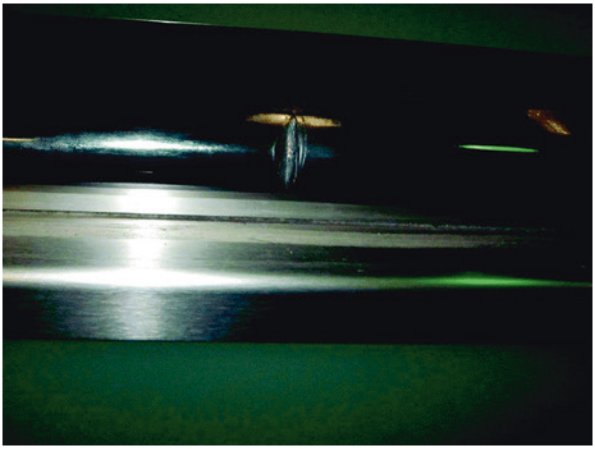


Fig. 32.3 Cut-in handrail. (Source: Author)

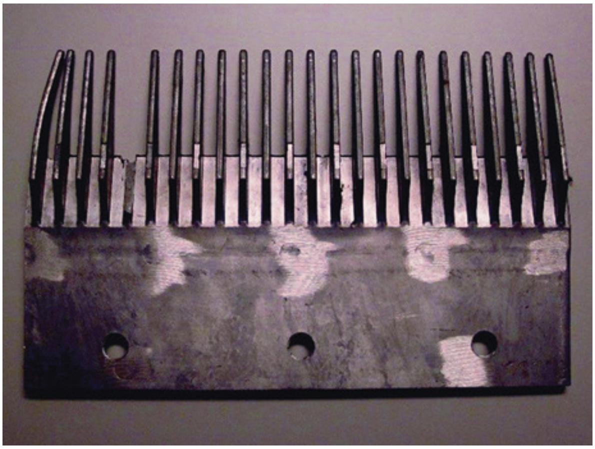
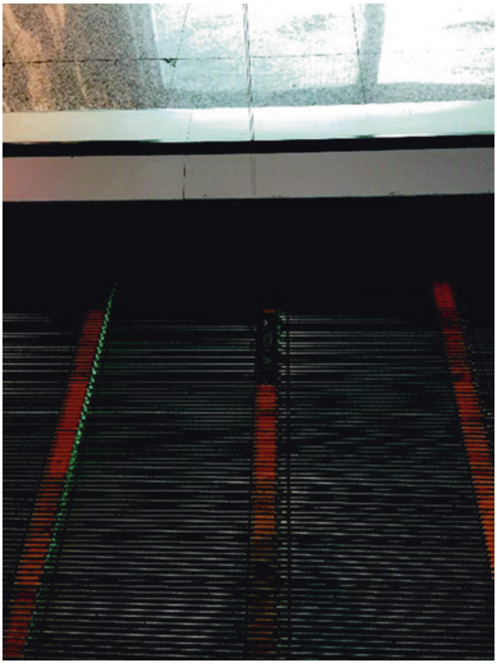


Fig. 32.4 Comb segment with one bent and one broken tooth. (Source: Author)

Fig. 32.5 Broken web on an escalator step. (Source: Author)

Fig. 32.6 Defective insert on an escalator step. (Source: Author)



Maintenance of Escalators

33

This chapter provides an insight into maintenance contents and quality measurement. The maintenance of an escalator is critical to its service life. An unmaintained escalator will always cause malfunctions, reducing availability. In addition, components will be damaged by lack of maintenance and the escalator as a capital good will lose value. In principle, the same conditions apply here as for a lift system.

33.1 Quality Measurement

There are fewer tools available to measure the quality of maintenance on an escalator than for measuring the quality of a lift system. The values and settings specified in the standard, such as the gap between the steps/pallets and the balustrade, can be checked using a folding ruler. No electronic aids are required for this. Furthermore, the depth of tooth engagement of the teeth on the comb segments in the steps must be checked and re-measured.

