The Importance of Choosing the Correct Door for Different Applications

Giuseppe De Francesco[1]

[1]Group Engineering Manager, Sematic Spa, Italy, marketing@sematic.com

Keywords: lift doors, high rise, goods, standard passenger, scenic, EN 81-20

Abstract. Each specific installation requires lift doors with distinctive, well defined features and technical characteristics, which allow to satisfy the expectations and needs, not only of those who designed the lift system, but also of those who designed the whole building and, above all, of those who will use it. The functional and aesthetic characteristics of automatic lift doors are always combined with the essential requirements of product described by the European and International standard for the lift sector which, in many cases, significantly contribute to the definition of the distinctive characteristics of the component "door" for each application context.

In the paper we will present some of the solutions that lift door manufacturers can offer to customers, architects, designers and installers even for the most complex and technically demanding projects: from standard to tailor-made automatic doors for any type of elevator, both for people and goods transportation, in skyscrapers, residential, civil, commercial and industrial buildings, as well as in hotels, hospitals and cruise ships. In order to improve the efficiency of any complete lift system, each lift door (and its components) should be specially designed and manufactured in order to offer customers the best possible solution for each specific application and requirement through the perfect combination of technology, functionality, security, comfort and innovative aesthetic solutions.

1 INTRODUCTION

Each specific installation requires lift doors with distinctive, well defined features and technical characteristics, which allow to satisfy the expectations and needs, not only of those who designed the lift system, but also of those who designed the whole building and, above all, of those who will use it.

The characteristics and intended uses of each building influence and affect the design of lift systems and their components, including doors. For example, due to the heavier use and higher traffic conditions, a public building or station will require lifts with higher resistance to vandalism than the ones of a private apartment block, which is inhabited and used only by a few families; an high-rise office building or a luxury 30-floor hotel should integrate more performing vertical transportation solutions and more prestigious finishes than industrial lifts used to transport goods and materials.

But building type is not the only criteria that has to be considered in the selection of elevator equipment; cabin capacity, speed, rise and, above all, standards are essential variables too. Focusing on lift doors, this means that during the design phase the functional and aesthetic characteristics of the doors have to be always combined with the essential requirements of the product described by the European and International Standard for the lift sector which, in many cases, significantly contribute to the definition of the essential characteristics of the component "door" for each application context.

For instance the new EN 81-20 will introduce some relevant changes, related to the safety of the passengers and the safety of the workers during installation and maintenance, that all the door manufacturers have to take into consideration in the development of their new products as well as in the improvement of their existing products, which are not compliant to the new European requirements.

2 MAIN APPLICATION CONTEXTS

Any lift type suitable for a specific application context presents well-defined, general characteristics that are strictly linked to its intended final use (see Table 1). A freight lift should be designed to maximize its resistance against potential hits and withstand heavy loads (forklifts etc.); an high speed lift should include specific devices in order to minimize noise and vibrations; a panoramic lift should feature aesthetics solutions, such as glass walls, and comfort devices that will enhance passengers' travel experience.

Table 1 Lift characteristics per application context

Lift type / Characteristics	High speed	Freight	Inclined	Vandal resistant	Modernization	Panoramic
Performance	••••• traffic management	••	•••	•••	•••	•••
Reliability	••••• high traffic application	•••	•••• optical coupling	•••• Installation in public places	•••	•••• high traffic application
Adaptability	•••	•••	••••• To different job site conditions	•••	•••	•••
Resistance	•••	••••• against potential hits	•••	••••• against vandalism	•••	•••
Accessibility	•••	•••	•••	•••	••••• small shaft dimensions	•••
Aesthetics	•••• top architectural projects	••	•••	••	•••	••••• iconic element of the building
Comfort	••••• noise, vibrations	•••	•••	•••	•••	•••• passengers' travel experience
Robustness	•••	••••• withstand heavy loads	•••	•••• withstand adverse conditions	••	••

Table 1: Correlation between lift type and general lift characteristics – source Sematic

Also all of the components of any type of lift should be designed, manufactured and fine-tuned according to building type and application context. For lift doors this means acting on a series of variables such as dimensions (width and height), type of openings, resistance to wearing of the door parts, opening and closing times, weight of the panels (see table 2), which all contributes to the overall performances of the lift in a specific context of use.

