Elevators in Emergencies: The Firefighter’s Perspective

By Larry Pigg
Executive Summary

For more than 40 years, the elevator industry’s message has been crystal clear: “Do not use an elevator during a fire.” That message was formalized in 1973 after a series of fatal fires in New York during the late 1960s and early 1970s prompted change. Prior to that, occupants tried to exit a building during a fire using elevators, stairs or any other available means of egress. Today, the elevator industry is taking a hard look at whether to change that message. The terrorist attacks of Sept. 11, 2001 have opened debate regarding whether elevators should be used during a fire. The debate is being fueled by the facts surrounding the evacuation of the World Trade Center. The fire service is now being forced to embrace change regarding the use of elevators for both tactical fire fighting and evacuation operations. This paper will discuss long held historical perspectives and explore emerging technologies.
Introduction

In the long history of fire prevention & protection in America, there have been many occasions where fire and life safety officials have taken major steps to enhance the level of survivability of occupants in a fire scenario by updating the fire and building codes requiring that business owners make substantial changes to existing structures and occupancies. Unfortunately, most of these changes have come as a result of catastrophic high-fatality fires that prompted a public outcry. History is full of examples. The “Shirtwaist Factory Fire”, the “Coconut Grove Night Club” and the “MGM Fire” all resulted in significant changes being made to both the new construction and to existing structures. Some fire officials will say that they do not have the authority to require these changes to older, existing structures. History does not support this position. Local officials, prompted by the political leaders, are just one major incident away from public scrutiny and being forced to make major changes.

Tragedy Mandates Change

September 11, 2001 changed everything. It changed us socially, in our awareness of terrorism and how those tasked with public safety approach their jobs. One area that has undergone incredible scrutiny and re-evaluation is how high rise elevators are utilized in an emergency. Conventional wisdom and established rescue tactics changed on 9/11. The use of elevators has historically been considered off limits for evacuation during fire emergencies, favoring the concept of a protected free flowing evacuation corridor like stairwells. However, this philosophy is increasingly being reconsidered—especially for “super” high-rise buildings in which stairs may not be the best evacuation option for people with disabilities or health issues like asthma or arthritis, not to mention the time involved.

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High Rise Fire Data

- Each year, an estimated 15,500 high rise structure fires cause 60 civilian deaths, 930 injuries, and $252 million in property loss.
- High rise fires are more injurious and cause more damage than all structure fires.
- Three-quarters of high rise fires are in residential structures, but these cause only 25% of dollar loss.
- The leading cause of all high rise fires is cooking (38%), but cause patterns vary by property type.
- 69% of high rise structure fires originate on the 4th floor or below; 60% occur in apartment buildings; 43% originate in the kitchen.
- High rise fires are inherently more difficult for the fire service.

Sources: NFPA
National Fire Incident Reporting System (NFIRS)

In the wake of the tragic events of September 11, 2001, high rise fires and high rise firefighting tactics have assumed a more prominent role in the consciousness of the U.S. fire service and American society as a whole.

Recently, several large cities, including Boston and New York, have experienced a number of hallway fires in high rises. The incidence of fires in hallways is troubling in that occupants must generally travel through a hallway to exit the structure, and firefighters will need to use that same hallway for rescue.

Source: USFA
Unique High Rise Fire Challenges

High rise structure fires pose a number of challenges both to the occupants and to the fire service. Several of these include:

- By nature of their height, smoke movement in high rise structures is very different from that of other structures. Temperature gradients result in varying pressures throughout the structure, which can allow for the rapid, uncontrolled movement of smoke and flame (known as the “stack effect”).

- High rises often contain multiple types of occupancies, including residential, commercial, restaurant, and underground parking. Each type of occupancy poses a challenge to firefighters and must be approached differently.

- By design, exits from high rise structures are limited. In an emergency, the movement of people out of a building is particularly difficult.

- The HVAC and other utilities in some high rises service multiple levels and can facilitate the spread of smoke and flame through a building.

- High rise structure fires require significantly more personnel and equipment to extinguish than do other types of fires. This further strains the responding fire department and firefighters.

- By their vary nature, fire department response times are significantly lower than the national average (Responding, Staging, Rescue, Extinguishing).

