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ABOUT CTBUH

The Council on Tall Buildings and Urban Habitat (CTBUH) is a non-profit organization headquartered at the Illinois Institute of Technology in Chicago, Illinois, whose membership includes architects, engineers, planners, technical specialists, building officials, builders, building owners and managers.

CTBUH is the only organization in the world that brings together all technical disciplines involved in the creation of the built environment.

CTBUH draws strength from the multi-disciplinary interaction of more than 3000 design and construction professionals located in 50 countries.

CTBUH focuses on issues related to tall buildings and the urban habitat.

CTBUH's mission is to: 1. Disseminate information on tall building technology and healthy urban environments; 2. Maximize the international interaction of professionals involved in creating the built environment; 3. Communicate the latest knowledge in a useful form.

CTBUH is the recognized source for information on tall buildings worldwide.

CTBUH publishes the CTBUH Review, which includes papers submitted by researchers, scholars, suppliers of building products and materials, and professionals engaged in the planning, design, construction and operation of tall buildings and urban environment throughout the world.

CTBUH hosts and maintains the "High-Rise Buildings Database", which contains data on thousands of tall buildings: the latest facts and statistics, still images, and listings of professional firms linked to specific buildings.

CTBUH hosts conferences around the globe on topics relating to tall buildings and urban habitat.
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1. INTRODUCTION

This Guideline will identify key issues that design teams should consider in the development of emergency evacuation systems. It is intended to serve as a tool for design teams who are considering the use of elevators as a part of the egress system serving their designed structure. Building designs, and the ultimate use of structures, vary widely enough that no two structures are likely to have the same design criteria.

Using elevators for evacuation has been a controversial topic during the past few years as reflected by the extensive research and development, publication and debate on the subject. As our structures reach ever so higher into the sky, and the type and impact of threats to them increase, design teams are faced with a myriad of challenges in considering how a structure is to be evacuated. The basic philosophy of protecting building occupants in place (i.e. not completely evacuating them from a building) may need to be reconsidered in high-rise structures. This may necessitate the use of elevators for total evacuation of a 100-story tower if the goal were to evacuate such a structure in less than 30 minutes!

Currently used egress systems are not comprised solely of stairs in protected envelopes. Rather, they are comprised of fire resistive building construction, compartmentation, fire detection systems, occupant notification systems, fire suppression systems and the interaction of these emergency systems with the building systems that are responsible for normal operation of a building. Therefore, careful consideration to the use and interaction of elevators in an emergency egress system is paramount to the overall life safety afforded to building occupants. Nothing in this Guideline is intended to suggest that elevators can or should be the sole means of egress used in a structure.

This guideline focuses on the use of the emergency egress system by distinguishing between evacuation-enabled elevator systems intended for Total, Staged or Fractional evacuation. The required elevator traffic handling capacities and durability requirements are different in Total, Staged or Fractional evacuation scenarios. Three design approaches for designing emergency evacuation elevators related to three generic evacuation types are outlined and one emergency evacuation elevator concept is described in more detail. These emergency evacuation elevator concepts include the use of stairs as an additional means of egress.

Building code requirements are considered as intact, except code requirements concerning the use of elevators for emergency evacuation. The concept of enabling self-evacuation to start before emergency responders arrive at the site is discussed together with requirements connected to this. The taskforce encourages further discussion of the ability to implement self-evacuation using elevators, which is probably a new requirement emerged in the post 9/11 reality.
While current Building and Fire Codes do not allow elevators to be used in the event of an emergency, consideration may be given to allow the automatic operation of an emergency evacuation elevator system after the onset of a fire, bomb threat, blast, or seismic event, and before the arrival of Fire Department personnel. Floor Fire Wardens, utilizing an approved Building Emergency Operation Plan, would coordinate and facilitate the use of this system prior to the arrival of Fire Department personnel.

This Guideline was prepared by a taskforce nominated by The Council on Tall Buildings and Urban Habitat, comprising some of the world’s leading architects, engineers, building owner representatives, elevator consultants, life safety consultants, fire engineers and elevator companies involved in design of structures.

The Council on Tall Buildings and Urban Habitat is not a code or standards making body. This guideline is not intended to develop or identify mandatory criteria, requirements or standards to be followed in the design of elevators to be used for emergency egress. These guidelines should be reviewed with design professionals and authorities who have jurisdiction for conformance with applicable building codes and regulations. The goal of this publication is not to provide technical solutions but rather to bring forth issues for debate and to generate awareness of emergency evacuation needs related to tall buildings.
2. ARGUMENTS FOR EMERGENCY EVACUATION ELEVATORS

2.1. SAFETY

Buildings that afford evacuations by emergency elevator systems will be seen as safer than those without this option. However, this is only an additional component of a building’s total safety capability. Management must have “walkable” stairs, trained security people and competent emergency management plans in place. Having elevator systems that can be used during total building evacuations will add to the orderly process. It will reduce congestion on existing stairs that are currently the only means of egress during fire situations. Less congestion equates to quicker evacuation times and less potential for injuries. It also provides a better evacuation method for disabled tenants as well as tenants who would be physically challenged by having to quickly walk down 50+ floors. With an ageing population the role of elevators for evacuation can only become more important.

Additionally to evacuation use, a Protected emergency evacuation elevator can also be used for ingress of emergency responders. The robustness proposed, as described in chapter 6, would be a significant improvement for firefighter use of elevators.

2.2. ADDITIONAL ASSETS

Some performance requirements that are required by emergency evacuation elevator systems, like the availability of excess electrical power can be considered as additional assets even when the building does not have to be evacuated. If there is an electrical blackout for example, the building can continue its operation as normal, using its own emergency power generators.

2.3. EXISTING BUILDING REMODELING OPPORTUNITIES

Marketing will be much easier if existing buildings with fire towers that are not in use are remodeled to take advantage of this space. For example, the current fire code in New York City requires totally sprinkled buildings, rendering the fire towers redundant. An elevator car can be constructed that makes use of this tower and most of these walls are already fire rated for up to 2 hours. New buildings can also be designed with such fire towers back in place and used for elevators that could accommodate disabled people as well as the general public. This would be cost effective and perhaps make building owners more acceptable to the idea of special, protected elevators.

2.4. ZONING AREA EXCLUSION

Authorities may facilitate the implementation of emergency evacuation elevator systems (EEES) by offering a trade off: The space required by EEES would be deductible from the zoning area, and thereby increase the rentable area of the building.
3. FIRE AND EXTRAORDINARY EVENT EVACUATION

3.1. CONVENTIONAL EGRESS ROUTE PLANNING

Building evacuation concepts have existed for as long as we have had structures to house our families, industries, businesses, and other forms of commerce. In the world of high-rise buildings, the useable space or floor areas bound by these construction assemblies are measured in terms of thousands of square feet (square meters) or even in acres. This available space is then directly used to help set limits on the number of occupants that might inhabit the space. This limit is also used as the number of occupants for which exits must be provided and dimensioned.

The methods used to set these limits involve a calculation that is based on the use of the space by the occupants, and termed occupant load factor (OLF). It may also be described as an occupant density and this approach is broadly used in building codes throughout the world. The type of building – typically referred to as the use or occupancy – is a critical part of this determination. The OLF will vary based upon the occupancy type. Table 1 provides a sampling of OLF’s for those occupancies that are most closely associated with the high-rise environment.

<table>
<thead>
<tr>
<th>Use/Occupancy</th>
<th>ft² (per person)</th>
<th>m² (per person)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hotels and dormitories</td>
<td>200</td>
<td>18.5</td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>200</td>
<td>18.5</td>
</tr>
<tr>
<td>Business Use</td>
<td>100</td>
<td>9.3</td>
</tr>
</tbody>
</table>

Table 1: Occupant Load Factors.

This table only provides the most basic values. The code-based regulation of the OLF is used to determine a number of criteria that relate to the means of egress components, which must be sized to allow for safe evacuation of the occupants.

The means of egress in a building consists of three distinct parts: the exit access, the exit and the exit discharge. In general terms, the exit access is defined as any path of travel that is covered to reach the exit. The exit is a protected enclosure that has some hourly fire resistance rated construction, typically 2-hours in high-rise buildings. The exit discharge is the termination point of the exit. The exit discharge must then lead to a public space, which involves a publicly deeded piece of land.

3.2. FIRE EVACUATION PROTOCOLS

Fire evacuation measures in mid-rise and high-rise buildings are markedly different from those procedures used in low-rise buildings. The vast majority of evacuation plans, drills and procedures are centered on a fire
event. The basic approach for actions to be taken in a fire event in a high-rise building is based on a staged evacuation of the occupants. Nearly every city in the world with high-rise buildings has embraced the staged evacuation concept.

Generally, occupants on the adjacent floors immediately above and below the incident area are notified. These groups are then commonly directed to the exit stairs and onto a refuge floor, or in some cases, they may be instructed to leave the building. The concept of staged evacuation is based on a number of elements, among which are the conservative design features that are associated with high-rise buildings. These include extensive use of fire resistive and non-combustible construction material and assemblies, automatic sprinkler systems (including retro-fit of many high-rise buildings in the US following such fires as the MGM Grand, First Interstate Bank, One Meridian Plaza), building vast fire alarm systems, most of which incorporate a voice communication component, and often great predictability on expected fire growth rates and fire behavior.