Table 2 Lift doors characteristics per application context

Typical application	Residential - offices	Modernizations	Goods transport	Heavy duty industrial	High traffic-flow high rise
Useful life (cycles)	7,8 mln	7,8 mln	7,8 mln	9 mln	11 mln
Door Panels mass	4x23 kg	8x12 kg	8x22 kg	12x50 kg	4x25 kg
Type of door	2 panels center opening	4 panels center opening	4 panels center opening	6 panels center opening	2 panels center opening
Avg. Width	1.100	800	1.400	2.400	1.100
Avg. Height	2.000	2.000	2.400	3.500	2.200
Average car door cycles per year	500.000	500.000	650.000	650.000	900.000
Opening time (default profile)	1.9 s	1.6 s	2.2 s	2.4 s	1.4 s
Closing time (default profile)	2.6 s	2.0 s	3.2 s	6.5 s	1.9 s

Table 2. Lift door typical characteristics per application context – source Sematic

2.1 High speed lifts

High speed is the most advanced application in the lift industry. Typically installed in residential and commercial high rise buildings with high traffic flows, super-fast complete lift systems, as well as all of their components, must guarantee top performances together with maximum safety and comfort.

High rise buildings have distinctive external, internal and regulatory characteristics that require special skills for the design and construction of their vertical transportation systems as well as of all of their components. Together with the need for longer shafts and higher transport speed, a number of specific factors, which are normally not significant in ordinary buildings due to low speed and air flows, must be kept under control during the design of high rise elevators, considering that high performances have to couple with strict constraints.

In high rise elevator design, the doors play a key role since they are the most critical device in terms of people safety, and also affect the overall performances of the system; therefore, one of the main concerns is allowing the door systems to work in the best conditions.

The starting point for achieving this goal is clearly defining all the variables that have impact on the doors systems (see table 3).

Table 3 Variables to be considered in the designing of lift doors per high rise buildings

In the building variables	Out of the building variables	Door specific variables
Height of the building	Fire and smoke	Performances required
Flow management	Wind	Quality perceived
Positive and negative pressure in the shaft well	Evacuation situations	Reliability
Tolerances in clearances of mechanical elements	Extreme weather conditions	Aesthetic requirements
Turbulences and vibrations	Regulatory environment	Energy efficiency and safety of the system
Management in case of power loss		Integration with other systems

Table 3: Variables to be considered in high rise buildings – source Sematic

The first group of variables identifies the status of the building in terms of structural configuration, population, flow management, etc. Each of these variables is responsible for specific effects that have to be carefully considered. For example the height of the building (i.e. of the shaft well), determines air pressure, which generate stack and piston effects. In such tall shaft-wells in fact, pressure can be so high that doors may experience difficulties in the very last part of the closing phase, resulting in reliability problems if not properly managed.

The influence of external factors must not be undervalued too, affecting door design and thus construction. These variables are normally codified in standards, norms, recommendations, specifications and strongly affect the doors systems. Fire and smoke regulations are probably one of the most critical topic. In high rise buildings some risks, such as fire and smoke propagation, are amplified by the structure of the building itself (lengths of shafts and consequent stack effect); poor protective systems of any building equipment can lead to disastrous consequences.

So satisfying top safety requirements is a must not only for architects and designers but also for the manufacturers of all the service facilities of the building, including elevator and elevator component manufacturers. A high rise elevator system must be able to safely manage any emergency and must be designed with special components (fire-resistant; vandal-resistant; etc.) and materials (i.e. non-combustible) that, for example, in case of fire do not permit the propagation of flames and smoke.

