Chapter D: The maximum speed of elevators (Draft)

Introduction

In the May 2016 issue of ELEVATOR WORLD, your author published an article with the same title as this chapter. His first article on this topic was titled "Pressurizing the cars of high-speed express elevators" (EW November 2013). In September 2014, EW published the article by another author: "Fastest Elevator – A competition in High Technology". The reactions and comments to this article and a further article: "How Fast Could the Fastest Elevators Be?" (EW Feb. 2016) disclose this matter is a subject of controversy and confusion in the elevator industry.

This chapter will demonstrate that Maximum Speed is a relatively simple logical problem. Elevators can accelerate to a high maximum speed; however, their average speed depends on:

- The maximum rate of change of air pressure, which can be tolerated by our hearing organs
- The travel distance, i.e. contract speed and rates of acceleration and deceleration.

The author assumes the maximum tolerable up speed is 12.5 m/s and 8 m/s for down trips. Apparently, our hearing organs are more sensitive to down speed. As far as known to the author, specific recommendations from elevator companies or medical experts do not yet exist. The investigation of these maxima is necessary, because for the planning of express elevators to Sky Lobbies standards or guidelines are required.

It is true that control of the interior air pressure of cars can optimize travel times; however, the time gains are small.

The maximum speed of express elevators to Sky Lobbies

Figure 1 shows the "car flight time" graphs for the up trip of an express elevator to a Sky Lobby at level 1000 m. The graphs disclose the car speed, travel distance, and the car travel time after the doors have fully closed until they start to open at the Sky Lobby. The graphs assume the car floor is level with the Sky Lobby floor when doors start to open.

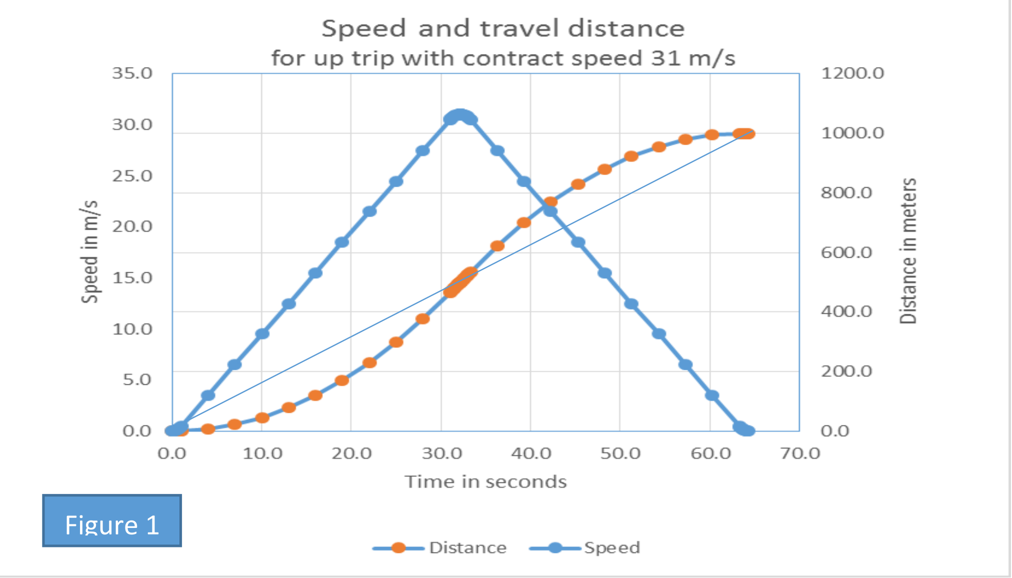

Figure 1

Note #:

If the air pressure at level 0.0 m is 1015 mbars, at level 1000 m it will be approx. 895 mbars.

The distance of 1000 m enables a car to accelerate to a maximum speed of approximately 31 m/s assuming acceleration and deceleration rates of 1 m/s^2. The periods for acceleration and deceleration are 32 seconds each. For a fraction of a second, the car will travel at its maximum speed of 31 m/s. The average car speed will be approximately 1000/64 = 15.6 m/s. The orange

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distance graph shows the car position (travel distance) and the air pressure in the hoist way during the up trip. See Note #. For an airtight car, the straight line between level zero and level 1000 m indicates the ideal car internal air pressure, which will give passengers the feeling as if the car is moving at a constant speed of 15.6 m/s. It is obvious, that during the first half of the up trip the car has to be de-pressurized and during the second half, the car has to be pressurized to maintain that feeling. On arrival at level 1000 meter, the doors can open, provided the rate of change of air pressure of speed 15.6 m/s was tolerable for passengers.