While exit stairs in tall buildings are designed to accommodate total building evacuation, there are practical matters associated with having to empty the total building population, such as:

1. **TIME TO EVACUATE**
   Total building evacuation in certain structures may easily take one hour or more. Evacuation of the WTC structures during the 1993 bombing took some occupants well in excess of 3 hours (Fahy, R.E., Proulx, G. 1997). Total evacuation for typical or small fire events is not normally called for.

2. **TIME TO RE-ENTER THE BUILDING**
   Tall buildings are not designed to have the total building population re-enter at exactly the same time. Elevators are designed according to the total number of floors, the total number of expected occupants and a range of times that the occupants are expected to arrive. The elevators are not designed to deliver all occupants to all floors, should people happen to re-enter simultaneously.

3. **HISTORICAL EXPERIENCE**
   The collective experience in high-rise and tall buildings in the US has shown that the defend-in-place (staged evacuation) concept works. Fire departments in the large metropolitan cities in the US embrace this idea.

These elements comprise the practical considerations. In fire events that are not manageable, a total evacuation of the building may be necessary. Although this type of event is rare, it must none-the-less be contemplated. In any of these scenarios, building occupants are exclusively directed to utilize the exit stairs.
Regardless of how the approach is codified or mandated by a particular procedure, plan, or course of action, the current protocols still do not leave many options for those who are mobility impaired due to locomotion issues, excessive weight, cognitive disorders or temporary incapacitation caused by injuries. This group requires special attention in evacuation planning.

3.3. CONSEQUENCES OF EXTRAORDINARY EVENTS ON CONVENTIONAL EVACUATION PROTOCOLS

The concept of conducting full-scale building evacuations, including for fire events is a relatively new idea in North America. Although there have been a few events requiring whole scale evacuation of high-rise buildings, such as the 1993 terrorist bombing at the WTC complex, the need to move large numbers of occupants simultaneously from a high-rise structure has been a possible but highly unlikely scenario.

For the first time in history, the need to perform total building evacuation in high-rise buildings became more of a reality. Traditional building perils such as fire, seismic events and windstorms must now include acts of terrorism, or hostile acts. The type of actions to consider might include: incendiary fires with multiple ignition points on multiple floors; explosives detonation either inside the building or on the exterior of the building; release of a toxic material (chemical, biological or radiological weapon) that may spread to occupied areas of the building. Events occurring in adjacent structures or buildings are also potential evacuation triggering events for surrounding structures.

Other events that have traditionally required some form of occupant evacuation have included bomb threats or catastrophic power failures. These are two examples of triggering events that may not be imminently life threatening, but illustrate how total evacuation of tall buildings, even under relatively normal conditions, can be a slow and sometimes difficult, but not impossible task.

In the realm of these new perils and new thinking on building evacuation issues, a number of changes are now being contemplated. Planning for, and integrating new rules for dealing with extreme events will be a multi-step task that is likely to take several years for mainstream acceptance, but change is progressing.

Firstly, all available information must be reviewed and used to reassure the general public that the staged or phased evacuation protocol works for the types of emergency events that are most common and that buildings are currently designed to handle.

Secondly, there is a need to emphasize that every individual is ultimately responsible for his or her own safety. Building codes, fire codes, those who enforce such codes, and building owners all work in harmony to help
provide a safe environment. However, awareness of the building’s emergency plan and procedures by the occupants is of paramount importance.

Thirdly, the public must be prepared to take action for a broader range of building emergencies. While fire continues to be the most likely emergency scenario building occupants will encounter, other perils that may require total or staged building evacuation exist, such as wind events, seismic events (in some older structures), bomb threats and extended power outages.

The changes in potential building threats will define a broader range of hazards to be considered, as well as redefine the process by which preparedness for these threats will be integrated into building design. Some of these changes will also involve the building’s operational characteristics. Increased use of personnel or tenants acting as building floor wardens will be necessary. Information and communication concerns to the occupants will be crucial if whole building evacuations are to be successfully accomplished. Metering of occupants to stairwells, elevators, or a combination of the two will be necessary to determine if one or both components can be safely used. Decisions regarding the reliability of the stairs, reliability of elevators (if permitted for use), the amount of time necessary to evacuate the building and the available time to evacuate the building will be key factors when determining the feasibility of total building evacuation.

Likewise, the ability of city streets to handle the addition of thousands, or even tens of thousands of people must be evaluated. Human gridlock vs. vehicle gridlock could potentially block urban streets. Open spaces and surface streets that can lead occupants away from the building must also be examined in more depth than has traditionally been required.
4. GENERIC EMERGENCY EVACUATION TYPES

4.1. CAPACITY NEEDS OF DIFFERENT EVACUATION TYPES

In order to identify requirements for evacuation elevator systems, the CTBUH taskforce has categorized evacuation into three generic types. The three evacuation types all require different vertical transportation capacities. The different capacities in turn, require or enable slightly different solutions for the vertical transportation system itself, including related building components and staffing. To accommodate these, two elevator concepts that differ from the standard US type of elevators have been outlined: the Enhanced elevator system and the Protected emergency elevator system (see chapter 5.).

Although this guideline addresses three basic modes of evacuation, there are a multitude of variations and combinations thereof. In a building project, the design team must be prudent and judicious in assessing the evacuation modes to be used within the structure they are designing.

Deciding upon the mode of evacuation that may be needed in a building is related directly to the type of protection systems that are to be provided in a building. For instance, occupants of a hospital are often incapacitated and unable to leave a building. Therefore, the structure is provided with redundant fire protection systems to protect the occupants while they remain within the building (protect-in-place, staged evacuation), or perhaps just relocated to an area of safety away from the incident origin.

Diagram 1: The diagram illustrates the differences in capacity needs that arise from the evacuation type. The designers of the elevator system must consider both the traffic handling capacities needed for the foreseen evacuation types, as well as the robustness requirements that the various emergency evacuation scenarios imply. Diagram by KONE elevators.
However, even in a hospital, the potential impact of a threat to the structure (such as chemical or biological attack) may necessitate completely relocating its occupants.

The modes of evacuation need careful consideration during the building’s design stage since they will ultimately affect the design of systems going into the structure. It is critical for building management to understand how their building will operate in order to develop their evacuation plans.

4.2. TOTAL EVACUATION

This type of evacuation is one in which the overall goal of the design team is to completely evacuate (remove) occupants from a structure. Staging occupants in areas of refuge while firefighters fight a fire in the structure is not considered Total evacuation.

Although total evacuation of a building is an unlikely event, there are circumstances where it may be required in a structure. Scenarios in which Total evacuation may be deemed necessary by the design team include catastrophic fire (e.g. wild land fires surrounding the structure), biological or chemical attack, weather, bomb threats and potentially catastrophic events in adjacent structures. Depending on the fire protection systems provided in a building, a “common” trashcan fire would not normally be an example of why a structure may be totally evacuated.

In Total evacuation, the target group of potential occupants to be evacuated via elevator would be all building occupants. Those in greatest need would be the primary users of elevators. The type of threat, as well as the occupants’ mobility, defines those in greatest need.

In this mode, the driving force behind using elevators in evacuation is to get all occupants out of the building the fastest way possible, especially those who are most incapable of achieving a quick evacuation time (i.e. those on top of the 100 story tower or those who may be physically challenged).

In total evacuation, it is likely that all building elevators will be used to achieve the overall goal of removing all occupants from a structure. Therefore, all building elevators need to be given due consideration.

A measurement for Total evacuation time of tall buildings must be established in order to further define the use of elevators in evacuation. The use of elevators for applicable Total evacuation scenarios may indicate that all the building’s elevators must be at least enhanced elevators (See chapter 5.).

4.3. STAGED EVACUATION

In this mode, complete evacuation from a structure is not considered. Relocation of occupants to protected areas of the building (areas of refuge as defined in most building codes) is the primary goal and is a more likely
event than that of Total evacuation. However, elevators may still be considered to assist in achieving the Staged evacuation.

The more “common” fire threats and/or adjacent tenant concerns are the more typical scenarios under which a Staged evacuation would be considered. Depending on the design of the building HVAC systems, a biological or chemical threat could also be a scenario resulting in a Staged evacuation.

This mode of evacuation forms the basic underlying philosophy of egress in high-rise structures and hospitals today. The goal is to relocate occupants that may be near the point of origin of an incident to an area that is otherwise protected.

The zone of the building to be evacuated should be quickly identified in order to ensure that building systems respond properly.

Depending on how elevators are to be used in assisting the Staged evacuation, one or more elevators, or perhaps even one elevator from each bank of elevators, may need due consideration for use in evacuation.

4.4. FRACTIONAL EVACUATION

In this evacuation mode, the elevators are to be used to evacuate a focused group of building occupants. Fractional evacuation may still be useful for total building evacuation, but use elevators for only a specific group. They can also be used to relocate the focused group of occupants to an area of refuge elsewhere in the building.

The reasons for Fractional evacuation are essentially the same as those cited for previous modes. The emphasis for the design team however, is on using elevators to evacuate only a specific group of building occupants vs. a broad range.

Since the occupants to be evacuated comprise a focused group, it is likely that only a limited number of the structure’s elevators need to be considered for evacuation use, i.e. a single elevator, such as the freight elevator may suffice.

Those who are mobility impaired due to locomotion issues, excessive weight, cognitive disorders or temporary incapacitation caused by injuries and therefore can’t use the stairs, are a primary consideration for Fractional evacuation.

