Floor Warden Control – a New Concept for Evacuation Lifts

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Abstract. We are introducing the Floor Warden (FW) controlled lift as a new concept for evacuating building occupants with the help of lifts. Existing evacuation lift concepts have the lift controlled either manually, by a member of the Emergency Response Team (ERT) present in the car, or (semi-) automatically supervised by an external third party Building Management System (BMS) and monitoring thus allowing self-evacuation. In the FW concept the lift is also manually controlled by a member of the ERT, but from the floor that will be evacuated, instead of being controlled from inside the car by a dedicated member of ERT. The advantage of this concept is that there is no need to appoint an extra ERT member exclusively for controlling the lift, thus making more efficient use of the ERT organization. On top of that the lift capacity is also used more efficiently, because 100% of the lift capacity is available for occupants that need to be evacuated. Based on this concept, we developed a system that can operate fully independently from external third party building systems, and has its own integrated intercom. It is therefore easy to implement in new or existing buildings. The system that we developed appears to be very simple in use. Details of the concept and its development are discussed in this paper.

1 INTRODUCTION

As a starting point of our development we analysed the current situation with regard to lifts being used for evacuation. The result of this study was published in a previous article [1]. One of the conclusions was that the various concepts that are available are rather complementary to each other, so there will be a market for each of them. However, another conclusion was that there is room for further development, more specifically for the development of a control system allowing a lift to be controlled from the landing of the floor that needs to be evacuated, rather than being controlled from inside the car. In the following sections we will give more comments about the current situation, and then explain our development of the Floor Warden control system.

2 CURRENT SITUATION / STATE OF THE ART

2.1 Literature

A long list of articles has been published about using lifts during fire emergencies. This proves the long existence of interest in this topic. In contrast to this literature the developments in this field seem to go relatively slowly, which can be explained by the concern which exists when it comes to actual application.

The main concern being discussed in literature is that of functioning of the lift being threatened by the results of fire, such as heat, smoke, water, or loss of power. As a result of all the literature one could come to the conclusion that there seems to be a certain common understanding of what would be needed to protect a lift against those threats.

A useful study of the literature in place is published by NIST as “Special Publication 1620” [2]

2.2 Practice

In our previous articles we have already discussed the evacuation lifts being applied as of this moment, especially with respect to ultra high buildings. Examples of such ultra high rise buildings are the Petronas Towers and Burj Khalifa [1,3] where the “Life Boat” principle is applied, as

described by Fortune [4]. According to this principle, occupants will first escape to a safe refuge floor, from which shuttle lifts will bring them to the main evacuation exit.

In the UK one will find more examples of lifts being assigned as evacuation lift, as the UK implemented the BS9999 [5] which specifies certain requirements for evacuation lifts.

In other countries, such as the Netherlands, if lifts would be applied for evacuation, the lift would be fitted as a firefighter lift in accordance with EN81-72 [6]. In some high buildings in the Netherlands arrangements are made with the fire brigade, allowing one of the two available firefighter lifts to be used as an evacuation lift. In these cases, members of the building's Emergency Response Team (ERT) are allowed to use the lift for that purpose. Examples of such buildings are Delftse Poort in Rotterdam and Rabobank Headquarters in Utrecht.

2.3 Regulations (codes and standards)

The main regulations that are currently in place for evacuation lifts are BS9999 in the UK, and A17.1 in North America [7].

The BS9999, "Code of practice for fire safety in the design, management and use of buildings" was published by BSI in the UK in 2008. It deals with fire safety of a building in general, but it dedicates one chapter to evacuation of the disabled, and some paragraphs to evacuation of persons in wheelchairs. Annex G of the document specifies recommendations for evacuation lifts and discusses the construction of the environment of the lift, the refuges, the power supply of the lift and the control of the lift. For the control of an evacuation lift 2 persons are needed: one person inside the lift for controlling it, and one on the main floor for coordination and communication.