Source: USFA

Elevators as a Solution

Why utilize emergency elevators? There is only one reason: Speed. The world’s two fastest elevators, located in the Taipei 101 building in Taiwan, carry people from the ground to the top (101st floor) in 39 seconds, or 25 mph. Elevators in modern towers are designed to move 12.5 percent of a building’s occupants within five minutes. That means a building can be completely evacuated within 40 minutes. Compare that to evacuation times of one or more hours through a stairwell in a tall building. On September 11, 2001 the south tower of the World Trade Center collapsed only 56 minutes after being struck. If, on average it took 1 minute per floor to egress the building given the overflow of people and those needing assistance, that would equate to roughly 1 ½ hours to descend all the way to the ground. At that rate those on the upper floors of WTC still had 30 floors or more to traverse when the building came down.
Only 14 people that were in the impact zone survived.

Combined with post-9/11 concerns, the unique characteristics of such high rise buildings has shifted the focus solely from phased and partial evacuation to the capability of full building evacuation, making elevators a critical part of the overall emergency egress system. With elevator-assisted evacuation now being allowed and corresponding changes to the model fire and building codes, the subject bears a closer look.

### Elevator Construction

Before we can examine and consider elevators for tactical use in an emergency we must understand how they operate and their inherit safety features. There are two main types of elevators commonly used: traction and hydraulic; however, there are a number of variations on each type. The ones used in high-rise buildings are electric traction elevators, and that is primarily because according to code a high-rise building is any building over six stories and hydraulic elevators are not reliable or fast enough for use at those heights. Everyone has felt this difference. Get on to an elevator at a nice 3-4 story hotel or office building. The elevator car moves so slowly and jerky that it is unnerving to some people. In a fire the hydraulic fluid that pressurizes these systems is unreliable and is, in most cases, flammable. Contrast this to an electric traction type which are fast, safe and rarely fault or get stuck between floors.

**Hydraulic elevators** are supported by a piston at the bottom of the elevator that pushes the elevator up. They are used for low-rise applications of 2-8 stories and travel at a maximum speed of 200 feet per minute. The machine room for hydraulic elevators is located at the lowest level adjacent to the elevator shaft.

**Conventional Hydraulic Elevators** have a sheave that extends below the floor of the elevator pit, which accepts the retracting piston as the elevator descends. Some configurations have a telescoping piston that collapses and requires a shallower hole below the pit. Max travel distance is approximately 60 feet.

**Holeless Hydraulic Elevators** have a piston on either side of the cab. In this configuration, the telescoping pistons are fixed at the base of the pit and do not require a sheave or hole below the pit. Telescoping pistons allow up to 50 feet of travel distance. Non-telescoping pistons only allow about 20 feet of travel distance.
Traction Elevators

**Traction elevators** are lifted by ropes, which pass over a wheel attached to an electric motor above the elevator shaft. They are used for mid and high-rise applications and have much higher travel speeds than hydraulic elevators. A counter weight makes the elevators more efficient.

**Geared Traction Elevators** have a gearbox that is attached to the motor, which drives the wheel that moves the ropes. Geared traction elevators are capable of travel speeds up to 500 feet per minute.

**Gear-less Traction Elevators** have the wheel attached directly to the motor. Gear-less traction elevators are capable of speeds up to 2000 feet per minute.

**Machine-Room-Less Elevators** are typically traction elevators that do not have a dedicated machine room above the elevator shaft. The machine sits in the override space and the controls sit above the ceiling adjacent to the elevator shaft. Machine-room-less elevators are becoming more common; however, many maintenance departments do not like them due to the hassle of working on a ladder as opposed to within a room.