Since this evacuation type concerns mainly a small number of occupants with restricted mobility, greater protective measures would be required for use in Fractional evacuation. This may be economically feasible however, given the smaller amount of elevators concerned.

A dual function of elevators intended for fractional evacuation may be: 1. Egress of the disabled or incapacitated and 2. Ingress of emergency responders.
5. DESIGN APPROACH

5.1. GENERAL

This chapter presents three basic approaches on how to design elevators for the generic evacuation listed in chapter four. These approaches are termed Standard, Enhanced or Protected emergency elevator system. The Protected emergency elevator system is studied more in detail in chapter six.

The efficacy of elevators to function as part of the evacuation system is dependant upon a number of factors related to the tenability of the elevators and the queuing spaces related to the elevators in emergency circumstances. Using current technology, the elevators and the elevator system arrangements can be designed to greatly improve the functionality and tenability of the system.

**Standard elevator**
1. Elevator car in standard hoistway
2. Unenclosed elevator lobby

**Enhanced elevator**
1. Hoistway improved with sensors, heat and water resistant electrical components, pressurization and blast resistant walls.
2. Lobby provided with two-hour rated fire doors.

**Protected elevator**
1. Pressurized elevator car in a hoistway improved with sensors, heat and water resistant electrical components, pressurization and blast resistant walls.
2. Lobby provided with two-hour rated fire doors.
3. Fire pressurization shaft and direct access to emergency stairs within a separate fire and blast protected compartment.
4. Standpipe and hose racks would be in the lobby.

Diagram 2 illustrates the three basic approaches to emergency evacuation enabled elevator systems by designing them for three levels of robustness: Standard, enhanced and protected.
Illustration by Skidmore, Owings & Merrill.
5.2. STANDARD ELEVATOR

The Standard elevator arrangement is one where the passenger elevators open on to an elevator vestibule at each floor that is not separated from the adjoining occupancy by fire or smoke barriers. Standard elevators comply with many existing safety norms but will then differ from each other depending on national norms and standards.

Standard elevators could be used as part of a building evacuation plan in response to conditions related to weather, power failure, bomb threat or other such non-fire scenarios where no damage to the elevator system has occurred. Standard elevators are also used by the fire services in some jurisdictions in a limited capacity for access and emergency evacuation under specific modes of operation. Standard elevators referred to in this text are considered to be enabled for such aforementioned fire service use.

5.3. ENHANCED ELEVATOR

Enhanced elevators are similar to standard elevators with only minor changes to the elevator equipment and hoistway design. They are different in that the elevator vestibule is separated from the adjoining occupied space by means of a smoke barrier including smoke stop doors. Since smoke migration via elevator hoistways due to stack effect or natural smoke buoyancy is one of the major causes of loss of tenability for elevator systems, this arrangement isolates the elevator vestibule and the entrances from a likely source of smoke: the occupied spaces. In the event that the source of fire and smoke originates from a space other than an occupied space and smoke migrates up the hoistways, such an arrangement serves to protect the occupied spaces from smoke infiltration.

The Enhanced elevator arrangement can be used in Total evacuation and Staged evacuation for both non-fire and restricted fire scenarios as well as various threat scenarios where no damage to the elevator system has occurred. The requirements of an enhanced elevator are almost identical to that of a firefighter operation enabled elevator in the US, with minor modifications and additions.

An enhanced elevator is equipped with US type smoke sensors, with complementary heat sensors and fulfills US firefighter operation hardware requirements. The vestibules of an enhanced elevator have doors that act as smoke screens. The enhanced elevator is equipped with an evacuation drive mode that enables self-evacuation and is also equipped with a remote control and monitoring system.
5.4. PROTECTED ELEVATOR

 Protected elevators are part of an arrangement that is equipped with extra protection to prevent possible damage caused by various threat scenarios i.e., fire, bomb threat, explosion, and earthquake. The basic Protected emergency elevator concept comprises a series of concentric rings of protection surrounding a center ring which is the safest possible area for building occupants during extreme circumstances. Given this structure, protected elevators are feasible for more rapid access by emergency responders and supervised evacuation of selected members of the building population who are unable to use the stair enclosures or whose use of the stairs might impede their efficient use by others.

 The best-known example of a Protected emergency elevator concept today is the dedicated firefighter’s lift as described in the European Union (EU) elevator standard EN81-72. For cost reasons, it is likely that new high-rise buildings will have a limited number of these protected elevators. However, as building service lifts generally have greater capacity, stop at every floor and frequently open out to an enclosed vestibule, upgrading of these elevators would be a probable cost efficient strategy. Slight modifications to the EN81-72 standard would thus enable the conversion of a service lift into a Protected emergency elevator with a much broader use i.e., for both evacuation and firefighting, than that of an EU-type dedicated firefighters elevator.

 Chapter 6. addresses a design concept for both high- and mid-rise buildings.
6. PROTECTED EMERGENCY ELEVATOR CONCEPT

6.1. PRINCIPLE

World events have prompted reconsideration of specially protected stair/elevator systems in tall buildings for both egress of those with impaired mobility and ingress of emergency responders. Most of the recent publications and research seem to focus on this type of solution for either high- or mid-rise buildings.

For protected elevators the strategy is to provide a tenable environment for an internal emergency evacuation system by isolating it from potential hazards and thereby creating a protected core within a core. This approach is employed in security planning using concentric rings of security where the emergency core would be the innermost ring and represent the highest level of life safety.

![Diagram 3: Protected emergency elevator system layout in high-rise buildings.
1) Protected emergency elevator car  2) Two-hour rated elevator lobby
3) Pressurization shaft for lobby and 4) stairs  5) Standpipe and Hose Rack.
Illustration by Skidmore, Owings & Merrill.]

To achieve a higher level of safety for this inner ring, the perimeter housing protected elevators and egress stairs must be designed to resist the effects of blast or impact. The Emergency Evacuation Core must contain the essentials for continued operation under extreme conditions within its protected “silo”. In addition to the emergency evacuation elevators, the Core must contain stairs within a fire rated enclosure for use by emergency responders in accessing an emergency, retreating from an untenable condition or for additional supervised evacuation. The Core should also include the means to fight a fire by supplying a fire standpipe riser and hose valve, possibly an air supply riser so that air bottles can be re-filled on a staging area several floors below the incident and communication risers both for wireless and hardwired connections. Furthermore, the electrical riser that serves the elevator machine room for both normal and emergency power must be included within the protective shell of the Emergency Evacuation Core.

The new Firefighter's elevator standard, EN81-72, that has been ratified in the EU is in its robustness requirements very close to the proposed solution. The main deviations from the EN81-72 standard on Firefighters' lifts' principles are that the elevator can be used during emergencies by people other than emergency responders, that the elevators are enabled to stop on a floor that is
involved in a fire emergency (as long as the fire is not within the Protected 
emergency elevator system), that the elevator car is pressurized and that 
there is a last possibility of automatic operation enabling self-evacuation 
and remote control operation of the elevator car. The Protected emergency 
elevator system is equipped with smoke and heat sensors and CCTV 
cameras are additional requirements. The concept presented here does not 
require the Protected emergency elevator to be dedicated to evacuation 
only but can double as the building’s service elevator (this implies size 
requirements).

This concept is feasible for evacuation of a fraction of the building’s 
population (within a 30 minutes time limit) – never for Total evacuation 
of a tall building within a 40-minute maximum time frame (See capacity 
discussion in chapter 9.).

6.2. TENABILITY PROVISION

To further maintain this tenable environment, the stairs and vestibule that 
serve the protected elevators must be pressurized. The machine room for 
the protected elevators must be similarly isolated and provided with fire 
suppression measures that are compatible with the elevator equipment.

The perimeter enclosure should be constructed using assemblies, which have 
a fire resistive rating of no less than two hours and should be constructed 
using assemblies with sufficient durability to resist impact and the effects of 
high-pressure hose streams after prolonged exposure to fire.

The lobby or vestibule is to function as a staging area on a location below 
an incident and serves as an attack point or refuge on the floor involved. It 
is therefore advisable to maintain a vestibule of no less than 120 square feet 
with a minimum dimension of eight feet. The vestibule is to be separated 
from the occupied spaces and any mechanical or electrical spaces open to it 
by construction having a minimum fire rating of two hours. The vestibules 
are to be pressurized against the intrusion of smoke and therefore the doors 
separating the vestibule from the occupied spaces are to be appropriately fire 
rated and gasketed.

The hoistway for emergency evacuation elevators must be constructed to the 
same level of durability as the perimeter enclosure. The materials used must 
be resistant not only to impact and fire but also to the effects of substantial 
water exposure. The elevator cars can be pressurized by means of a fan that 
blows air into the car through a filter.

Stairs that are designed to work as part of the Protected emergency elevator 
core should be designed to the same standards as egress stairs and should 
be entered from the pressurized vestibule. In certain high-rise buildings it is 
anticipated that these stairs would be primarily used by emergency responders 
in accessing an incident from several floors below the incident level or in a 
retreat mode should the conditions at that level become untenable.
6.3. EXAMPLE OF A PROTECTED EMERGENCY ELEVATOR IN A TYPICAL MID-RISE BUILDING

Diagram 4: A typical mid-rise building core. Illustration by Heller Manus Architects.