The American Society of Mechanical Engineers (ASME) published in 2013 the document A17.1, "Safety Code for Elevators and Escalators". It describes Occupant Egress Operation (OEO) which allows occupants that are within the five closest floors to an emergency, to call for the lift and evacuate themselves. This is thus a completely different approach than the BSI approach presented in BS9999, and it aims at contributing to fast evacuation of any occupants from high rise buildings, rather than focusing on disabled persons or persons in wheelchairs.

Other regulations are still under development such as the draft prEN81-76 being developed by CEN with the aim of coming to a harmonized standard based on published technical specification CEN/TS 81-76 [8]. The approach is quite similar to that of BS9999, aiming at evacuation of disabled persons. In 2014 ISO published a Technical Specification ISO/TS 18870 "Requirements for lifts used to assist in building evacuation" in order to get some experience on the market before publishing it as an ISO standard [9].

Around the world building regulations are making more and more reference to using lifts for evacuation either for disabled persons in any building, or in the case of high rise buildings not only for disabled but for any occupants.

2.4 Summary of the current situation / analysis

Summarizing the current situation we could say that lifts are more and more accepted as a means for evacuating occupants from a building. In practice the focus is on high rise buildings where the Life Boat principle is applied, or where one out of two firefighter lifts is available for evacuation. Another focus is on evacuation of disabled persons. There seems good common understanding of the way the functioning of the lift should be protected.

With regard to control systems for evacuation lifts, we feel that there is room for development. At this moment evacuation lifts would be controlled either (semi-) automatically, or manually from

inside the car (see Fig. 1, left side). However, in many cases controlling the lift from the landing being evacuated would lead to certain advantages and more effective evacuation.

This is why we developed the Floor Warden control. The advantages of this concept will be discussed in the following parts. From our point of view these various kinds of control are complementary to each other (see Fig. 1, right side). In some cases they could even be combined in a single building.

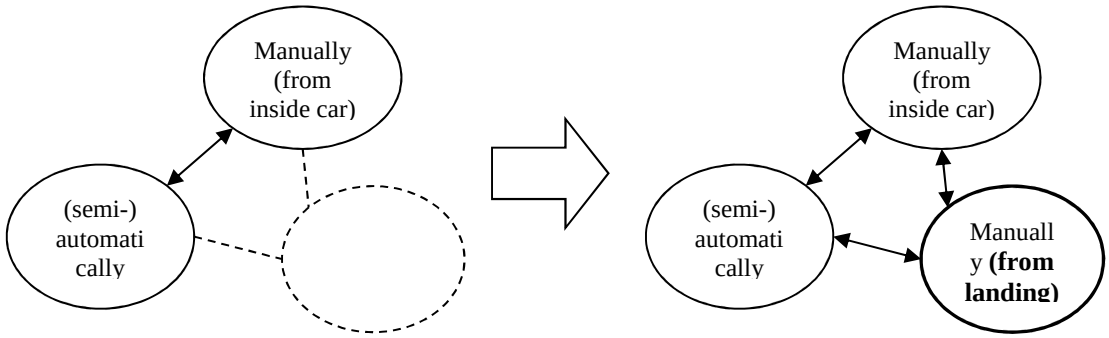

Figure 1 A new concept for the control of evacuation lifts

3 THE FLOOR WARDEN CONCEPT

3.1 Starting point

In our Floor Warden concept, the evacuation lift is not controlled from inside the car (manually, such as in BS9999), and not semi-automatically (as in A17.1), but from the landing that needs to be evacuated. Many buildings will have a kind of Emergency Response Team (ERT) or similar kind of organization. Within such organizations Floor Wardens are often appointed. These Floor Wardens would be the suitable persons to call for control over the lift in need of an emergency. This is why we called our concept the Floor Warden concept, sometimes abbreviated with 'FW'. One of the applications of the FW-control would be for the earlier mentioned Life Boat principle where occupants gather at a refuge floor, and lifts will shuttle between that floor and the main evacuation exit floor. The FW-concept makes it feasible to use this principle not only in very tall buildings but also in smaller buildings, and serving more than only one refuge floor. Indeed, all floors could be served if the number of emergency staff is sufficient.