When checking the switch-off conditions of the comb plate switches, which is also carried out during maintenance, the manufacturer's instructions must be followed. Whether the available setting devices work correctly can be checked with the help of a test device for the comb plate thrust switch-off. The tester, which is shown in Fig. 33.1, is placed directly on the comb plate, as shown in Fig. 33.2. To do this, one stage must be removed to perform the test procedure. The force on the comb plate is increased by muscle power or with the help of hydraulics. When the comb plate switch has been triggered, the force required for this can be read off a scale on the test device, as shown in Fig. 33.3 [1].

Further points can be inspected by an experienced expert. When checking a maintenance service, attention should be paid to the cleanliness of a system. After all, dirt and dust are the biggest enemies of a system. Especially where

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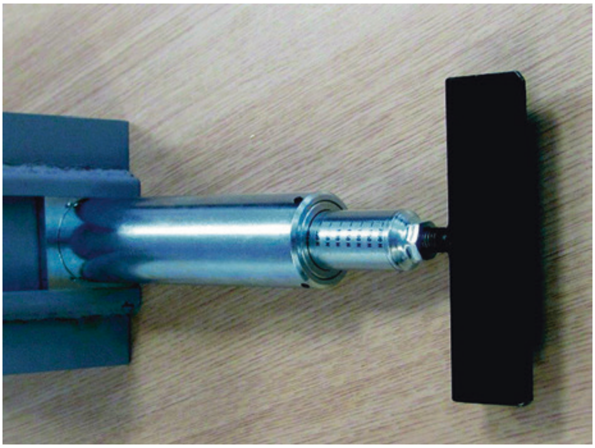

Fig. 33.1 Test device comb plate thrust switch. (Source: Henning GmbH, Schwelm, Germany)

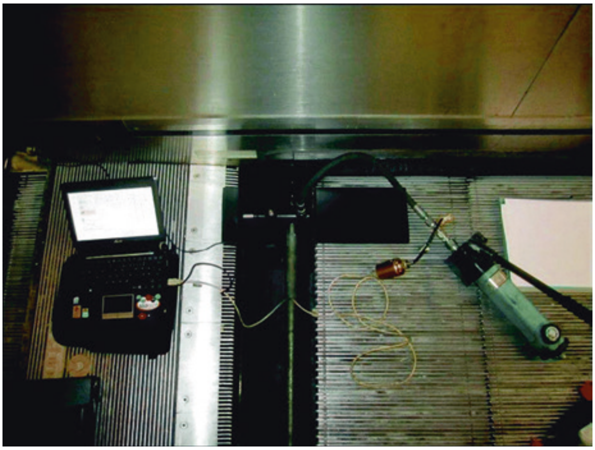

Fig. 33.2 Test device in use on a comb plate. (Source: Henning GmbH, Schwelm, Germany)

components are treated with lubricant, this dust can settle. This forms a dust-oil mixture, which can have an abrasive effect.

Further deficiency points can be detected by moving on the step band. A jerking escalator, for example, can be a sign of elongation of the step or drive chains. In this case the chains should be retensioned. If this is no longer possible because the adjustment possibilities have been exhausted, the chain must be replaced.

A listening test should also be carried out when the escalator is moving. Knocking noises at the end of the step band may indicate, for example, that the rail joints of the running rails are not exactly on top of each other at the transition

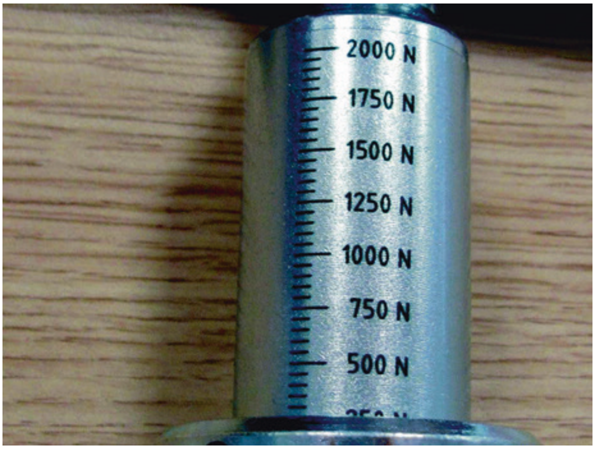

Fig. 33.3 Scale for reading the thrust. (Source: Henning GmbH, Schwelm, Germany)