Most contemporary high-rises have fire stairs at opposite ends of their cores, with elevators, bathrooms, and various utility and air handling shafts located between those stairs. During an emergency, tenant elevators are usually recalled to the ground floor and building occupants head for the fire stairs to exit to the relative safety of the street.

High-rise buildings, particularly those over 25 stories, typically have dedicated service elevators adjacent to the elevator bank serving the highest floors. The service elevator usually opens to a separate small lobby designed for the exclusive use of that elevator. Because the service elevator serves every floor of the building, it is usually the one unit designated for operation during an emergency. It is normally controlled by the fire department from the fire control room in the lobby. Sometimes, firefighters have more than one elevator at their disposal, but typically, only a single service unit provides emergency elevator access.

A self-contained unit that has the service/firemen’s elevator, service lobby, and one of the normal egress stairs can provide this enhanced opportunity without utilizing additional rentable area. The efficiency of this approach is the basis for its acceptability.

Diagram 5: Example of Protected emergency elevator concept for a typical mid-rise building.
1) Protected emergency elevator car (converted service elevator)
2) Protected emergency elevator vestibule (service lobby)
3) Emergency stairs vestibule
4) Emergency stairs, accessible from Protected emergency elevator vestibule through emergency stairs vestibule. Illustration by Heller Manus Architects.
This proposal combines the fire stairs and service lobby into a unified evacuation core that can be pressurized and strengthened. In the case of an emergency, able-bodied people would go to the staircase, as usual. People who were injured or disabled, however, would have the option of going into the pressurized service lobby, now transformed into an area of refuge. Once in the refuge area, the disabled and injured could either be assisted down the staircase by able-bodied building occupants, or if conditions permit, wait safely in the pressurized evacuation core until emergency personnel rescue them by escorting them down the service elevator.

NFPA 5000 regarding improved stair codes and illumination enhancements with the stairs and core would further reinforce the capabilities of this system.

![Diagram 6: Typical core modified for mid-rise protected elevator. Illustration by Heller Manus Architects.](image)

Because the elevator service lobby and stairs would be a single, hardened and pressurized unit, there would be a substantial level of security within that area. Even if the service elevator was inoperable and/or the emergency was so urgent that it was infeasible for occupants to wait for firefighters to come by elevator, the interconnecting door to the fire stairs would permit an alternative means of evacuation.

Having an area of refuge at each level of the building is more disabled-friendly than an alternate scenario calling for occupants and emergency personnel to move vertically to intermittent refuge floors. In the case of badly injured occupants, the opportunity to have an area of refuge at their level would clearly provide a far more viable option.

With the proposed layout, the service elevator would safely become the best access route for firefighters and other emergency workers. The evacuation core could also provide an opportunity for advanced communications so that people in the refuge area could advise the fire control room of the status on that particular floor. Smoke and fire sensors as well as camera units within the refuge core could help firefighters determine whether it was safe to stop the elevator at the floor in question. If firefighters felt the floor (or floors) in the emergency zone was too dangerous to stop at, they could, as is their normal practice, get off at an upper or lower floor and descend or ascend one to two floors to the scene of the emergency.
7. ELECTRICAL SYSTEMS

7.1. GENERAL

The electrical, mechanical, fire alarm, security and communication systems should be configured for enhanced reliability and sustained operation in the event of a severe fire, blast, or seismic event within or around the building.

Phase I Elevator Recall, which requires smoke detection in elevator vestibules, hoistways or machine rooms so that elevators can be automatically recalled to a predetermined floor, should be included. Phase II Elevator Operation, which enables firefighter’s use during emergencies, should also be included.

A monitoring and control panel in the firefighters control center should be provided, as well as a listed Fire Alarm System with connections to initiate related automatic sequences such as elevator recall and pressurization system activation. The concept of self-evacuation discussed in this guideline is conceived to start before emergency responders arrive on site. Systems for notification of Fire Alarms throughout tenant areas, stairwells, elevator vestibules and elevator cars are required. A communication system that supports firefighters' communication is also required.

7.2. NORMAL ELECTRICAL SERVICE

Connection of overcurrent protection for protected feeders ahead of the main electrical service circuit breaker, similar to that of a fire pump, should be considered.

7.3. EMERGENCY POWER SYSTEM

Standby power for 100% of the protected/enhanced/standard elevator(s) and related systems should be provided. In larger buildings, multiple generators should be provided and configured to enhance reliability together with dedicated automatic transfer switch(es) for the elevator branch of the emergency power system.

7.4. POWER DISTRIBUTION

Power feeders and branch circuits (normal and emergency) for emergency evacuation enabled elevator systems should be installed in hardened and fire protected locations. The power distribution system should be dedicated and provision of multiple feeders configured to enhance reliability should be considered.

7.5. STAIRWELLS

A dedicated distribution system should be provided. Lighting fixtures and exit signage should be provided with integral battery backup
units and connected to the emergency power system. Provision of a permanent firefighters' communication system, an emergency supervised telephone system for occupant's use and dedicated smoke exhaust and/or pressurization systems should be considered.

7.6. ELEVATOR VESTIBULES

Automatic heat detectors, automatic smoke detectors, permanent firefighters' communication system, emergency supervised telephone system for occupant's use and CCTV camera connected to a video switch & monitor system in the Fire Control Center (FCC) should be provided. Lighting fixtures and exit signage should be provided with integral battery backup units and connected to the emergency power system. A dedicated smoke exhaust and/or pressurization systems should be considered.

7.7. ELEVATOR MACHINE ROOM

Equipment and electrical systems should be protected from discharge of the sprinkler system within the room. Automatic smoke and heat detectors to monitor whether the elevator system is in danger of incapacitation are needed. The ventilation and/or air-conditioning system should be installed within a hardened and fire protected enclosure. The room should be configured to prevent water intrusion or provided with electrical systems that are listed for use in wet locations. Dedicated smoke exhaust and/or pressurization systems should be provided.

7.8. HOISTWAYS

An automatic smoke detection system should be provided. The hoistway should be configured to prevent water intrusion or provided with electrical systems that are listed for use in wet locations. Dedicated smoke exhaust and/or pressurization systems should be provided.

7.9. ELEVATOR CAR

The elevator car should be equipped with a permanent firefighters' communication system, an emergency supervised telephone system for occupant's use as well as lighting fixtures and exit signage that are provided with integral battery backup units and connected to the emergency power system.

7.10. PROTECTED/ENHANCED/STANDARD ELEVATOR VESTIBULES

Automatic smoke detectors, a permanent firefighters' communication system, an emergency supervised telephone system for occupant's use, a CCTV camera connected to video switch & monitor system in the Fire Control Center and dedicated smoke exhaust and/or pressurization systems should be provided. Lighting fixtures and exit signage should be provided with integral battery backup units and connected to the emergency power system.
8. INTEGRATION OF BUILDING AUTOMATION SYSTEMS

8.1. GENERAL

In the standard scenario of a typical high-rise building under fire alarm condition, alarm information will flow to the Fire Safety Director (FSD) from the Fire/Life Safety System. An elevator control panel will provide elevator control and status information. The goal of enlisting the functionalities of other building automation systems is to create a sensory network that will enhance the capabilities of the FSD to exert maximum possible command of the evacuation processes.

The other automated systems now present in the typical high-rise building environment, that could enhance the FSD’s capability during the evacuation process, but which he/she does not typically have access to include:

- Building Automation System
- Security Access Control & Alarm Monitoring Systems
- Security Closed-Circuit Television Surveillance Systems
- Intercom Systems

Additional information that may be provided to the FSD by the other building systems include:

- Status of smoke exhaust and pressurization in the stairs, elevator hoistway & vestibules
- Occupant assembly processes pre-evacuation
- Presence of injured parties
- Power failures
- Emergency power generation operation
- Loading of the elevator
- Environment of the elevator vestibule, hoistway and car
- State of electrically locked doors in the path of egress
- Status of evacuation process: prompt and orderly vs. panic among evacuees

8.2. BUILDING AUTOMATION SYSTEM (BAS)

Building Automation Systems provide the means to activate damper actuators and initiate smoke exhaust and pressurization measures, typically in fire stairs, but also importantly in the vestibules and hoistways of elevators that are used in the evacuation process. The activation may be automatic through a direct interface with the Fire Protection and Life Safety System, or through manual control. Through the BAS, the Fire Safety Director may exert control and be apprised of system status changes.

8.3. SECURITY SYSTEMS

Security systems can provide CCTV views of disaster affected areas and places of assembly connected to the elevator evacuation process, feedback on the operation of electrified door release functions, information on
other doors in the path of egress being accessed in the evacuation process, that the number of people who were logged into the building at a given time through the access control system archive, or a muster capability for verifying the occupants evacuated from a building through portable laptop computers integrated with the access control system database. If a digital video recording system is used at the facility, access to the stored video from a security terminal at the Fire Command Center has the potential to provide valuable information related to the past occupancy conditions of an area following a localized event that disrupts the real time CCTV camera view.

8.4. INTERCOMS

Voice intercoms should be used to supplement Fire Warden Telephones. Effective communication between the Fire Command Center and occupants, floor wardens and emergency staff may mean the difference between a controlled process, one that is out of control, one that raises the threat to evacuees and one that mitigates it.