Historical Elevator/Fire Operation

Elevator use in America is governed by the American Society of Mechanical Engineers (ASME) A-17 life safety code for elevators and escalators. These standards have been adopted throughout the fire service and are the accepted operating standards. Under ASME standards, once a fire has been detected, elevators operate under either Phase I or Phase II regulations. Under Phase I Operation, elevators that are 25 feet or more above the main floor return either to a designated landing area or an alternate area. Phase I operation is activated either manually by a special key, or automatically by a fire alarm initiating device. A sensor could detect smoke in the hoistway or machine room, for example, and trigger Phase I. The goal is to remove the elevators from service so that building occupants do not use elevators during a fire and become trapped. Phase II Operation is an override meant for firefighters after Phase I has been activated. Under Phase II operation, firefighters can use a key switch to operate the elevator, provided the hoistway is clear of smoke and the elevator has electricity.
Change

Things started to change in the way people looked at elevators as possible escape routes at an elevator industry conference in 2004. There were a number of both technological and human obstacles.

• How do you prevent overloading?
• How do you tell people what a particular elevator can and cannot do?
• How do you keep the elevator lobbies clear of the fire?
• How long will they have to operate during a fire?
• Could they be operated by trained civilians?

Many in the fire service resist the idea of civilians’ operating elevators during emergencies, even after the systems have been engineered to protect them against fire, smoke, and water intrusion. They argue with good reason that such systems are not failure-proof and that operators need the equipment and training to deal with such emergencies. They also argue that civilians lack the training and discipline needed to run a coordinated and efficient rescue operation. On the other hand, the arguments for allowing trained civilians to operate the elevators are also persuasive. Most importantly, seconds count during building emergencies, and a considerable amount of time can elapse before a fire department can respond, assess the situation, and begin rescue operations. During these critical minutes, elevators can be used to evacuate people who may otherwise suffer injuries or death, because they eventually were overcome by spreading fire or smoke after having been trapped or delayed while waiting to access crowded stairs or for rescue because they couldn’t use the stairs. Firefighters will have the option of taking over elevator operations when they are ready or leaving it in the control of civilian responders. Everything considered, my best guess is that the advantages of starting evacuations with trained building occupants are too great not to use elevators before emergency responders can take charge, but only if the strategies, operator interfaces, and training are carefully designed, executed, and maintained.

While the analysis showed that elevators could be safely used in a fire, many questions would still remain to be addressed before new requirements went into effect. One question that arose was how these systems would be phased into the market. The development of these standards took several years. It took the intervention of several powerful groups of fire professionals to make it happen, the National Association of State Fire Marshals (NASFM), International Code Council (ICC), and the National Fire Protection Association (NFPA).
The Codes and Standardization

The fire and building codes generally do not give guidelines on when a building should be evacuated. The code simply lists the key safety features that a structure must have to offer a safe passage out in an emergency. Fire sprinklers, alarms, positive pressure smoke proof exit enclosures, directional signage along with an emergency communication system help people evacuate in a timely manner. We said earlier that modern tactics and conventional wisdom regarding evacuation do not normally include the use of elevators, but the code does not absolutely prohibit their usage. There are signs that read: “IN FIRE EMERGENCY, DO NOT USE ELEVATOR. USE EXIT STAIRS”, but it also gives guidance for emergency communication and firefighter override that does offer the capability that they can be utilized when managed by emergency crews when the opportunity for safe egress arises.

In an effort to bring some level of standardization to the collection of keys in use and offer a more reliable tool for first responders, the National Association of State Fire Marshals (NASFM) introduced a significant code change proposal to both the ICC and NFPA for consideration and adoption into the 2012 code cycle. These proposals were overwhelmingly approved into the 2012 codes. The code changed into the International Building Code, which covers new construction reads:

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**INTERNATIONAL BUILDING CODE**


607.5 Standardized Fire Service Elevator Keys.

“Buildings with elevators equipped with Phase I Emergency Recall, Phase II emergency in-car operation, or a Fire Service Access Elevator shall be equipped to operate with a standardized fire service elevator key approved by the fire code official.”

Exception. “The owner shall be permitted to place the building’s non-standardized fire service elevator keys in a key box in accordance with Section 506.1.2”
In their overall code change proposal, NASFM addressed the thousands of elevators that are already in use and submitted a code change proposal that would be cost effective and still provided a limited access, secure retrofit option: the key box.

2012 INTERNATIONAL FIRE CODE 506.1

“Where access to or within a structure or an area is restricted because of secured openings or where immediate access is necessary for life-saving of fire-fighting purposes, the fire code official is authorized to require a key box to be installed in an approved location. The key box shall be of an approved type listed in accordance with UL 1037 and shall contain keys to gain necessary access as required by the fire code official.”