from the straight rails to the curved rails or that there is insufficient ambient lubrication. These should then be readjusted in order to obtain a clean transition again or the lubrication should be renewed. If the damage lasts too long, it can lead to damage to the step rollers due to the strong impact of the step rollers on the rail curves.

The handrails should run evenly with the step band. A handrail which runs faster than the step band is less critical than a handrail which runs slower. Adjustment options are available in the handrail station.

33.2 Maintenance Plans/Cycles

The figure below shows some examples of maintenance contents (the figure is not exhaustive).

Activities
Inspection of the handrails
Examination of the steps
Testing of the comb plates, segments
Testing the comb plate shut-off
Testing the step break contact
Inspection of the step band chain
Inspection of the main drive chains
Testing the balustrade lighting
Testing and adjusting the handrail tension

Activities
Cleaning of the reversing station from operational impurities
Cleaning of the drive station from operation-related impurities
Testing the electrical safety devices

The maintenance contents can be defined by the operator and agreed with the manufacturer or the manufacturer's specifications can be used.

The maintenance cycles are recommended by the manufacturer in his operating instructions. The following points are taken as a basis:

- the weekly operating time
- the environmental conditions (temperature conditions, indoor or outdoor)

Various models of maintenance procedures are possible, such as the combination of large and small maintenance. Ultimately, it is a coordination between the operator and the maintenance company. However, escalators should also be serviced at least 4 times per year.

33.3 Cleaning

The escalator also requires regular cleaning both inside and outside. Internal cleaning is important to increase the life of the internal components and to prevent fire inside the escalator. Heavy soiling inside the escalator increases the risk of fire.

The escalator steps should also be cleaned regularly. Not all dirt can be removed from the step band by the comb segments. Stubborn dirt such as chewing gum can stick between the steps and cause malfunctions.

For internal cleaning, it is important to remove all steps and then clean the escalator by hand. In any case, the use of a high pressure cleaner should be avoided as this will damage the electrical equipment.

Reference

1. Product brochure Test device for the cam plate switch-off, Henning GmbH, 2014

34 Modernization of Escalators

In escalator modernizations, the individual components are dismantled down to the truss and replaced by new components. For interior escalators, the probability of damage to the truss, for example through corrosion, is low. Therefore, dismantling of the truss is not necessary.

Individual components can be replaced in the event of a partial modernization. Depending on the condition of the plant, either individual stages or the complete step belt are replaced. In addition, the control system or the drive can also be replaced. Depending on the maintenance concept of the plant, partial modernizations can also be carried out in stages within a defined period in order to spread the costs.

Partial modernization should focus on increasing safety. In order to achieve this, the measure should be carried out in accordance with EN 115-2. Figure 34.1 shows a partly dismantled escalator.

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Fig. 34.1 Partly dismantled escalator. (Source: Author)

Planning of Escalators

35

Here you can learn about planning of escalators. Escalators are mainly used in large buildings where many people need to be transported vertically. This is the case in shopping centres or railway stations. The expected number of people to be transported determines the width and speed of the escalator. Speeds of 0.5 m/s and 0.65 m/s are possible. Higher speeds of up to 0.75 m/s are permitted in accordance with EN 115-1. For example, the escalators in the London underground have a speed of 0.75 m/s. The escalators are manufactured in widths of 800 mm, 1000 mm or 1100 mm.

The escalators can be arranged in the building in various ways. A distinction is made between the following arrangements:

Parallel side by side, single sided or crosswise. Figure 35.1 shows a simple arrangement of the escalator in one direction. It is also possible to arrange two escalators in parallel, one for up and one for down.