With the Floor Warden concept we aim to achieve the following benefits (see Table 1):

Table 1 Aimed-for benefits of the Floor Warden concept

Aimed-for benefit	Explanation
Efficient use of ERT organization	There is no need to appoint an extra ERT member exclusively for controlling the lift or coordinating such as in BS9999. So, the staff of the ERT organization can be used more efficiently.
Reduced psychological work load	In the existing concepts the one person in the car has a complex task with large responsibility. This is reduced.
Panic Control	By controlling the lift from the landing, it will be easier to reassure occupants that remain on the landing if the car is full. And in the worst case it will allow the floor warden to keep persons away from the landing doors while closing.

Saving car space	The lift capacity is used more efficiently, because 100% of the floor area is available for occupants that need to be evacuated.
Wide range of applications	Our concept relates to a way of controlling the lift, but it is not restricted to certain application. For example it can be used for small buildings serving each floor for evacuation of disabled persons. But it can also be applied as the control system for Life Boat lifts that are used in tall buildings for evacuating occupants from intermediate refuge floors.
Simple and low threshold system	Independent from a Building Management System (BMS) or alike, such as required for the system described in A17.1. In addition to the above intrinsic advantages of the principle, the principle also allows the creatione of a system that can (when needed) operate independently from external systems such as a BMS. In order to keep this independency we also included a fully integrated intercom system.

In his article "On the development of Occupant Evacuation Elevators" [10] Dr. Albert So discussed some issues that arise with lifts that are controlled from inside the car. The benefits that follow from our FW concept seem to solve several of these issues mentioned by So.

3.2 Floor Warden control – the basic concept

The concept of the Floor Warden (FW) control is very simple, and has some similarity with the Life Boat principle. The basic routine is as follows (see also Fig. 2):

1) A floor warden takes exclusive control over the lift by operating the FW-key-switch with the special FW-key (either triangular key or unique cylinder key).
2) Any coincidental passengers are first delivered at the Main Evacuation Exit Floor (MEEF) before the lift arrives at the assigned floor of the Floor Warden.
3) Building occupants enter the lift under supervision of the Floor Warden.
4) By continuous pressure on one of the hall buttons, the doors will close and the car will shuttle to the MEEF.
   Step 3) and 4) are repeated until the Floor Warden has fully cleared his own floor.
5) When the floor is cleared, the Floor Warden will join the last group of passengers with their journey to the MEEF. He cannot close the doors with continuous pressure on one of the hall buttons, but instead the doors will close automatically just this one occasion when the Floor Warden gave up the priority control by switching back the FW-key-switch to its original position.
6) The lift will now become available for another Floor Warden on another floor.

The similarity with the Life Boat principle is that the lift will shuttle up and down between one floor and the MEEF. What we added to this principle is:

- We described a method of controlling the lift from outside the car, from the landing being evacuated.
- We developed a method to allow several floors to be served by one lift in an organized way with a simple algorithm for deciding the priority and order of serving: first priority goes to the Floor Warden who activates the FW-control for the first time, when 2 Floor Wardens are

waiting, the control system will pick the Floor Warden who asked for priority on the highest landing.