In case, the maximum tolerable up speed is 12.5 m/s the shortest possible car flight time over 1000 m is 1000 / 12.5 = 80 seconds. In this case, the maximum speed has to be reduced to 16 m/s to realize a car flight time of 80 seconds as shown by the speed / distance diagram of Figure 2.

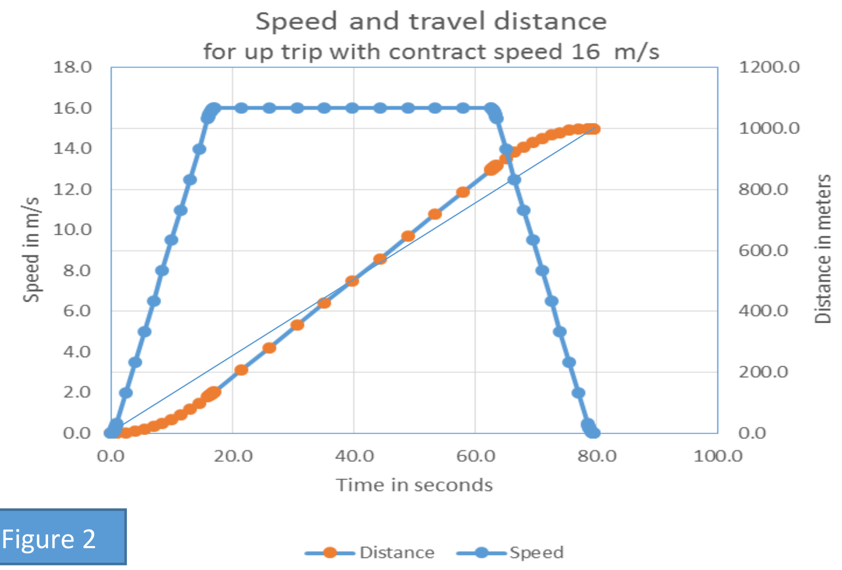

Figure 2

For this trip, the periods for acceleration and deceleration are 17 seconds each plus 46 seconds at 16 m/s. The total car flight time is 80 seconds. The straight line between level zero and 1000 m shows the internal air pressure of the airtight car, which declines as if the car is travelling at 12.5 m/s.

The speed / distance diagram Figure 3 is valid for a trip of a non-airtight car to level 1000 m and contract speed 12.5 m/s.

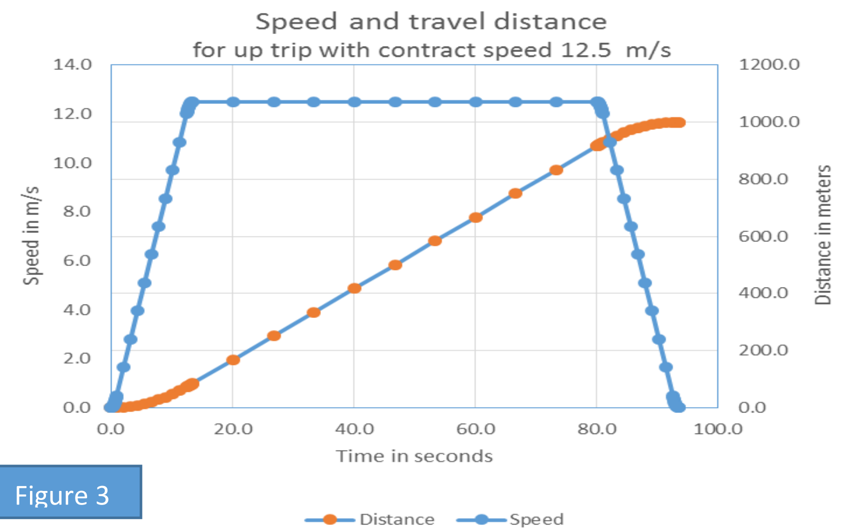

Figure 3

For this up trip, the periods for acceleration and deceleration are 13.5 seconds each plus 67 seconds at 12.5 m/s. The total car flight time is 94 seconds. The car flight time is 14 seconds longer in comparison with an airtight pressure-controlled car.

The speed / distance diagram Figure 4 shows the same data for a Sky Lobby at a level of 500 m. Over this distance, an airtight car can achieve a maximum speed of almost 22 m/s. The periods for acceleration and deceleration will be 23 seconds each and the total car flight time will be 46 seconds, The average car speed will be 500/46 = 10.9 m/s.