8.5. SYSTEMS INTEGRATION

Currently there are listed Fire Life Safety Systems that are integrated with Building Automation Systems. Having a combined system of this nature brings a facility a little closer to attaining access to the total of available building and building systems conditions. However, total integration of the various systems is not yet attainable, nor perhaps advisable. Integrated systems containing both the Fire Detection functions and Security Access Control and Alarm Monitoring functions are not commonplace and when available are not the feature rich systems that Security program directors require. Integration between separate Fire Detection Systems and Building Automation Systems through standards group promulgated data communication protocols, BACnet as an example, are progressing well in reaching across manufacturers of BAS equipment and participating fire detection and security systems manufacturers, but are not yet widely applied.

8.6. CONSIDERATIONS FOR IMPLEMENTATION

In view of the applications present today, separate subsystems for Fire Life Safety, Building Automation, Access Control and Alarm Monitoring, CCTV Surveillance and Intercom must be maintained. Interfaces may be implemented between the Fire Life Safety System and the BAS, between the Access Control/Alarm Monitoring System (ACAMS) and the CCTV System, and between the ACAMS and the Intercom System. Interfaces are commonly achieved through serial data exchanges, through a high-speed bus connection or through point- to-point hard wired connections. Higher degrees of integration are not generally practiced at present. Future developments may find the common mode of communications for all systems to be across the building LAN. This will enhance the exchange of information between systems and further accentuate the sensory network.
A critical requirement is that all of the aforementioned systems be available in at least the Fire Command Center and preferably duplicated at a secondary location. In addition, all systems should be backed by emergency power, have redundant communications paths that are well separated and operate on redundant servers.

Finally, to enhance the effectiveness of the sensory network, the number of devices typically used in a high-rise for security purposes, such as intercoms and CCTV cameras, will have to be increased to fulfill the new-shared function.
9. CAPACITY REQUIREMENTS USING ELEVATORS AND STAIRS FOR EMERGENCY EVACUATION.

9.1. GENERAL

Currently there are no set International standards on capacities for elevators that are used in emergency situations. Local governing codes vary greatly ranging from the extremely small 630 kg. requirement under the EN81-72 European lift code, the 2100 lb. (950 kg.) minimum ADA car size in the U.S. to the 1000 kg. minimum size for firefighters lifts in Moscow.

The speed of the protected elevators should be such that a full run from bottom to top should take no longer than one (1) minute. This recommendation is in line with the similar requirement in the EN81-72 standard, which governs firefighters' lifts in Europe.

The quantity and width of egress stairs are governed by the prevailing building codes as they relate to building population and type of occupancy. In planning stairs the population of only one floor is considered, and the height of the building is not taken into account.

9.2. EVACUATION TIME CALCULATION FOR ELEVATORS

![Diagram 7: Building up-peak filling times and down-peak egress times for different up-peak handling capacities.](image)

Passenger elevators in a building are usually planned with a certain up-peak handling capacity. For instance, an office building is typically planned to ensure that 12-16 per cent of the population can be transported to their respective floors within five minutes from the main entrance lobby (5HC). With a 5HC of 13.5 percent the building can be filled in about 37 minutes.
According to extensive experience using simulations for up-peak and down-peak traffic, the elevators' transportation capacity in down-peak traffic is greater than in up-peak traffic. In down-peak traffic roughly 1.5-1.8 times more passengers can be transported with the same elevators depending on the elevator group control system. The egress times in down-peak traffic become roughly 1.6 times shorter than the up-peak filling time.

If the handling capacity of the elevators is known and people have to use only one elevator on their way to a rescue area, the egress time given in minutes is

\[ T_{\text{Elevator egress}} = \frac{100 \times 5}{5HC} / 1.6 \]  

*Equation 1*

### 9.3. Evacuation Time Calculation for Stairs

In total evacuation, congestion in the stairwell will occur. When the full flow density is achieved or exceeded, passenger flow out of the building using stairs begins to decrease. At full flow, a measure of two persons per square meter is assumed.

![Diagram 8: Relation between passenger flow and density in stairs (Weckman, 1997)](image)

Staircase egress times of can be calculated from the handling capacity, \( C \), for instance. Staircase handling capacity is 83% of the handling capacity of a corridor (Barney, 2003), and expressed in persons per five minutes is

\[ 5C = 0.83 \times (300 \times s \times D \times W) \]  

*Equation 2*

where \( s \) is the walking speed of a person on the stairs (typically 0.6 m/s), \( D \) is density of people on the staircases (at full flow 2 persons/m2) and \( W \) is the effective width of the stairs.
Egress time equals total population $A$ divided by handling capacity $C$ and the number of staircases $L$.

$$T_{\text{Stair egress}} = \frac{A}{5C/L}$$ \hspace{1cm} \textbf{Equation 3}

If it takes longer to walk from the furthest floor to the escape level (walking distance/s) than $T_{\text{Stair egress}}$, then the egress time on the stairs is the longer of these two.

\[\text{Diagram 9: Total evacuation egress times with two staircases for different floor occupancies (N), and typical office and residential elevator groups.}\]

Diagram 9 shows the egress times for 1.1 m (effective width) wide staircases for buildings with two staircases and with different numbers of floors. $N$ refers to the number of occupants per floor. Four different floor areas with 50, 100, 150 and 200 persons per floor are compared. The building heights vary from 10 floors up to 70 floors. With 100 persons per floor, egress times with all elevators become shorter in buildings higher than about 30 floors.
9.4. CASE STUDY

To exemplify how elevator capacities for evacuation use may be evaluated, a case study on a typical Mid-Rise office building is presented. Calculations are made for three types of evacuation: Total, Staged and Fractional evacuation, applicable to various threat scenarios.

![Diagram 10: Illustration of case study building's standard and enhanced elevators for each group and the protected elevator. The diagram also illustrates how the elevators are used in the example scenarios. Illustration by KONE elevators.](image)

**CASE STUDY BUILDING ASSUMPTIONS:**

- Number of Floors: 47
- Floor to floor height: ~ 4 m
- Travel Height: 200 m
- Population: 3 300 persons, about 70 persons per floor
- Total Floor Area: 55 000 m²
- Desired evacuation time: 25 minutes (Total, Staged, Fractional)
- 1 protected elevator (service elevator)
- 3 x 2 enhanced elevators
- 12 standard passenger elevators
- 19 elevators in total
Handling capacity differences are explained through these three examples.
The main requirements that enable the use of elevators for emergency evacuation concern the emergency preparedness and building-elevator system robustness, as has been discussed in previous chapters.

The most crucial decision when planning for emergency evacuation is to define a maximum egress time as well as the applicable evacuation scenarios for the building in question. These Up- and Down-Peak time criteria together with the robustness requirements can then be met by building planners and elevator suppliers in a cooperative effort.

It is also assumed that designing buildings with emergency evacuation elevators for any dedicated occupant groups other than the disabled or injured (those most in need of elevator transportation) is not possible. When making an emergency evacuation plan for total evacuation it is assumed that occupants use either the elevators or the stairs – which affect the capacities of both. For redundancy's sake the stairs still have to be dimensioned according to current standards and may not be reduced in size.

When egress time is mentioned in the case study, it is assumed that all necessary building notifications have already taken place and that occupants know the emergency procedures well.
### 9.5. Bomb Threat Scenario: Total Evacuation Using Elevators

<table>
<thead>
<tr>
<th>Population to be evacuated</th>
<th>Elevator groups</th>
<th>Capacity</th>
<th>Speed m/s</th>
<th>Up-Peak SHC % of population in 5 minutes</th>
<th>Down-Peak SHC % of population in 5 minutes</th>
<th>Egress Time minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Rise</td>
<td>5 cars for 17 persons</td>
<td>2.5 m/s</td>
<td>13.5 %</td>
<td>21.5 %</td>
<td>23.1 [For Low-Rise section]</td>
<td></td>
</tr>
<tr>
<td>Mid Rise</td>
<td>6 cars for 17 persons</td>
<td>5.0 m/s</td>
<td>13.9 %</td>
<td>22.2 %</td>
<td>22.5 [For Mid-Rise section]</td>
<td></td>
</tr>
<tr>
<td>High Rise</td>
<td>6 cars for 17 persons</td>
<td>6.0 m/s</td>
<td>13.6 %</td>
<td>21.8 %</td>
<td>22.9 [For High-Rise section]</td>
<td></td>
</tr>
<tr>
<td>All groups</td>
<td></td>
<td></td>
<td></td>
<td>21.6 %</td>
<td>Roughly 23 minutes for the whole building, provided that exit floor(s) can handle the people flow.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Population to be evacuated</th>
<th>Elevator groups</th>
<th>Capacity</th>
<th>Speed m/s</th>
<th>Up-Peak SHC % of population in 5 minutes</th>
<th>Down-Peak SHC % of population in 5 minutes</th>
<th>Egress Time minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Rise</td>
<td>2 cars for 17 persons</td>
<td>2.5 m/s</td>
<td>5.4 %</td>
<td>8.6 %</td>
<td>58 [For Low-Rise section]</td>
<td></td>
</tr>
<tr>
<td>Mid Rise</td>
<td>2 cars for 17 persons</td>
<td>5.0 m/s</td>
<td>4.6 %</td>
<td>7.3 %</td>
<td>67 [For Mid-Rise section]</td>
<td></td>
</tr>
<tr>
<td>High Rise</td>
<td>2 cars for 17 persons</td>
<td>6.0 m/s</td>
<td>4.5 %</td>
<td>7.3 %</td>
<td>69 [For High-Rise section]</td>
<td></td>
</tr>
<tr>
<td>All groups</td>
<td></td>
<td></td>
<td></td>
<td>7.3 %</td>
<td>Roughly 69 minutes for the whole building, provided that exit floor(s) can handle the people flow.</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Handling capacities for total evacuation using either all elevators or only enhanced elevators.