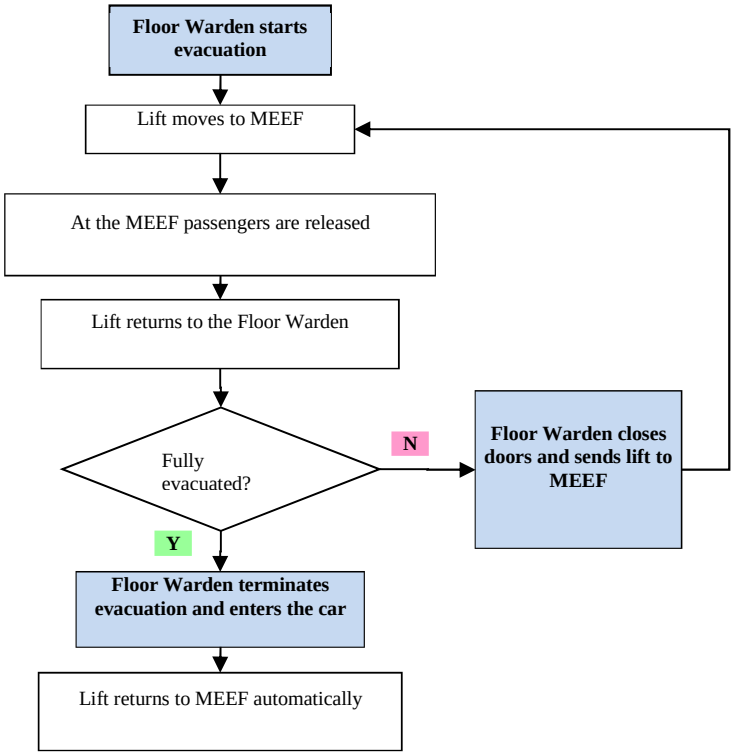

Figure 2 Basic routine of the FW-concept in case of a single Floor Warden

3.3 Applications

The most obvious application of the FW-control is within the Life Boat principle, where one floor in a high rise building is assigned as intermediate refuge floor. One or several lifts will shuttle up and down between this floor and the Main Evacuation Exit Floor (MEEF). The FW-control is particularly suitable for this application (see Fig.3, left example).

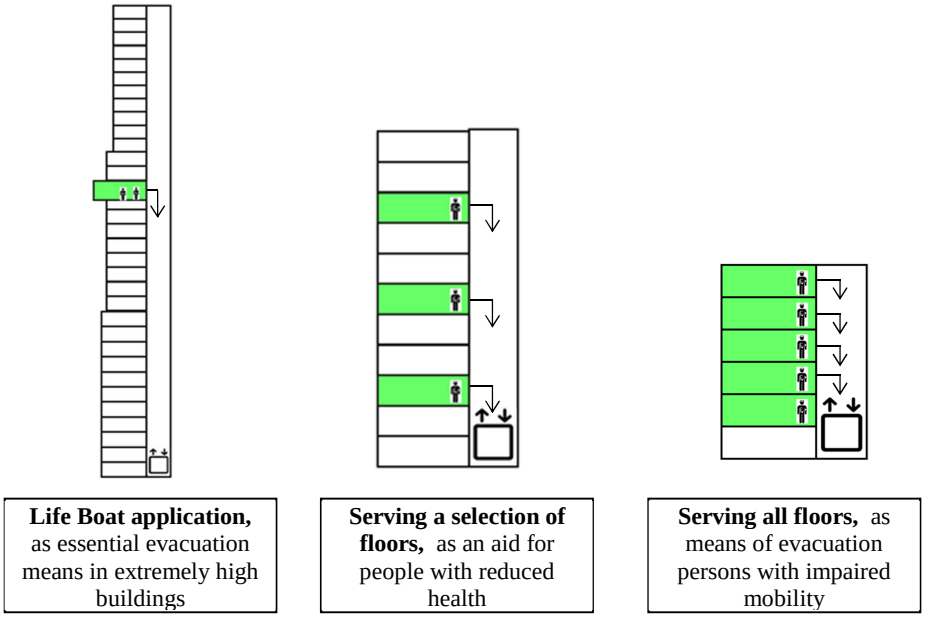

Figure 3 Possible applications of the FW-control system

However, with the system that we developed we aimed to make it applicable for various applications. For this reason we added the possibility to have FW-controls on more than one floor only. As a result it is up to the designer of the building which floors would be dedicated as FW-floors. One option would be to divide buildings into zones, each zone comprising several floors, and each zone to be provided with one collective refuge and FW-floor with FW-controls, as shown in the middle of Fig.3.

The building designer could even decide to install FW-controls on each of the floors. This would especially be the case if the FW-lift is being used as the main measure for evacuating persons with mobility problems or persons in wheelchairs (see Fig.3, right example).

4 DEVELOPMENT OF THE FW-CONTROL

Based on above concept we made a risk assessment, and developed countermeasures and several FW-functions.