Figure 35.2 shows an arrangement of two escalators arranged one after the other in one direction. Again, the escalators can run parallel, one for the up and one for the down direction. The user has to walk around the escalators to get to the next escalator.

Figure 35.3 shows a crosswise arrangement of escalators. Here, too, it is possible to travel in two directions at the same time when arranged in parallel.

With this simple arrangement, traffic flows smoothly and the user can continue his journey directly with the adjacent escalator. The opposite direction of travel is on the opposite side. In this arrangement, up and down moving users do not meet, so there is no risk of collision between users moving in different directions.

When using moving walks in shopping centres, care must be taken to ensure that sufficient space is available in front of the landing points when using shopping trolleys, as the turning circle of people with shopping trolleys must be taken into account. It is also important to ensure that only approved shopping trolleys are used. These have special wheels that fit into the grooves of the pallets and prevent

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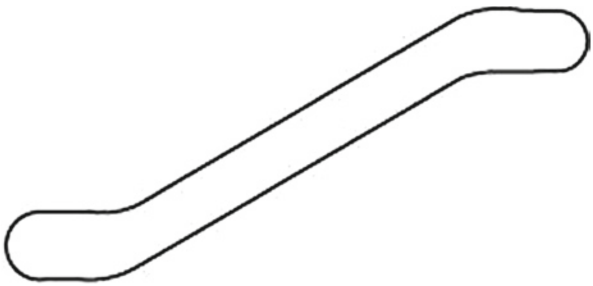

Fig. 35.1 Simple arrangement

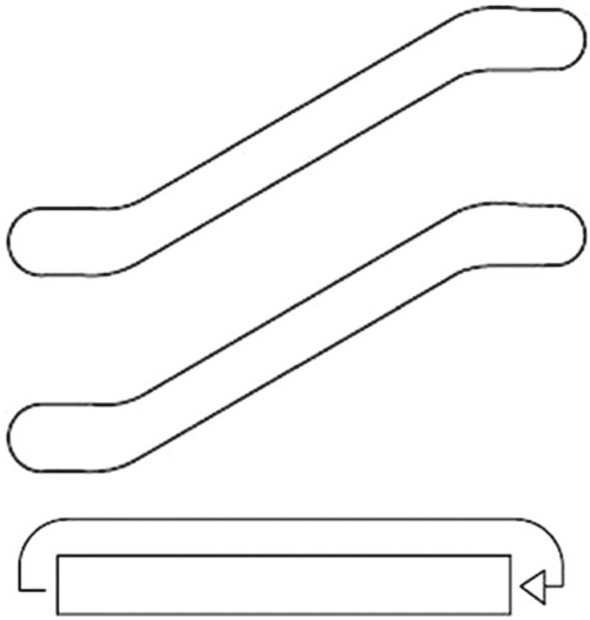

Fig. 35.2 Two escalators arranged in one direction

them from rolling away. When using moving walks with shopping trolleys, the moving walks should be arranged in such a way that a flowing traffic is created.

During planning, all required spacing dimensions according to EN 115-1 must be observed. These include headroom to the next higher escalator or ceiling, sufficient storage space in front of landing points and sufficient distance between handrails and adjacent building parts. To determine the number of escalators, the geometry of the building and the number of entrances in the building must be taken into account. These are all factors that influence the design of escalators. It is also important to consider whether there are lift installations in the vicinity of