International, European (EN 81-58) and local standards, norms, recommendations, specifications give some guidelines and hints to design safe components in elevator systems as well as to improve their fire resistance. Firefighters elevators and fire-resistant components are among the solutions that the elevator industry offers to increase the safety in high rise buildings. Furthermore also the introduction of new standards, such as for example the EN 81-20 and EN 81-50, can considerably impact on elevator door design and manufacturing.

The last group of variables is related to the door systems only, which includes: performances required in terms of opening/closing cycles (which affect significantly travel time), quality perceived (noise, vibrations, smooth profiles), reliability both in terms of call-back rate and preservation of performance and quality over time, energy-saving, safety and aesthetics (design and flexibility to suit different claddings and executions, together with the ability to master glass for example).

Considering all these variables automatic lift doors for high speed lifts must feature high adjustability, reinforced and high performing components, panels and headers, that are designed to move heavy panels in short times and with low noise emissions. Their main characteristics can be defined as the followings:

- Performances (speed in terms of opening and closing time: 1,4 s + 1,9 s for high rise elevator doors vs 1,9 s + 2,6 s for standard elevator doors)
- Reliability (life cycles)
- Robustness (increased panel masses)

To satisfy all these requirements, door manufacturers have developed a complete range of solutions, which includes special features of the door drive controllers (adjustable opening and closing speed profiles; real-time moving mass calculation algorithm; speed profile automatic downgrade; stand-by mode; battery back-up) or specific mechanical devices in order to take care, for example, of sealing the cabin and landing doors during the elevator ride (increasing comfort).

2.2 Freight lifts

Freight lifts are used to transport goods in airports, undergrounds, railway stations, shopping centres, hospitals (e.g. for stretchers), industrial premises and parking lots; contexts where resistance and durability of all the components are crucial. In particular, automatic doors for freight lifts must withstand heavy loads (i.e. forklift) and potential hits, so they need to be not only robust, but they have also to guarantee high level of service and reliability in all operative conditions, even in the extreme ones.

Automatic lift doors, which openings can reach even 6000 x 5000 mm, satisfy these requirements thanks to a set of constructive solutions specially designed for this application such as reinforced clutch, frames, panels, hangers, bigger rollers as well as upper and bottom tracks in high resistance materials (i.e. steel, extra-reinforced steel – see table 4).

This set of constructive solutions enables the doors to withstand the impact of a collision with vehicles (i.e. forklifts, mobility scooter, objects) and guarantees that the door panels stay in their position and don’t exit from their bottom track guides in case of accident, preventing people and objects from falling into the shaft. Also installation mode contributes in enhancing the stability of the entire door systems, for example with the partial installation of door posts on the floor.

Table 4 Correlation between sill types and application contexts

Elevator rated load (Kg)[1]					
Private, office, hotels, hospitals	**Freights (standard)**	**Freights (forklift / pallet)**	**Suitable sill and support types**	**Sill load (Kg)**	**Concentrated load (Kg)**
4.000	2.600	1.800	Standard aluminium sill with reinforced brackets	1.600	800
---	6.600	4.700	Reinforced aluminium sill with reinforced brackets	4.000	2.000
---	13.300	9.400	Steel / stainless steel sill with full width angular support	8.000	4.000
---	> 13.300		Reinforced steel / stainless steel sill with full width angular support	> 8.000	> 4.000

Table 4: Correlation between sill types and application contexts – Source Sematic

2.3 Inclined lifts

Inclined lifts allow the overcoming of slopes and guarantee transport between different levels on an oblique path. The lifts used for this purpose always include high tech solutions and must guarantee a high degree of adaptability to the different job site conditions, which include also the impossibility of mechanical coupling of car and landing doors, one of the fundamental working aspects of this specific component.

To solve this problem some door manufacturers have developed doors with optical coupling. Here follows an example of its working: car and landing doors are both equipped with linear belt traction operators, each one with its own engine, and couple through an optical device, which should allow only a minimum misalignment between the centres of the emitter and the detector.