4.1 Risk Assessment

As the starting point of our development we made an extensive risk assessment, which was also used to prove the compliance with the Essential Safety Requirements (ESR's) of the Lifts Directive. For this risk assessment we used the format of the risk assessment table as presented in EN-ISO 14798:2013 [11]. Some examples of risks and our countermeasures are presented in Table 2:

Table 2 Risks and countermeasures

Risk	Countermeasure
No fire alarm system in the building, or not functioning	The evacuation, or 'FW-mode' can be initiated by the Floor Warden who is present on the floor where the emergency is by means of FW-key-switch
Floor Warden may forget to give up priority, leaving the lift idle at the floor	1) Continuous pressure on hall button needed to send the lift away. 2) 'Self-evacuation' of Floor Warden only possible by switching the FW-key-switch to normal (giving up priority) 3) Automatic termination of priority after predefined time-out.
Unnecessary time waste at MEEF	1) The door-open time at the MEEF can be adjusted by parameter setting to shortest required time, before returning to the assigned FW-floor (at the MEEF, the door sensor remains active) 2) When rescue staff is present at the MEEF, the doors can be closed manually even before the pre-set time has exceeded.
Other Unnecessary time waste	When present in the building, a fire alarm system can direct the lift to the MEEF allowing coincidental passengers to leave the lift at the MEEF, even before a Floor Warden has initiated FW-control.
Power Failure	1) Power supply shall comply with the same requirements as that of firefighter lifts. 2) A battery pack will allow the lift to bring the passengers to the nearest floor with a protected lobby

4.2 Hall panels with Floor Warden control functions

In our concept, the designer of the building and/or evacuation plan has the freedom to assign one or several floors as 'Floor Warden-floor'. The hall panels on these landings will provide the special Floor Warden controls, either integrated or in a separate Floor Warden panel (see Fig. 4).

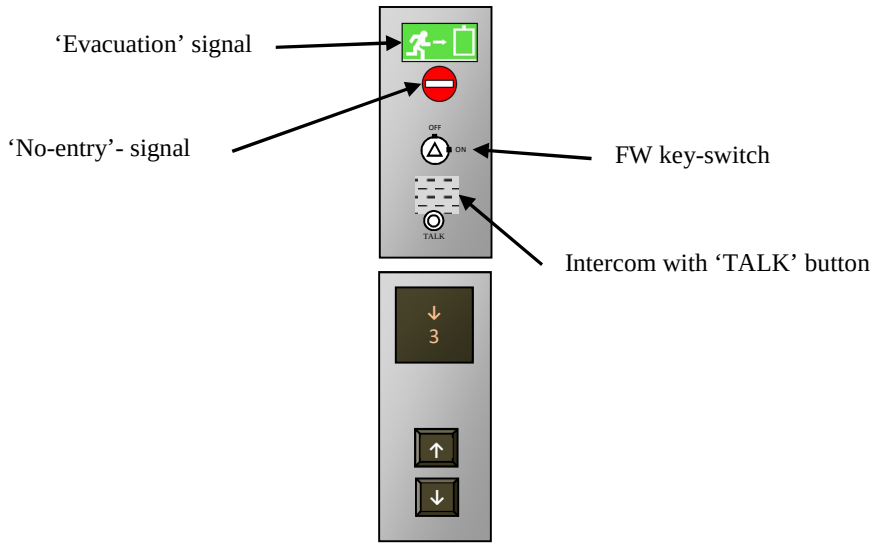

Figure 4 Hall panel with FW-functions

Upon directions of the fire brigade, additional functions can be provided on the main evacuation exit floor, so that the fire brigade can take over the control in a safe manner after their arrival when needed.

4.3 Interaction with building alarm

One of the advantages of our FW-system is that no alarm system is needed to start evacuation with the lift. The system can simply be initiated manually by means of the FW-key switch. However, when an alarm system is present in the building, it may be connected to the FW-system, and direct the lift to the main evacuation exit floor in a similar manner as described in EN81-73 [12]. This would further reduce the time for evacuation, because it will already release any passengers who happen to be traveling with the lift when an emergency is detected by the alarm. This would eliminate such home-return trip, which otherwise would be necessary when the FW-key switch is operated, while passengers are still using the lift.