Likewise the National Fire Protection Association has passed very similar code language including the requirement that any and all boxes used for emergency access be listed against physical attack by Underwriters Laboratories.

2012 NFPA 1: 18.2.2.1

“The AHJ shall have the authority to require an access box(es) to be installed in an accessible location where access to or within a structure or area is difficult because of security. The access box(es) shall be of an approved type listed in accordance with UL 1037.”

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UL 1037

What does “Listed” mean?

In the context of fire protection and life safety, ‘Listed’ refers to products that have been tested and meet nationally recognized performance standards acceptable for project implementation. By code, these products are on a list published by an approved testing laboratory. While there are several good testing organizations, the two premiere testing labs in America are: Factory Mutual-FM and Underwriters Laboratory-UL. Factory Mutual, along with providing risk management and commercial insurance services, evaluates and approves products like glass flood barriers and combustible dust ignition control devices that support commercial property fire and disaster loss prevention. Federal regulations and OSHA recognize UL and FM as Nationally Recognized Testing Laboratories. If a product is listed by one of these two independent premiere testing laboratories, individuals, including fire and building officials, can rely on the product and with confidence allow it to be used in their jurisdiction.

UL 1037 Standard for Antitheft Alarms and Devices applies to the construction, performance, and operation of equipment intended to provide antitheft protection.

UL 1037 Testing Parameters:

- An antitheft device is intended to protect property by significantly limiting the mobility or portability of the property.
- An antitheft device, as defined in 1.3, shall resist for at least 5 minutes an attack that would defeat its purpose. See 53.5.
- Any disassembly of the protected property required to make it removable, is to be included in the 5 minutes of an attack test.
- The tools used in the test are to include hammers, chisels, adjustable wrenches, pry bars, punches, and screwdrivers. Hammers are not to exceed 3 pounds in head weight, and no tool is to exceed 18 inches in length.
- The product under test is to be mounted securely in its intended position, and the attack is to be performed by one operator.
- If the attack would cause an audible alarm to operate, the duration of the attack may be reduced to 2 minutes.
Firefighter Emergency Elevator Service:

**Phase I** – In Phase I service, a smoke detector is installed in each elevator lobby. Activation of the smoke detector causes the elevator to recall to the designated floor, which is usually the ground floor of a building. Upon arrival, the elevator door opens and the elevator is no longer operable by the occupants.

**Phase II** – Phase II firefighter service allows firefighters to control the elevator and travel to any floor served by the elevator.

Explanation of the Code Regarding Elevators

The following section is excerpted/reprinted with permission from “Significant Changes to the International Fire Code” by Scott Stookey, 2012 Edition

Requirements for the design, construction, and testing of elevators are contained in ASME/ANSI A17.1, *Safety Code of Elevators and Escalators*. ANSI A17.1 requires all new elevators to be equipped with Phase I and Phase II firefighter service features. In Phase I service, a smoke detector is installed in each elevator lobby. Activation of the smoke detector causes the elevator to recall to the designated floor, which is usually the ground floor of a building. Upon arrival, the elevator door opens and the elevator is no longer operable by the occupants. In any building that is equipped with an elevator having a travel distance of more that 25 feet, IFC Section 607.1 requires that it be equipped with Phase I firefighter service. This requirement is applicable to all new and existing buildings. In the event a smoke detector fails or if emergency responders wish to use the elevator such as for the transportation of equipment in the treatment of a patient, a key switch is provided in the elevator lobby. Activation of the key switch captures the elevator and recalls it to the floor level where the switch was activated.

Phase II firefighter service allows firefighters to control the elevator and travel to any floor served by the elevator. The operating controls are located inside of the elevator car. When the elevator is placed into the fire service mode, the elevator can only be operated by personnel in the elevator car. To return the elevator to normal service, the elevator must be reset using the Phase I switch.