The diagram above lists the elevator groups, their respective speeds, their Up-Peak and Down-Peak handling capacities (SHC) as well as the egress times for the respective sections of the building that they are assigned to. The outcome of the calculations is that in a scenario requiring total evacuation, where all elevators can be used, the egress time would be roughly 23 minutes in the case study office building.

If the scenario requires that only enhanced elevators are used, then the handling capacities and egress times would be as follows, under the assumption that 2 elevators of each group are of enhanced type. We can see that the egress time would be roughly 69 minutes for a total evacuation of the case study building. It seems that a total evacuation using only part of the elevators is not very feasible when egress time is a critical factor.
9.6. BOMB THREAT SCENARIO: TOTAL EVACUATION USING ELEVATORS AND STAIRS

For the case study building we assume that there are two 1200 mm wide staircases. According to equations 2 and 3, handling capacity of two staircases is about 20% of the population in five minutes, and the egress time will be 25.1 minutes (Case a in table 3.). If both stairs and elevators are used for evacuation, the egress times will drop to about half, i.e. from 25.1 minutes to 12.1 minutes. (Case b in table 3). If only two enhanced elevators are used in each elevator rise in addition to two staircases, the egress time will be 18.4 minutes. (Case c in table 3).

<table>
<thead>
<tr>
<th>Population to be evacuated</th>
<th>Capacity</th>
<th>SC % of population in 5 minutes</th>
<th>Egress Time minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two 1200 mm wide staircases</td>
<td>19.9 %</td>
<td>25.1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Population to be evacuated</th>
<th>Capacity</th>
<th>SC + 5HC % of population in 5 minutes</th>
<th>Egress Time minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two 1200 mm wide staircases and all elevators</td>
<td>41.5 %</td>
<td>12.1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Population to be evacuated</th>
<th>Capacity</th>
<th>SC % of population in 5 minutes</th>
<th>Egress Time minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two 1200 mm wide staircases and two enhanced elevators in each rise</td>
<td>27.2 %</td>
<td>18.4</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Up-peak and down-peak handling capacities and egress times for total evacuation a) using stairs, b) using all elevators and stairs and c) using only enhanced elevators and stairs.

9.7. FIRE SCENARIO: STAGED EVACUATION USING ELEVATORS

The actual quantity of enhanced elevators provided may vary according to local codes or standards and building design. Prudent core design will generally locate the service elevators in common hoistways. Therefore, it can be assumed that all elevators in a common hoistway that are incorporated into the protected area be designed as protected elevators. In hotels where it is not uncommon to have stand alone service elevators, each should be designed as a protected type elevator.

The staged evacuation scenario of the case study requires at least enhanced elevators. In the scenario there is a fire at upper floors that requires evacuation of five floors. The enhanced elevators of the High-Rise group and the Protected (service) elevator will be used for emergency evacuation. In the case study two elevators in each group are enhanced, and the service
elevator is protected, to ensure that the Low-Rise, Mid-Rise and High-Rise sections of the building all have access to enhanced elevators. In this scenario only the High-Rise and Protected elevators are used, due to the location of the fire. The handling capacities of the two elevators in each group are shown in Table 4. Using only part of the case building's elevators for a staged evacuation seems very feasible, as the egress time in the case example's fire scenario is only 10.4 minutes.

<table>
<thead>
<tr>
<th>Population to be evacuated</th>
<th>Type of elevators</th>
<th>Elevator groups</th>
<th>Capacity</th>
<th>Speed m/s</th>
<th>Up-Peak S4C</th>
<th>Combined Up-Peak S4C</th>
<th>Combined Down-Peak S4C</th>
<th>Egress Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 floors, 157 persons = 285 persons</td>
<td>Enhanced Elevators</td>
<td>High Rise</td>
<td>2 cars, 17 persons</td>
<td>6</td>
<td>19.8 %</td>
<td>24 %</td>
<td>38.4 %</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Protected Elevator</td>
<td>High Rise</td>
<td>1 service car, 24 persons**</td>
<td>3.5</td>
<td>4.2 %</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Up-peak and down-peak handling capacities for five floors.

*) It's assumed that disabled or injured persons occupy 3 times more space than other passengers given different moving aides, stretchers etc.

9.8. FRACTIONAL EVACUATION: EVACUATION OF DISABLED OR INJURED USING ELEVATORS

In creating the base design concept of the Protected Elevator, it is logical to assume that the protected elevator will be one or more of the building's service elevators or goods lifts. With this assumption, there is a natural tendency to provide a larger size car that will function in either mode of operation. Depending on the height and size of the building service elevator applications vary from 4000 lbs. (2000 kg.) to 6000 lbs. (3000 kg.) and are adequately sized to accommodate 19 or more people, facilitate wheelchairs and gurneys as well as six (6) to eight (8) firefighters in full gear with equipment.

In this fractional evacuation scenario elevators are planned only for evacuation of the disabled and injured. It is estimated that roughly 3% of the occupants cannot evacuate using stairs, and must be evacuated via the protected service elevator. The assumption is that a disabled or injured person occupies the space of three people given moving aides, etc.

<table>
<thead>
<tr>
<th>Population to be evacuated</th>
<th>Type of elevator</th>
<th>Capacity</th>
<th>Speed m/s</th>
<th>Up-Peak S4C</th>
<th>Down-Peak S4C</th>
<th>Egress Time minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>99 persons</td>
<td>One Protected Elevator</td>
<td>1 service car for 24 persons (=8 disabled)</td>
<td>3.5</td>
<td>SHC =12 %</td>
<td>19.2 %</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 5: Up-peak and down-peak handling capacities and egress time for disabled people scattered throughout the building.
9.9. CONCLUSIONS DRAWN FROM THE CASE STUDY

In this case study, almost the same time was calculated for total evacuation using either two staircases or all elevators of the building. The reasons are: low floor population and low number of floors. Using both stairs and elevators would cut total evacuation time roughly in half.

When setting the building’s performance level for evacuation, the desired evacuation time should be one main driver, be it total, staged or fractional evacuation. In this case an acceptable total evacuation time is judged to be roughly 25 minutes following evacuation alert.

Given the above evacuation time criteria it would be economically feasible to design the case study building’s elevators as follows:

- One protected elevator for evacuation of disabled and injured that can handle necessary traffic within 26 minutes (3% of the population).
- Design the rest of the elevators as standard elevators, because total evacuation is manageable within roughly 25 minutes using either stairs or elevators.
- Based on calculations and set evacuation time criteria, the enhanced elevators are judged to be unnecessary. For a staged fire evacuation, the low number of occupants per floor and the existence of a protected elevator are regarded as a satisfactory solution.

**Important! These analysis results are not applicable on a general level. Analysis should always be based on evacuation time criteria and calculations for each building individually.**

Buildings with higher floor populations and a higher number of floors than the case example discussed here gain substantially from emergency evacuation elevators that enable a total evacuation of the building (See diagram 9).
10. USING EMERGENCY EVACUATION ELEVATORS

10.1. OCCUPANTS

The means of evacuation at hand is used so that those in imminent danger or incapable of using the stairs are prioritized as users of elevators for evacuation, regardless of whether the building is equipped with emergency elevator evacuation systems for Total, Staged or Fractional evacuation.

10.2. USING ELEVATORS IN TOTAL EVACUATION

This procedure is based on minimum manpower for manual operation of the elevator cars. The Fire Command Center (FCC) activates the manual evacuation mode that would dispatch the Protected/Enhanced/Standard elevator car (see chapter 5) to the floors to be evacuated in each elevator group.

1) The floor warden or a member of the Fire Safety Team on the affected floors will supervise boarding of the elevator and select the floor as directed by the Fire Command Center.

2) On arrival at the designated floor and discharge of the occupants, the car will return to its first stop to pick up additional occupants to evacuate.

3) This will continue until the original floors are fully evacuated and then the elevator cars will move to the next group of floors and so on until the building is fully evacuated.

4) As each group of tenants is discharged at the evacuation floor a report will be given to the fire command station indicating the number of people who have evacuated and the number of floor occupants yet to be evacuated.
   - This information can be transmitted via the elevator intercom, two-way radio or in person to the FCC.

10.3. USING ELEVATORS IN STAGED EVACUATION

This procedure is based on minimum manpower for Manual operation of the elevator cars. Activation of a Control at the Fire Command Station would dispatch a designated elevator bank (using both Protected, Enhanced and Standard elevators, when applicable) to selected floor/s.

5) The floor warden or a member of the Fire Safety Team on the affected floor/s will follow the instructions as described above in subchapter 10.2. points 1), 2), 3) and 4).

10.4. USING ELEVATORS IN FRACTIONAL EVACUATION

The following is based on minimum manpower for Manual operation of the elevator cars. Activation of a Control in the Fire Command Station that would dispatch a Protected emergency elevator car or cars of a bank to the selected floor/s.
6) The floor warden or a member of the Fire Safety Team on the effected floor/s will follow the instructions as described above in subchapter 10.2. points 1), 2), 3) and 4) above.