As prescribed by the recently released EN 81-22, optical coupled doors for inclined lifts must guarantee the perfect functioning of the systems on levels with inclinations, usually between 15° and 75° are allowed, and, for complex installations, it's even possible to have different inclinations from floor to floor. Since this type of lifts are often installed outdoor also the protection of the components is fundamental, for example a fully covered operator with high IP rating and materials that guarantee satisfactory performances even in extreme weather conditions.

2.4 Vandal resistant lifts

[1] The relation between the sill load and the elevator rated load is calculated according to EN 81 standard as following:

- Elevators with rated loads less than 2500 kg in private premises, office buildings, hotels: 0,4 x Elevator rated load;
- Elevators with rated loads of 2500 kg or more: 0,6 x Elevator rated load;
- Elevators with rated loads of 2500 kg or more in case of forklift truck loading: 0,85 x Elevator rated load

Unluckily the lifts installed in public places, such as stadiums, airports, underground and train stations, schools, universities and public parking, are often subject to vandalism. Even if it's quite impossible to develop a 100% vandal-proof system, the lift industry's efforts to improve lifts' resistance to vandals' destructive tendencies have already achieved significant results.

Component manufacturers have developed a wide range of solutions that contribute to the improvement of the overall lifts' safety. If we speak about doors these instances are translated into a series of precautions, which make the system more robust and resistant to damage and breaking.

As prescribed by EN 81-71 standard, for the landing doors these precautions includes, for example, mechanism cover plate, protected emergency unlocking device, corrosive fluid resistant bottom track and reinforced panels with adequate thickness and made in anti-scratch materials. In addition to all these safety measures, for the car doors, attention has to be paid to prevent its forced opening, that can cause serious hazard, through special car door locking devices. Furthermore as per EN 81-71 class 2 requirements, door construction should not include the use of rubber profile and detector on the panels beating edge as well as of vision panels (allowed for class 1).

2.5 Lifts to be modernized

Lift modernization projects aim to improve safety, accessibility, reliability, efficiency, performances and comfort in existing systems, whilst simultaneously lowering maintenance activities and energy consumption.

Door manufacturers are able to offer a wide range of solutions for the complete replacement of old lift doors (both manual and automatic), as well as of some of their key components. In this market segment, the product offer is suitable for an extensive range of existing installations and customized according to the different destination markets and their characteristics, such as for example shaft dimensions or local regulations.

Space saving of the components is one of the most important issues in order to maximize cabin capacity and accessibility; to reach these goals, bottom track packages with minimal amount of space (approx. 115 mm), availability of non-conventional opening types (i.e. asymmetric opening), frameless doors and recess installation are just few examples of the solutions that can be adopted.

2.6 Panoramic lifts

Lifts aren't always just about moving people; sometimes they can be a distinctive, iconic feature of the building itself. Aside from their functional ability, panoramic lifts can be a focal point of any building providing a combination of elegant finishes and all-round visibility – ideal for making the most, for example, of an open hotel foyer or a shopping centre atrium.

Each panoramic lift can be tailor-manufactured to suit a particular architectural requirement or design concept and its components must be customized in order to guarantee the best possible aesthetic and functional performances.

For automatic lift doors these requirements are satisfied through material selection (full or framed glass panels), panel shape (round doors) and special executions such as doors with hidden bottom tracks or doors with under-driven operators, which comprise exclusive design advantages such as for example reducing the visible size of the car door operator from the floor hiding the lift door mechanisms under the floor level.

Focusing the attention on glass panels, the new EN 81-20 (see also paragraph 3) introduces a series of means to minimise the risk of dragging of children hands, one of the typical threats for this type of doors. According to the new standards, automatic power operated horizontally sliding doors made of glass shall be provided with means to minimise this risk, for example, by making the glass opaque on the side exposed to the user by the use of either frosted glass or the application of frosted material to a height of minimum 1,10 m or by sensing the presence of fingers at least up to 1,6 m above sill and stopping the door movement in opening direction, or by limiting the gap between door panels and frame to maximum 4 mm at least up to a minimum of 1,6 m above sill.