2012 IFC sections 506 and 607.5 establish new requirements for elevator keys used by the fire service. The provisions in Section 506 address non standard elevator keys. The provisions in Section 607.5.1 now require that keys for any new elevators installed in the jurisdiction use a standard format, regardless of the manufacture or model. Standardizing the type of elevator key creates a consistent arrangement for firefighters who utilize the elevators for EMS incidents, or for the deployment of personnel and equipment in a multi-story firefighting operation. The keys must be manufactured to prevent unauthorized duplication and their access is limited by Section 607.5.2 to emergency responders, elevator mechanics, fire officials, and the building owner. Section 607.5.4 requires that at least three keys of the same standard design be provided when an elevator is installed and is equipped with Phase I and II service or is a Fire Service Access Elevator.
Since 2006, ASME/ANSI A17.1 has required the installation of a standard key and switches for fire recall, fire operation, and, when provided, emergency power. The key is interchangeable with all of the required switches. This common key has become standard for the operation of the firefighter emergency operations (FEO) systems, regardless of manufacturer. The key is designated as “FEO-K1” and is marked as such.

Many jurisdictions have elevators built prior to the introduction of a standardized elevator key, and as a result each building with an elevator requires its own elevator key. The key is most likely based on the model of the elevator and the year it was manufactured. Section 506.1.2 sets forth new requirements to assist jurisdictions in managing the issue of different elevator keys in different buildings. This section authorizes the jurisdiction to require the installation of a key box to house elevator keys. The new provisions specify where the key box is to be located inside the building and require it to be compatible with the existing key boxes used by the jurisdiction. The exception to Section 506.1.2 permits installations adjacent to fire command centers or in other locations where approved by the fire code official.

Section 506.1 was modified by requiring that key boxes installed under the 2012 IFC be listed as meeting UL 1037-99, Standard of Antitheft Alarms and Devices. Previous editions of the IFC did not require the jurisdiction to select key boxes that were listed. Based on the new revision to Section 506.1, any fire department key box now must be listed in accordance with UL 1037.

**Elevator Door Tool**

Different from the emergency elevator key used to control the elevator cars is the elevator door tool. Sometimes referred to as a key, it is actually a mechanical pry tool that helps rescue workers manually open the outside doors on each floor adjacent to the elevator cars. Why does it exist?

*The elevator door tool is a mechanical pry tool that can be used to open the elevator bay doors from the outside, even when the elevator car is not present.*
Deadly Surfing

During the 1970s and 1980s, there were several accidents involving elevator passengers who manually pried open the car doors and attempted to exit an elevator stopped between floors. Youngsters living in public housing projects and students in college dormitories have been known to pry open the car doors of a moving elevator, which immediately stops the hoisting machine and sets the brake. This can stall the elevator between floors, enabling the passengers to climb on top of the car. “Elevator surfing,” as it is called, is undoubtedly a thrilling experience, riding the top of an elevator traveling at high speeds. Unfortunately, some of these “surfers” were killed when they were crushed between the elevator car hoistway (shaftway), counterweights. As a result of reported injuries and the need to make these elevators a safe environment for people, the American Society of Mechanical Engineers, has incorporated required door restrictors since 1980. Additionally, the fear of liability for elevator accidents has resulted in the retrofitting of door restrictors on many older elevators.

Safety Mechanisms

There are two basic types of mechanisms in these door opening devices, commonly called door restrictors. The clutch-type restrictor consists of a latch located at the top of the car doors. On some assemblies, the latch is released, permitting the car doors to fully open when the clutch or driving vane on the car doors lines up with the release rollers of the shaftway door. When the elevator is within its landing zone, the hoistway door release rollers depress a release mechanism located next to the driving vane or clutch of the car door. The release mechanism is connected to the latch at the top of the car doors by a reach rod, similar to the linkage between the door release rollers and the interlock at the top of the hoist way doors. The key to releasing this type of restrictor is to duplicate the pressure of the hoistway door release rollers on the restrictor release located on the car door. When the release mechanism is within reach, simply depress it and push open the car doors. When an elevator is too far above or below a floor landing to reach the release by hand, use a pike pole to depress the release or access the top of the car from a landing above the elevator and directly release the latch at the top of the car doors.