4.4 Monitoring

The FW-control system is equipped with interfaces allowing signals from detection systems monitoring the safe environment of the lift. Some basic monitoring is always provided as a standard. When a dangerous situation is detected, the lift will be put out of service in a safe way, and this will be indicated by the 'No-entry' signal on the FW-panels.

4.5 Signalization

The FW-control system is provided with 2 signals, the 'lift-evacuation' or 'evacuation' signal (internally we would abbreviate this as the EV-signal), and the 'no-entry'- signal. The illuminated status of these signals shows the operational mode of the lift. The meaning of the illuminated signals is explained in Table 3:

Table 3 Signalization & mode of operation

Signal	Operational mode	Remarks
No signal illuminated	Normal service	
Evacuation signal illuminated continuously 	Floor Warden operation	One Floor Warden has operated the FW-key-switch and has control
Blinking 	Waiting queue	One Floor warden has control, a second Floor Warden has also operated the FW-key-switch and is waiting for control
No-entry signal 	No service	Situation 1) the building alarm has terminated normal service, the lift is ready for FW-control
		Situation 2) FW-control overruled, either by building monitoring, or by fire service.

4.6 Intercom

During FW-mode, an intercom system allows the Floor Wardens to communicate with passengers in the car, and also with each other. Floor Wardens will need to press a 'TALK'-button, to make themselves heard. Passengers do not need to press a button; the microphone in the car is always open when the lift is in FW-mode. The messages will be heard on all intercom stations.

5 EVALUATION

5.1 Review of prototype

Apart from the risk assessment, which was revised several times, we built a prototype and had it reviewed by experts and users with different backgrounds. This helped us to further improve the design of our FW-system. Even after the type certification of our system by the Liftinstituut, a well respected notified body from the Netherlands, we continued with reviewing and further improvement.

5.2 Evaluation of aimed benefits

As a conclusion of this paper we make an evaluation based on the benefits that we aimed for when we started the development. The evaluation of these benefits is listed in Table 4 below.

Table 4 Evaluation of the aimed-for benefits of the Floor Warden concept

Aimed-for benefit	Evaluation
Efficient use of ERT organization	**Achieved**. No need to appoint 2 extra members for controlling the lift as in prEN81-76 or BS 9999 ***Remark:*** Each assigned floor will need at least one Floor Warden. In some cases this may result in a need for extra staff. Some floors may need extra staff for controlling the FW-lift
Reduced psychological work load	**Achieved**. No person has the single responsibility of controlling the lift until evacuation has completed. Floor Wardens have good overview and control over their own floor.
Panic Control	**Achieved**. Floor Warden at the floor can reassure passengers who are waiting, and if needed the Floor Warden can guard off the lift door when closing.
Saving car space	**Achieved**. No need for a Floor Warden to be present in the car. Car capacity fully used for evacuation of occupants ***Remark:*** This benefit only counts when larger groups need to be evacuated.
Wide range of applications	**Achieved**. The FW-system can be applied both in low rise as in extreme high rise, and intermediate rise. It can be applied for evacuation of occupants with mobility problems, serving every floor, or large groups in tall buildings. ***Remark:*** Only applicable in buildings where there is some form of emergency organization ***Remark:*** There is a limitation in the number of floors that should be served by one single lift in order to avoid waiting queues;
Simple and low threshold system	**Achieved**. Intercom is integrated and, if needed, the FW-system can be used as simple standalone system, independent from fire alarms or other third party building systems. Controlling the FW-system appeared to be simple and easily understood.

6 CONCLUSION

We have developed a new control system which can be used effectively for evacuation of occupants from buildings where some kind of emergency organization is present. The FW-control system is controlled from the landing on the floor that needs to be evacuated. This is a new way of controlling, and is a useful supplement to the control systems that already existed. When starting the development we aimed to develop a simple and low threshold system, that is simple to use and with a broad range of applications. The system that we developed seems to meet these goals. We obtained type-certification under the Lifts Directive, and the development is now reaching its final steps.

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BIOGRAPHICAL DETAILS

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