THE NEW EUROPEAN STANDARD: EN 81-20

If application context characteristics are relevant to the design and manufacturing of lift doors, standards are even more influencing factors. The new EN 81-20 will have for sure a deep impact on the design and development of lift systems and components for the next decades and one of the largest changes it will introduce is related to car and landing doors, for every type of lift.

The new European standard require, for example, that doors will be increased in strength and their integrity will be improved under impact conditions. All of the landing doors will need to successfully pass a pendulum shock test, and the forces (300 N for concentrated load and 1000N for distributed load) that they have to withstand are well increased compared to EN 81-1/2. After such testing the doors must be within certain defined limits regarding permanent deformation. Some products on the market are already compliant with these new requirements, some others will need a revision of their designs, including for example the addition of reinforcing profiles and stabilizing elements on the panel ends, in order to satisfy the more stringent testing requirements.

These changes are necessary to increase the robustness of the doors and, together with the prescription of using additional retainers, to hold the door panels in position in case of a consistent impact when the main guiding elements of the door fail. These precautions will prevent accidents, even dangerous, which imply the falling in the shaft of people and goods.

From the passenger's safety perspective, another significant change will be related to the protection from being hit by closing doors. Investigations carried out by national and European lift associations show that the collision with the doors during their closing phase is one of the leading causes of injury in lifts, especially for elderly people.

EN 81-20 defines that automatic power operated doors must be fitted with non-contact protection devices that shall automatically initiate the re-opening of the doors or take the lift out of service in the event of a person crossing the entrance during the closing movement. This prescription includes stringent requirements regarding the position and coverage of the device (between 25 and 1600 mm above the car door sill), the minimum dimension of obstacles to be detected (50 mm diameter) as well as the kinetic energy at the average closing speed (limited to 10 J with the protective device perfectly working and to 4 J when deactivated).

For glass doors, protection is even increased (see also paragraph 2.6). They will have to be provided with means to limit the opening force to 150 N and to stop the doors in the event of obstruction as well as with thickness, gaps and sensors that will avoid the dragging of children's hands.

For the safety of the workers during installation and maintenance, new limitations have been placed on the height of the unlocking mechanism to avoid persons falling into the shaft whilst trying to unlock and open doors at the same time. Also, a "bypass operation" for the car and landing door locks has been added. Workers sometimes need to over connect contacts to determine the cause of the failure in a lift, but there is a risk that they may forget to remove those over connections, causing enormous risk when the lift is in normal operation. EN 81-20 describes how to avoid it.

3 CONCLUSIONS

New standards and directives as well as a better understanding of the application contexts and intended uses of lifts give door manufacturers motives to improve and develop their products.

The correct approach for the design and development of lift doors, in order to give lift companies the best possible components for the intended use of their lift systems, is than to combine all the regulatory and technical aspects which are relevant to tackle the application context issues, such as for example, safety, speed, reliability, perceived quality and comfort, together with the non-technical requirements (aesthetics) posed by architects, engineering and construction firms.

Lift doors must be seen not only as a component of the lift but as a perfectly integrated and connected piece of the building/context where they are installed.

BIOGRAPHICAL DETAILS

Born in 1973, Giuseppe De Francesco holds a degree in Electronic Engineering from the Politecnico of Milan. Since 2002 he has been working in the Sematic Group, holding positions of increasing responsibility in the Engineering and R&D areas of the company. Nowadays he is responsible for all the product development activities of Sematic worldwide. Having 12-year experience in the elevator industry, Mr. De Francesco has gained significant know-how and expertise in the development of innovative solutions for the design and manufacturing of automatic elevator doors, including glass and fire-resistant executions, in any application context: from high-rise to modernization.