The second basic type of door restrictor, the angle iron restrictor (commonly found on Otis elevators), consists of projections fastened to the car door and hoistway similar to an angle iron. When an elevator equipped with this restrictor is outside its landing zone, the car door restricting angle will strike the angle iron on the shaftway doors and
the shaft, preventing the car door from opening more than four inches. The car door can only open completely when the elevator car is within its landing zone, where the car door angle and shaftway angles do not line up to strike each other. On older installations, the angle-type door restrictor could not be manually released. Some Otis elevators, however, have restrictors that are hinged and spring-loaded. Depressing the angle on the car door will allow it to clear the angle iron fastened to the hoistway and hoistway doors.

**Conclusion**

As with all fires, those that occur in high rise structures are largely preventable, and while they are convenient high rise residences offer unique challenges to first responders.

Elevators in tall buildings can be safely operated during fire and other emergencies and have the potential for improving emergency operations. Even if used solely by fire departments, suppression and rescue operations could be significantly improved. However, before emergency responders begin their tactical operations these systems could be used to especially great effect in evacuating occupants more quickly, to the very great benefit of those persons unable to easily descend stairs because of disabilities and injury.

Engineering the safety hardware to prevent intrusions of heat, smoke, and water is not the primary obstacle. The greater challenge is in the real-world use of these systems—in the strategic planning, interface design, and operator training that will enable the safe, effective, and efficient use of elevators during emergencies. Installing protected elevator systems without attention to these concerns will result in an unacceptable risk to using the systems. However, by working out the details of strategic planning and tactics, the human factors of functional design and appropriate training for operators, these systems will be entirely workable and will reduce the risk to building occupants and emergency responders.

An emergency elevator key is an important tool for firefighters. The key allows firefighters to access the interior of the elevator shaft housing of an elevator car to initiate rescue in the case of emergency or the loss of building power. Most often, an elevator key is used to capture and control an individual elevator. However they are used, these keys must be located in close proximity to the elevator car and must be secured in a safe container, only accessible to rescue workers. This is an emerging technology that will take years to implement and administer.

**Photo Courtesy of Peter Ubriaco**

*This is an Otis Elevator locked out in Phase I Firefighter Operation. When the “Firefighter Helmet” indicator lamp is lit steady, a smoke or heat alarm was activated on one of the landing floors. When the indicator flashes, the smoke or heat alarm was activated inside the machine room or hoistway.*

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**Code Compliant Solution**

The Knox Elevator Key Box is a UL 1037 Listed high security box designed specifically for the elevator lobby. The standard size elevator box has room for 2 elevator door access tools and up to 30 emergency override keys. This UL listed key box offers superior resistance to physical attack than the average elevator key box. This all steel box comes standard in Deep Red with the “Fire Dept. Use Only” banner as required by the IFC and NFPA standard. The Knox Elevator key box can be keyed to a department’s existing Knox System. The Knox Elevator Key Box comes in four standard colors, Deep Red, Aluminum, Dark Bronze and Black to accommodate code requirements and interior design preference. It is also available in a “Mini” model that stores keys only.
References

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Note:

For the purposes of this report, a high rise structure is defined as a structure that has an occupied floor of 75 feet or greater in height. This definition is based on the 2009 IBC Definitions for High Rise Buildings:

2009 International Building Code Chapter 2, Definitions:

“A building with an occupied floor located more that 75 feet (22,860 mm) above the lowest level of fire department access.”
About the Author

Larry Pigg retired from the Garland, Texas Fire Department in 2000 to join the Knox Company as Director of Public Affairs. Larry’s experience ranges from line firefighter, fire investigator, to fire inspector/plans examiner. Larry is certified by the State of Texas as a Master Firefighter, Investigator & Fire Inspector. Larry is a voting member of NFPA and serves as a Principal member on several committees, including: NFPA 1037, Fire Marshal Professional Qualifications, 551 Risk Assessment, and 550 Guide to Fire Safety Concepts Tree. Larry is also a past member of the ICC Standards Council (ISC) and a member of the ICC Disaster Response (EDC), which develops testing criteria for post disaster incident inspector certification. Larry holds a Bachelor of Science degree in Emergency Administration and Planning, and a Master of Public Administration, both from the University of North Texas, Denton Texas.

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