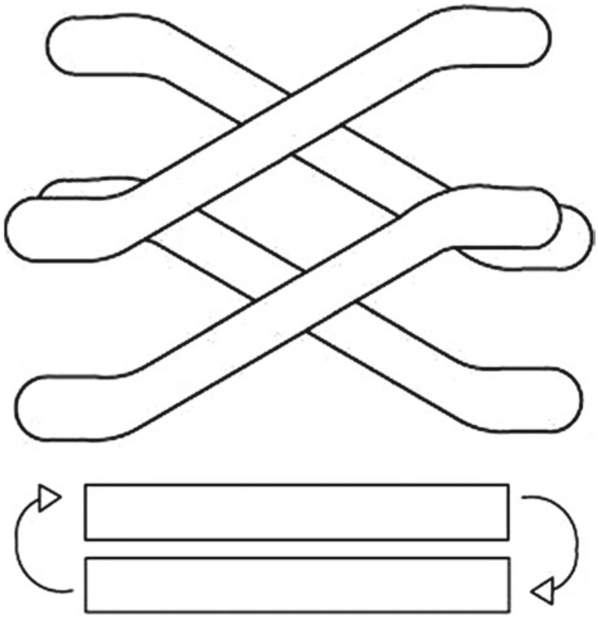

Fig. 35.3 Crosswise arrangement

the escalators. This is because the presence of lift installations influences the use of escalators. Traffic flows can change as a result and should be taken into account in planning.

The following example should clarify this. Assuming it is a department store with 6 floors. There are escalators in the entrance area for both up and down (to the basement). Near the escalators there are lifts serving all floors of the building. It is likely that visitors will use the escalator if they only want to go to the 1st or 2nd floor, as this is the quicker and more convenient way than using the stairs. If visitors now want to get to the top floors, the probability of using the lifts increases. On the other hand, more escalators are used in interfloor traffic. People with walking disabilities or elderly people as well as people with prams will generally use the lifts.

This example shows that there are some influencing factors that must be taken into account when planning escalators. Using the existing data, the width and speed of the escalators must now be determined. The number of escalators required must also be determined. In the example described above, the result of an investigation and traffic calculation could well be that on the ground floor, two escalators for the downward direction and two escalators for the upward direction must be considered, while on the last floor one escalator per direction is sufficient. If the department store described above now has a connection to public transport like metro on the basement floor, then the traffic volume will behave differently.

Then it would be conceivable to provide sufficient escalators with a width of 1100 mm and the maximum possible speed according to EN 115-1 already in the basement. From the influencing factors considered above, it can also be deduced which operating mode should be selected for the escalators. The escalator company or the specialist planner will provide sufficient assistance in questions of planning.

36 Traffic Calculation of Escalators

This chapter briefly explains the principle of traffic calculation on escalators, as mathematical methods can also be used to determine the speed and width of an escalator when planning escalators. There are different approaches that consider the exact environment (where is the escalator installed?) and additional alternatives such as the use of lifts or stairs. The behaviour of pedestrians must also be considered. Stairs, for example, are used more disciplined by users. This allows more people to use the staircase, i.e. the density of people is higher. For escalators the density of people is slightly lower.

The following simple calculation in principle can be used to calculate the travel capacity [1]:

Travel capacity $= 60 \times v$ x k x s
in persons/minute.

v = escalator speed
k = person density (number of persons/level)
s = number of steps per escalator in m

The person density k is theoretically calculated:

k = 1.0 with 1 person per step with a step width of 600 mm
k = 1.5 with 1.5 persons per step with a step width of 800 mm
k = 2 with 2 persons per step with a step width of 1000 mm [1].

Various sample calculations with variable speeds and step widths show that the higher the speed of the escalator, the more people can be transported. Similarly, the higher the step width, the more people can be transported. However, these calculations also have their saturation limits, so this is not a process that can go on indefinitely.

In addition to the simple calculation example described above, there are other calculation methods that also take into account the exact installation situation of

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the escalators in the building. The escalator arrangements mentioned above have a different influence on the calculations, as the traffic flows in the different installation situations differ. Other influencing factors are the geometry of the building and the number of entrances and exits in the building.

When calculating traffic in shopping centres or department stores, the calculations for escalators and lifts are carried out together, since the mutual influence of the two transport options is great here.

When carrying out a traffic calculation as a basis for escalator planning, specialist planners or even escalator manufacturers are helpful. The optimum solution can be found using modern calculation programs.