10.5. ADDITIONAL PROCEDURE DESCRIPTIONS

The above steps would be followed in Total, Staged or Fractional evacuation when sufficient manpower from building staff is available to man all the required elevators, building staff members would operate the selected cars until the appropriate evacuation is complete.

When not all occupants of a building are meant to be evacuated by elevators, a list of designated users is kept up to date by the building's security function. Visitors are treated ad hoc.

Each floor has appointed fire/emergency floor wardens who receive training on emergency management and the use of elevators in emergencies. This may include issue of elevator keys that would allow the wardens to operate the elevators on independent service.

10.6. STAFF

Trained staff operates protected/enhanced/standard elevators until the emergency responders arrive on site. The emergency responders assume command and decide on further actions on site. The Fire or Safety director carries out the training of staff and tenants at regular intervals.

The training should begin with the arrival of the first tenant and continue throughout the occupancy of the building. The training will be for the tenants, tenant safety teams, building engineers and property management team. There should be a strong mission statement from the CEO or other executive of the property management company and the tenants confirming their commitment to building safety to include evacuation.

This training is to be followed by simulation exercises and actual implementation of the procedures in a Total evacuation to ensure that the system works and/or make appropriate modifications to the program.

Each tenant should be issued an Emergency Pack either from the property or his or her employer. The pack would contain items to assist the individual during evacuation.

There should be at least one Total evacuation every 2 to 3 years with smaller Staged evacuations completed on a semi-annual or quarterly basis. This Staged evacuation of different tenants should be completed quarterly with all tenants participating in at least one evacuation a year. This will help maintain the skills and the plan up to date and under regular review for improvement.
Whenever there is an emergency situation at hand, command is surrendered to the emergency responder authorities as soon as they arrive on site.

10.7. EMERGENCY RESPONDER AUTHORITIES

Emergency responders are made aware of protected/enhanced/standard emergency evacuation elevators and the circumstances of when and how they should be used. Special training sessions should be scheduled for Emergency responders to ensure they are fully familiar with the operation of this system.

In the future, emergency responder authorities will most probably require standard modes of evacuation operation and standard user interfaces as well as standardized protective solutions for protected/enhanced/standard elevator systems intended for emergency evacuation.

10.8. OPERATION OF PROTECTED ELEVATORS

Trained operators operate the elevators. Intelligent drive modes should be available as a last resort.

The elevator system should be equipped with monitoring systems enabled for remote control in the event of elevator operator disability.

The usability of protected/enhanced/standard emergency evacuation elevators should be similar to that of standard non-protected elevators.

10.9. COMMUNICATION DEVICES

An intercom solution should be provided for communication between the elevator car and the fire command center as well as the elevator landing and the fire command center. The communication must be two-way and can be accomplished by installing an Emergency Phone in the floor elevator vestibule.

10.10. OTHER MONITORING DEVICES

The protected/enhanced/standard evacuation elevator system should be provided with CCTV systems in car and on landings that reports to the Fire Command Center or the location designated as the control center for evacuation.

Access control devices should not prohibit the emergency use of protected/enhanced/standard emergency evacuation elevators. This will require Fail/Safe operation of the doors on the affected floors.
11. INTEGRATION INTO THE PLANNING AND CONSTRUCTION PROCESS

The following table is a simplified overview of actions by the different stakeholders during various phases of the construction process that are required in order to implement a reliable emergency evacuation elevator system. The list of actions is not complete, but it gives the reader an overall picture of how to implement emergency evacuation elevator systems. The implementation order may also vary from project to project, depending on contract formats and local design and construction processes.

Table 6. Overview of implementation of emergency evacuation elevators in the building design and construction process. →
<table>
<thead>
<tr>
<th>Player/ Phase</th>
<th>Program development</th>
<th>Schematic design</th>
<th>Design development</th>
<th>Contract/ Bid/ Construction documents</th>
<th>Construction</th>
<th>Post Construction Occupancy start</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tenant</td>
<td>• Security needs</td>
<td>• Iteration of needs</td>
<td>• Iteration of needs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Owners</td>
<td>• Use, location, size</td>
<td>• Defines targeted performance of building in evacuation situations</td>
<td>• Management function</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupants' risk management officers/ Head of security (Alternative to security consultant)</td>
<td>• Definition of applicable threat scenarios</td>
<td>• Security &amp; emergency management concepts with evacuation scenarios</td>
<td>• Specification to subcontractors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Security Consultant (Alternative to own risk management officers/ Head of security)</td>
<td>• Definition of applicable threat scenarios</td>
<td>• Security &amp; emergency management concepts with evacuation scenarios</td>
<td>• Finalized security concept, including evacuation plans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Core architecture planners</td>
<td>• Consultative function</td>
<td>• Form and shape</td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td>• Guidance concepts</td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Elevator company/ consultant</td>
<td>• General info on Emergency Evacuation Elevator Systems (EEES).</td>
<td>• Consultation on capacity and performance of EEES.</td>
<td>• Definition of when elevators can be used and when they no longer can be used</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Structural engineers</td>
<td>• Structural concept</td>
<td>• Integration of how safe areas and exit routes are constructed</td>
<td>• Communication interfaces to building automation and security systems</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Electrical engineers</td>
<td>• Electricification concept</td>
<td>• Redundant power cables and power sources for the EEES.</td>
<td>• Communication interfaces to EEES</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Mechanical (HVAC) engineers</td>
<td>• HVAC concept</td>
<td>• Pressurization concept for EEES spatial components</td>
<td>• Security systems and automation system providers quote and carry out own engineering based on system specifications.</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Fire protection/fire safety engineers</td>
<td>• Fire protection and life safety program for any project is developed and negotiated with authorities</td>
<td>• Additional requirements on spatial organization and structures</td>
<td>• Security systems and automation system providers quote and carry out own engineering based on system specifications.</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Construction companies</td>
<td>• Communication interface to EEES</td>
<td>• Communication infrastructure</td>
<td>• Security systems and automation system providers quote and carry out own engineering based on system specifications.</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Automation Providers, Subcontractors responsible for signaling and annunciation.</td>
<td>• Automation concept</td>
<td>• Communication interface to EEES</td>
<td>• Security systems and automation system providers quote and carry out own engineering based on system specifications.</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Security systems provider</td>
<td>• Security system concept design</td>
<td>• Communication interface to EEES</td>
<td>• Security systems and automation system providers quote and carry out own engineering based on system specifications.</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Authorities, Fire officials</td>
<td>• Consultative and normative function</td>
<td>• Approval of scenarios where an EEES may be used</td>
<td>• Security systems and automation system providers quote and carry out own engineering based on system specifications.</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Building department officials</td>
<td>• Evacuation use negotiated with authorities</td>
<td>• Definition of when elevators can be used and when they no longer can be used</td>
<td>• Security systems and automation system providers quote and carry out own engineering based on system specifications.</td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Emergency responders</td>
<td>• Insurance schemes based on the designed security and safety of the building</td>
<td>• Security systems and automation system providers quote and carry out own engineering based on system specifications.</td>
<td></td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
<tr>
<td>Insurance industry</td>
<td>• Insurance schemes based on the designed security and safety of the building</td>
<td>• Security systems and automation system providers quote and carry out own engineering based on system specifications.</td>
<td></td>
<td></td>
<td>• Integrating different spatial and systems requirements so that space is organized and provided for</td>
<td></td>
</tr>
</tbody>
</table>
GLOSSARY

9/11
The terrorist hijacking of several airplanes on September 11th, 2001, that resulted in two of the airplanes crashing into the WTC towers in New York, one airplane crashing into the Pentagon and a fourth airplane crash in Somerset County. The WTC towers collapsed, as did part of the Pentagon building complex.

ACCESS CONTROL SYSTEM DATABASE
A database containing user identification, access levels, time authorizations and possible additional data on users of a building's access control system. The database is typically contained, maintained and managed from a main access control computer.

AIR SUPPLY RISER
The In-Building Riser is used to connect the primary air supply to the building's landings so that firemen can fill their air bottles on the landings, instead of having to move to a central location.

AREA OF REFUGE
An area that is protected from potential hazards of extraordinary events like fire, bomb threat, dirty bomb, toxic agents etc. In this area of refuge it is safe to wait for rescue or further instructions, usually for a defined finite time.

AUTOMATIC CONTROL
An automatic control device drives the elevator cars without call buttons having to be pushed.

AUTOMATIC OPERATION
Under automatic operation the elevator cars are driven by the elevator controller according to algorithms that optimize the traffic handling efficiency of the elevator system for currently activated elevator calls.

AUTOMATIC TRANSFER SWITCH(ES)
A switch that connects to the backup power system during a power outage. This switch is necessary to isolate backup power from utility power to ensure there is no power feedback onto the utility side.

BACNET
An industrial open standard for building control suppliers. It enables integration of various aspects of a building's automation components into one building management system.

BUILDING AUTOMATION SYSTEM (BAS)
A system that enables the monitoring and control of a building's various devices such as Heating, Ventilation and Air-Conditioning (HVAC) components. In some cases locks, doors and elevators can also be part of such monitoring systems.

BUILDING EMERGENCIES
Examples of building emergencies include fire, earthquake, hurricane, bomb threat, explosion, toxic agent and violent attack. The most probable emergency may still be fire.

