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ELEVATOR DESIGN FOR THE 21ST CENTURY

DESIGN CRITERIA FOR ELEVATORS WHEN USED AS THE PRIMARY MEANS OF EVACUATION DURING FIRE EMERGENCIES

by Elmer F. Chapman

The elevator for use in the 21st century must be designed for safety under all conditions that may be expected in the building for which they are to be installed. The integration of smoke control and fire protection systems, along with evacuation procedures for the use of elevators during fire emergencies, are discussed. A total approach for the safe use of elevators for occupant evacuation during fire emergencies is examined and recommendations are made to bring elevator systems to a level of safety that can permit their use during fire emergencies. It is suggested that by introducing a number of safety measures existing and practical, elevators can become the primary means of egress, just as they are the primary means of ingress to a building.

Introduction

Elevators transport more people than any other means of transportation and do it more safely. The utilization of today's high-rise buildings is feasible only because modern, fast-moving, reliable elevators permit access to, and egress from, upper stories. Persons who are physically limited especially require the use of elevators for access to stories above the ground floor. It is essential that the elevator industry provide elevators that are just as safe for evacuation during a fire emergency as they are for entry. The physically limited person must have safe egress from buildings by way of elevators which have provided them with safe entry. But one might also ask — why only the physically limited? Shouldn't everyone be provided with safe means of egress? National Institute of Standards and Technology studies indicate that high-rise buildings can be completely evacuated 40% faster using properly-programmed elevators than by using stairs.

Thirteen Points of Criteria for Safe Elevator Design

Following are 13 proposed requirements to assure elevator safety during fire emergencies. It is not all-inclusive nor in any order of priority. Nor is it a pick-and-choose list of options. Rather, it is intended as a compendium of safeguards that must be included in a total approach to designing elevator systems that can be safely utilized for evacuation during a fire emergency, enhance fire-fighting operations, reduce costly fire damage to the elevators and diminish the time that businesses within a building must endure interruption. Additional studies will be required to ensure that all potential events have been considered.

1. The building shall be fully protected by a sprinkler system.
2. Elevator shafts should be pressurized.
3. Elevator lobbies on all floors should be enclosed.
4. Elevator lobbies should be pressurized.
5. Air intakes for the elevator shaft and lobby pressurization systems should be from a smoke-free location.
6. All elevator lobbies should be protected by smoke detectors.
7. Elevator systems should be made resistant to water.
8. When a power failure occurs all elevators should return to their designated level.
9. All elevators should be capable of being operated from a dedicated emergency power generator.
10. All elevator lobbies should have access to a pressurized stairway without passing through another fire area.
11. All elevator cars should have means for two-way voice communication between the elevator car and the Fire Command Station.
12. All elevator lobbies should have means for two-way voice communication between the elevator lobby and the Fire Command Station.
13. A program for the priority of elevator response during fire emergencies should be developed.

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ELEVATOR DESIGN

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Warrants and Justification for Criteria

#1. The Building Shall Be Fully Protected by a Sprinkler System

Sprinklers have proven the best means of preventing small fires from becoming big fires and are also the best smoke control system available. To moderate the danger to persons using elevators during the occurrence of fire, the building must be sprinklered throughout in accordance with NFPA 13 Standard for the Installation of Sprinkler Systems. This is a prime requisite and any attempt to circumvent or "trade off" this provision should be resisted. Elevator machine rooms and the bottom of all elevator shafts shall be sprinklered. The shaft of passenger elevators need not be sprinklered, but the shaft of freight elevators should.

#2. Elevator Shafts Should Be Pressurized

Elevator shafts, as a result of "stack effect" in high-rise buildings, are usually the area of lowest pressure on a floor. In the event of a fire, the tendency is for smoke and heat to flow towards and up elevator shafts. If the elevator shaft was pressurized to .05 in. of water (12 Pa), it would no longer be the low pressure area on the floor, and smoke and heat would no longer migrate towards it.

Most jurisdictions require that elevator shafts be provided with means of venting smoke and hot gases to the outer air. This vent area is required to be 3.5% of the total shaft area or at least 3 sq ft per elevator car, whichever is greatest. A variance for this requirement can usually be obtained in such an instance. The variance should provide that elevator shaft vents may be maintained closed as long as provisions exist to open them during a fire if necessary. Controls for this purpose should be located at the Fire Command Station in the lobby. This is an area where existing codes should be changed to permit application of advances in smoke control in which air flow is controlled. The closing of these elevator vents would permit the elevator shaft to be pressurized and prevent the flow of smoke.

Pressurizing elevator shafts brings additional benefits. including:

1. As in stair pressurization, the constant and critical need of the fire service to gain the use of a smoke-tight elevator shaft is achieved. All openings between the shaft and the rest of the building must be sealed in order to obtain the pressure differential necessary to assure a smoke-tight elevator shaft.

2. By closing the elevator shaft vents the shaft will no longer be a conduit through which heat is wasted during the heating season and cool air is lost during the time when air conditioning is required. This could result in a significant reduction of costs and conserve energy.

3. During cold and windy days the opening and closing of the shaftway and elevator car doors will be achieved with much less strain and wear on door-operating motors. Maintenance costs are thereby reduced and down time lessened.