Reference

1. Elevator Traffic Handbook, Theory and Practice, Barney, G. C. Tailor & Francis Routledge, 2003

37 Building Management System

As with lift systems, escalators can also be monitored via a building management system (BMS). The same conditions must be created as for lift systems. Since escalators do not have an emergency call, the infrastructure for a connection to a service control center, for example, is not available and must first be created. A separate telephone connection or a connection via a dedicated line must be provided for this purpose. Via this transmission link, data and system statuses can be called up remotely, just like in a lift system. It is also possible to establish a connection via GSM.

All further points on this subject can be found in chapter 23.

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38 Avoiding Accidents

This chapter is intended to give some advice on how to avoid accidents. Accidents on escalators happen every year. Most accidents are due to human error. However, when used as intended, the escalator can be used safely. There are just a few rules to be observed.

According to EN 115-1 escalators must be marked with mandatory signs, the pictograms. These indicate to the user which actions are prohibited. Some owners are using additional pictograms to those according to EN 115-1. The following rules and procedures must be observed to ensure safe escalator operation:

- Do not bring prams on the escalator. In the event of an emergency stop, the escalator comes to a stop within approx. 30 cm. As users do not expect an emergency stop, there is a very high risk that the pram can no longer be held by the attendant. This can cause the pram to fall down the escalator in an uncontrolled manner. The risk of injury to the child and other users is high.
- No taking bicycles on the escalator. The consequences are the same as when you take a pram with you.
- Users wearing rubber boots or shoes with rubber soles must stand correctly on the escalator, otherwise there is a risk of being pulled in. This means that contact with the balustrade must be avoided. If there are side brush deflectors, they should not be touched. Misuse of the brush deflectors as a shoe polishing tool should be avoided.
- Dogs are to be picked up. As the steps enter the comb segments at the landing points, there is a high risk that the paws or parts of the coat may be pulled in.
- The escalator should not be used in a seated position. Children like to sit on the steps. When the steps are driven into the comb segments, clothing can be pulled into the comb segments, this can cause injury. In general, children should be restrained when using the escalator.

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- The escalators must be used in standing position. From the author's point of view, the popular rule in the past "stand right, walk left" should be omitted. Walking on the escalator increases the risk of falling.
- The transport of bulky goods on the escalator is prohibited. Particularly when transporting long goods such as poles or roof battens, there is a high risk that the transported goods will get caught on the ceiling and wedge between the ceiling and the escalator. This can lead to steps being pushed up and broken.
- When wearing long dresses, care should be taken at the transition from the step band to the comb plate to ensure that no clothing is pulled into the teeth of the comb segments.
- When travelling on the escalator, the comb plate must be stepped on with one step at the transition from the step band to the comb plate at the landing. It is not advisable to allow yourself to be driven onto the comb plate without moving, as there is also a risk of getting trapped.
- The erection of construction scaffolding on escalators is prohibited. The additional weight can damage the grooves of the steps. If it is necessary to erect construction scaffolding in the immediate vicinity for renovation work, the steps must be adequately protected with a wooden base. Furthermore, the escalator must be covered if dust is expected.
- If moving walks are approved for the transport of shopping trolleys, only the shopping trolleys intended for this purpose are to be used.
- In shopping centers it is common practice to use pictograms in accordance with EN 115-1 as well as to prohibit the use of walking aids or wheelchairs.

39 Decommissioning of escalators

Escalators can also be temporarily taken out of service. To protect the installation, at least the following points should be carried out:

- Relaxation of all chains (main drive chain, handrail drive chain, step belt drive chain)
- Relief of the handrail (via pressure belt or other devices depending on the manufacturer)
- Conservation of the engine
- Cover the escalator to protect against dust. Dust penetrating into the lubricated system components can cause the dust particles to become embedded in the lubricated system components and have an abrasive effect when the escalator is put back into operation.
- Furthermore, the escalator should not be left to itself, but should be inspected regularly to check at least the covers for tightness.

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