BUILDING ENGINEERS
The technical staff of a building.

BUILDING PERILS
See building emergencies.

CCTV
Closed Circuit Television network, used for surveillance purposes. The video signals on this network are understood to be contained and private, not publicly available to the general public.

COMMUNICATION RISERS
Vertical cabling used for communication devices that technical staff or emergency responders may plug their emergency telephones into during an emergency callout.

COMPARTMENTATION
The principle used to divide a building into smaller sections so that each might contain a fire for a specified time. The fire compartmentation for the wall structure around the Protected emergency elevator concept is suggested to be at least two hours.

CONCENTRIC RINGS OF SECURITY
A security planning principle of applying levels, layers or "rings" of security from an outer most point of the property to a specific object, where the security measures get stricter when one moves towards the innermost "ring".

CTBUH
Council on Tall Buildings and Urban Habitat.

DAMPER ACTUATORS
A device that can operate a valve by remote control.

DEFEND IN PLACE
Defend in place refers to a fire emergency that is resolved by evacuating only those building compartments on fire or directly at risk. It means that a staged evacuation of the building is carried out as part of the firefighting process.

DESIGNATED USERS
The defined and intended users of an emergency evacuation elevator system.
EGRESS
The process of exiting a building or for example a portal in a fence around the building.

ELEVATOR CONTROL PANEL
The set of buttons in an elevator car that are used for controlling the elevator.

EMERGENCY CORE
The principle of concentric rings of security used in security planning is used here for the concept of a protected emergency evacuation elevator system that is its own structural unit within the building. In a high-rise building, it could be described as a tower within a tower.

EMERGENCY EVACUATION CORE
See emergency core.

EMERGENCY EVACUATION ELEVATOR SYSTEMS (EEES)
Elevator systems designed to be used for emergency evacuation during a pre-specified range of possible building emergencies.

EMERGENCY EVENTS
See building emergencies, building perils.

EMERGENCY MANAGEMENT PLANS
An action plan on how to manage potential building emergencies.

EMERGENCY PACK
A pack containing first aid supplies, drinking water, food, a flashlight and possibly protective gear such as gas-mask or tools.

EMERGENCY PLAN
See emergency management plans.

EMERGENCY POWER SYSTEM
A reserve power generator or battery that is started upon electrical power blackout.

EMERGENCY RESPONDER AUTHORITIES
The public administration units that manage the Fire brigade, police, ambulance personnel and anti-terrorist strike force etc.

EMERGENCY RESPONDERS
The Fire brigade, security force, police, ambulance personnel, anti-terrorist strike force etc.

EMERGENCY SCENARIO
See building emergencies, building perils, emergency events.

ENHANCED ELEVATOR
An elevator with some non-standard additions to its functionalities; for example smoke sensors in hoistway, vestibules and machine-room, evacuation drive mode and smoke protected vestibules.

ENHANCED ELEVATOR SYSTEM
See enhanced elevator.

EVACUATION DRIVE MODE
An algorithm that maximizes evacuation traffic handling efficiency of an elevator and disables the option of stopping on floors where elevator vestibules are compromised.

EVACUATION PLANS
Response plans to potential emergencies that require evacuation measures.

EXIT ACCESS
The path of travel covered to reach the exit.

EXIT DISCHARGE
The termination point of the exit.

EXTRAORDINARY/EXTREME EVENT EVACUATION PROTOCOLS
See evacuation plan.

FIRE ALARM CONDITION
An indication of fire in the fire alarm system.

FIRE COMMAND CENTER
A dedicated space in the building containing fire system control panel and monitoring equipment. It can also be the same space as the security centre.

FIRE COMMAND STATION
See fire command center.

FIRE EVACUATION PROTOCOLS
See Extraordinary / Extreme event Evacuation Protocols.

FIRE PROTECTION AND LIFE SAFETY SYSTEM
A comprehensive system where construction type, compartmentation, interior finish, combustible loading limits, egress systems, fire alarms, sprinkler systems, smoke management etc. variables and subsystems are integrated into a functioning whole.

FIRE RESISTIVE RATING
A rating, which defines how long a construction component resists a standard building fire (wall, door etc.). These ratings are a key factor in designing how a building performs in the event of fire.

FIRE SAFETY DIRECTOR (FSD)
Technical staff member who is responsible for ensuring that the property owner fulfills fire safety requirements. The FSD may be responsible for one or many buildings.
FIREFIGHTER'S ELEVATOR
An elevator especially equipped for use by emergency responders (mainly firefighters) during building emergencies.

FLOOR WARDEN
A representative of the tenants who is trained for emergency management. Each floor should have appointed floor wardens. See also Fire warden.

FRACTIONAL EVACUATION
Evacuation process of a small fraction (1-3%) of a building's population.

GENERIC EVACUATION TYPES
In this publication three generic types of evacuation are defined. The definition is according to how large a part of the building is to be evacuated.

HOISTWAYS
The structural component in which the elevators move in a building.

INGRESS
The act of entering a building or point of entry into a building.

INTELLIGENT DRIVE MODES
Refers to possible future functionality of elevators where they would be capable of performing automated evacuation functions.

INTERCOM SYSTEMS
System that enables audible point-to-point communication within a building. The public announcement system enables announcements from the security/fire command center to chosen floors of a building.

LAN
Local Area Network, a computer network that is confined to a limited geographical area.

MEANS OF EGRESS
Means of exit from a building.

MODES OF EVACUATION
Refers to specially defined evacuation operating modes of an elevator system.

OCCUPANT ASSEMBLY PROCESSES
PRE-EVACUATION
Gathering of occupants in a building prior to evacuation.

OCCUPANT DENSITY
Occupants per square foot or square meter in a building.

OCCUPANT LOAD FACTOR (OLF)
See occupant density, the OLF is typically different for different types of structures, e.g. the occupant density in a hospital is different to that of an office.

OCCUPANT NOTIFICATION SYSTEMS
See intercom systems

OPERATIONAL CHARACTERISTICS
Refers to emergency performance of both building and emergency management organization.

PHASED EVACUATION
Evacuation of a building in stages, whereby only certain floors are evacuated at a time.

PRESSURIZED VESTIBULES, HOISTWAY AND CAR
Overpressure is created in elevator vestibules, hoistways and elevator cars to prevent smoke from entering them.

PROPERTY MANAGEMENT COMPANY
A company that offers building owners comprehensive services related to the building's maintenance and
operational service needs. The range of services offered can vary from management of subcontractor's contracts to providing some or most of the services in question.

**PROTECTED CORE**
The concept of a core within the core of a building. Usually the building core contains technical amenities, elevator banks, stairs and various riser spaces. In this guideline a structurally independent core that contains the Protected emergency elevator system is called a protected core.

**PROTECTED ELEVATOR**
An elevator system with some enhanced functionalities that are built within a protected core. The vestibules, elevator hoistway and machine room, necessary communication and surveillance instrumentation, emergency stairs, necessary risers, fire system, fire suppression, smoke management and pressurization equipment are also within this core.

**PROTECTED EMERGENCY ELEVATOR SYSTEM**
See protected elevator.

**PROTECTED EMERGENCY ELEVATOR VESTIBULES**
See protected elevator.

**PROTECT-IN-PLACE**
Firefighting principle whereby the fire is fought so that only those in imminent danger are evacuated (Staged evacuation).

**REFuge FLOOR**
Space especially protected against pre-conceived building threats where occupants may wait for the emergency to pass, further instructions or rescue.

**REMOTE CONTROL**
Refers to remote control of elevators by emergency responders.

**RENTABLE AREA**
The area not occupied by technical amenities, stairwells, shafts etc. in a building.

**SCENARIOS**
Scenarios refer to preplanned emergency events like fire, hurricane, windstorm, earthquake, bomb threat, threat to adjacent building, power blackout, toxic agent etc.

**SELF-EVACUATION**
Self-evacuation refers to occupants evacuating by themselves, before emergency responders have arrived on the site, using available means of evacuation, i.e. elevators and stairs.

**STAGED EVACUATION**
Evacuation is carried out so that only a portion of the building occupants is evacuated, for example occupants on floors 23-27. Sometimes total evacuation can be carried out so that one section of the building after another is evacuated in this manner.

**STANDARD ELEVATOR**
In this guideline the standard elevator concept refers to a standard US elevator that is enabled for phase I recall and phase II fireman's operation.

**STANDARD USER INTERFACES**
Refers to the look and use logic of elevator control devices.

**SYSTEMS INTEGRATION**
Refers to the need of various building systems to be able to automatically exchange data with one another so that they together form a larger, integrated system, such that an input from one system can create a desired output on another system.

**TENABLE ENVIRONMENT**
Refers to an environment that supports the life of the occupants.

**TIME TO EVACUATE**
The time passed between an evacuation alert and the egress of the last evacuee.

**TIME TO RE-ENTER**
The time it takes for evacuees to re-enter after an emergency event is over.

**TOTAL EVACUATION**
A complete evacuation of a building, whereby occupants are evacuated at once.

**USER INTERFACES**
See standard user interfaces.

**ZONING AREA**
Zoning area refers to the allowed maximum floor area of a building as stated by authorities. If technical or special types of spaces are to be excluded, the building owner can build more rentable space. The zoning area definitions for a given city area are controlled by the city authorities. Zoning can also refer to intended use of land or built space, among other things.
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