#3. All Elevator Lobbies Should Be Enclosed

Elevator lobbies on all floors shall be enclosed by at least two-hour-rated partitions. The doorways in these partitions shall be protected by at least 1½-hour-rated door assemblies. Such doors may be maintained in the open position provided they close automatically when an alarm of fire is received in the building from any source. Freight elevators should not be permitted in the same enclosure with passenger elevators.

These enclosed lobbies provide an area of refuge for building occupants while awaiting elevators — a fire-protected area between the elevator shaft and the rest of the floor.

Enclosure requirements on the lobby or street floor may be omitted provided one of the following conditions is met:

1. The floor is fully sprinklered.
2. The fire load on this floor is limited.
3. Any area on this floor where a fire load might exist is separated from the elevator lobby by a two-hour-rated partition. Any openings in this partition should be provided with 1½-hour-rated enclosures. Openings in enclosures shall be protected by self-closing devices maintained in the closed position. No devices should be permitted to hold these doors in the open position.

#4. All Elevator Lobbies Should Be Pressurized

The elevator lobbies on all floors shall be pressurized to a pressure differential of at least .05 in. of water (12 Pa) with respect to the adjacent compartments. This will prevent the entry of smoke into the elevator lobby and, thus, provide the building occupants with an area of refuge while awaiting elevators. This measure will also assist in pressurizing the elevator shafts and preclude the need for gasketing of the shaftway doors, needed if an attempt is made to pressurize the elevator shaft only. Pressurization of elevator lobbies will also supply building occupants with an ample supply of fresh, breathable air while awaiting elevators during a fire emergency.

Having an airtight seal between the elevator lobby and the rest of the floor, obtaining the necessary pressure differential, will also help to ensure that all openings in the partitions are properly sealed and, thus, prevent the entry of smoke into the elevator lobby. The enclosed lobby will also assist in the retention of conditioned air in occupied portions of the building, thus reducing costs and conserving energy.

#5. The Air Intakes for the Elevator Shaft and Lobby Pressurization Systems Should Be from a Smoke-Free Location

Location of air intakes for elevator shaft and elevator lobby pressurization systems must be as smoke-free as possible under fire conditions. Roof and upper level locations are generally problematic since smoke from a fire in a building will rise under most conditions, and the roof and upper levels be contaminated with smoke early in the fire. To locate air intakes at these locations is usually not acceptable. It should be noted in the same context that protection of these intakes by smoke detectors has also not proven satisfactory since these devices are not reliable during cold weather and when they do function the pressurization system is lost. It is advisable to locate these intakes as remote from the building as possible where structures are in a campus-like setting. Where this is impossible, they should be located as low in the building as possible. Considering the design of most high-rise buildings in major city environments, the second floor is probably the most likely location. This is the usual location of air inlets for lobby and below-ground HVAC systems intakes. The least desirable location for the air inlets is at the roof. If this location is dictated the prevailing wind direction must be considered. Intakes should be provided on both the lee and the windward sides. Provisions should assure selection of the smoke-free side at the time of a fire.

#6. All Elevator Lobbies Should Be Protected by Smoke Detectors

Smoke detectors in elevator lobbies are required where elevators are to be used to evacuate building occupants during a fire. This is to prevent the elevator from stopping on any floor where the elevator lobby may have become contaminated with smoke. Phase I recall could be replaced with evacuation programming as outlined in item #13.

#7. The Elevator Systems Should Be Made Resistant to Water

Because water has an adverse effect upon safe operation, it is imperative that elevators be made resistant to water. It is not expected that elevators be made to operate under water, but much can be done to reduce the present vulnerability of elevator systems to the presence of relatively small amounts of water. Water in an elevator shaft can enter controls and other electronic devices, causing the elevators to operate in an erratic and unsafe manner. As more and more buildings are fully sprinklered, the potential for elevator failure due to water intrusion will become greater. If elevators can be designed to operate on the exterior of buildings exposed to the elements, it is not beyond current design capabilities to have elevators within buildings operate safely when foreseeable amounts of water enter the elevator shaft.

In addition to preventing water from entering elevator shafts, precautions should be taken to contain any water that does enter the shaft. The entire electrical control system of elevators, including door interlocks, door protective devices, motors, brakes, drives, door operating devices, door controllers, cabinets, junction boxes in hoistway and on cars, conduits, limit switches, safety switches, floor selection and leveling systems, all signal fixtures, car lights, outlets, etc. should be NEMA 4 rated or of NEMA 4 type approved design. Traveling cables should be of a type approved for outdoor use in wet environments.

The elevator car should be designed to deflect falling water away from door openings. The roof of the car should be designed to prevent pooling or collection of water. The car shall be sealed to prevent water from entering through panel joints, lights, fans, vents or emergency exits. Sprinklers located in elevator lobbies shall be the type that turn off when the temperature is reduced. The floors of elevator lobbies should be graded, with the grade sloping away from the elevator shafts.

#8. If a Power Failure Occurs All Elevators Should Automatically Return to the Designated Level

All elevators used to evacuate building occupants during a fire shall return to the designated level in the event of a power failure. Precautions must be taken to prevent building occupants from becoming trapped due to a power failure during a fire. A failure of electrical power during a fire in a building is a foreseeable event requiring pre-planning. It is

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