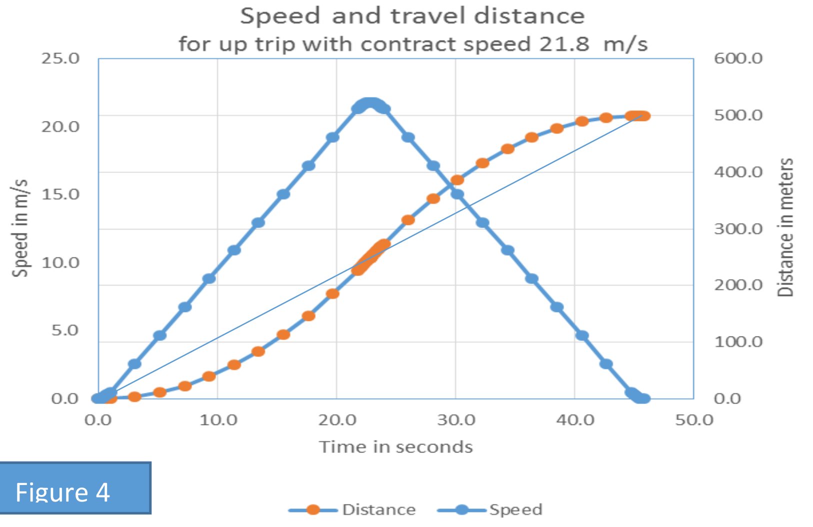

Figure 4

Figure 5 shows the car flight time for a non-airtight car to level 500 m. In this case, the periods for acceleration and deceleration are 13.5 seconds each and the period at contract speed is 27 seconds. The total car flight time is 54 seconds, i.e. only 8 seconds longer in comparison with the airtight and pressure controlled option. The average car speed is 500/54 = 9.3 m/s.

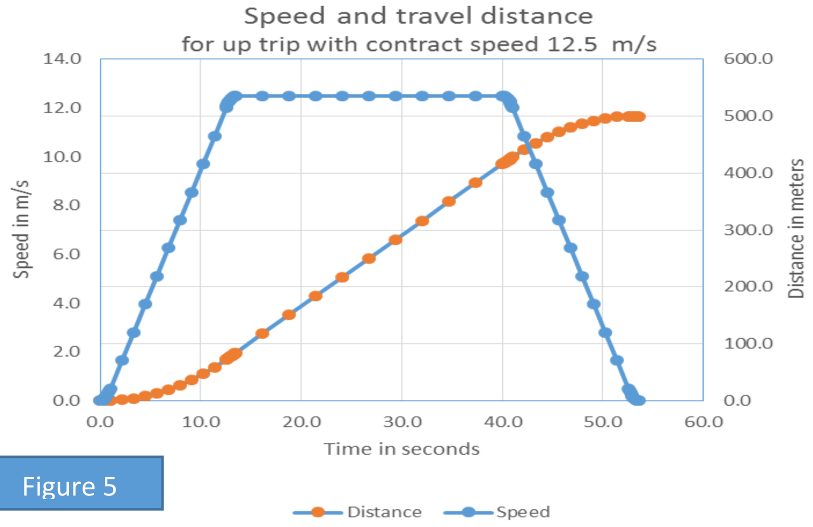

Figure 5

Car Flight Times for down trips

The time savings for down trips of airtight pressure controlled cars can be assessed with the same methods. For example, the shortest possible down trip, for an airtight car over a distance of 500 m,

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at speed 8 m/s, will be 500 / 8 = 62.5 seconds. For a non-airtight car and a maximum permitted speed of 8 m /s, the car flight time will be 71.5 s, i.e. 9 seconds longer.

Pressure controlled cars

Controlling the internal air pressure of airtight elevator cars is a complex technical problem, particularly if we consider ventilation and air-conditioning requirements. To make car doors airtight is a problem all by itself. In case a car is stopped, because of, for example, a power failure, an immediate solution for adequate ventilation will be required to prevent suffocation of passengers. Passengers of airtight cars will be exposed to new risks for modest time savings. High maximum speeds entail extra costs for drive systems, safety components, airtight cars, and energy consumption.

Concluding remarks

The writer doubts the viability of airtight cars. To precisely control, the interior air pressure of cars is technically possible; however, in combination with ventilation, air-conditioning, and two sets of doors (express cars usually have through openings) it certainly presents an undesirable technical and maintenance challenge.

For a round trip to a Sky Lobby at level 500 m the maximum time saving will be approximately 17 seconds.

It is obvious that the maxima for tolerable up and down speeds also apply for self-propelled cars.

The author’s articles in ELEVATOR WORLD can be read or downloaded via page: downloads.

P.S. The second line of the headings of the diagrams should be
“for up trip if contract speed is ……. m/s”

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