The Code Corner

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Elevators

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One hundred and sixty years ago, Elisha Otis invented the first braking mechanism for the elevator, which made vertical travel within a building feasible and safe. A little over forty years later, the gearless traction elevator was developed, which allowed movement in buildings of significant height. Thus, along with the advent of inexpensive materials and advanced engineering and construction methods, the automatic elevator became a pivotal step that led to the surge of high-rise construction in the United States. Since its introduction, the elevator has seen numerous advancements, but its purpose remains the same: moving people between floors of multi-story buildings efficiently and safely.

Like other systems within a building, elevators are regulated by the building code. In the *International Building Code* (IBC)[1], Chapter 30 establishes the primary criteria for elevators, while other sections of the IBC supplement the primary criteria with special provisions, such as requirements for accessible means of egress, elevator lobbies, and shaft enclosures for hoistways. In addition to the provisions in the IBC, elevators must also comply with the requirements in the American Society of Mechanical Engineers' (ASME) A17.1, *Safety Code for Elevators and Escalators*[2], and ICC/ANSI A117.1, *Accessible and Usable Buildings and Facilities*[3], which are referenced by the IBC.

General Elevator Planning and Design

With a couple of exceptions, neither the IBC nor ASME A17.1 dictate the number of elevators that must be provided in a building—any number of elevators may be provided at the discretion of the building owner. The owner or architect may hire an elevator consultant to determine the elevator needs for buildings with high traffic or complex usage requirements.

As stated, there are a couple of exceptions in which the code regulates the number of elevator cars. The first exception is in Section 1007.2.1, which requires at least one elevator be provided as one of the required accessible means of egress if an accessible story is located four or more stories above or below the level of exit discharge. However, the elevator is not required if the building is sprinklered throughout per Section 903.3.1.1 (NFPA 13) or Section 903.3.1.2 (NFPA 13R), and includes either a ramp from the stories, or the stories incorporate a horizontal exit at or above the level of exit discharge. The second exception is in Section 403.6, which requires at least two elevators be designated as fire service access elevators in buildings with occupied floors greater than 120 feet above the lowest level of fire department vehicle access.

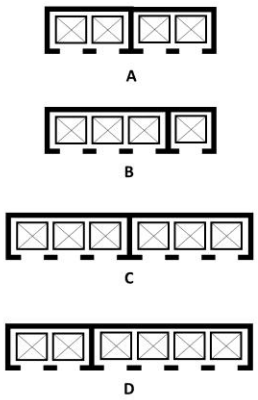

Figure 1 - Number of elevator cars in a hoistway.

If multiple elevators are provided in a building, the IBC requires that the number of cars within a single hoistway enclosure be limited to no more than four. However, if four or more elevator cars serve all or the same

[1] References to the IBC are for the 2012 edition unless indicated otherwise.
[2] The 2007 edition of ASME A17.1 is referenced by the 2012 IBC.
[3] The 2009 edition of ICC/ANSI A117.1 is referenced by the 2012 IBC. The elevator requirements in the 2009 ICC/ANSI A117.1 is virtually identical to the *2010 ADA Standards*, which were adopted by the Department of Justice to replace the *ADA Accessibility Guidelines* (ADAAG).

stories, then the elevators must be located in a minimum of two hoistway enclosures. Thus, if four elevator cars are provided, then they must be located in two hoistways in a 2-2 or 1-3 combination (See A and B in Figure 1). If six elevator cars and two hoistways are provided, then the only combinations permitted would be 3-3 or 2-4 (See C and D in Figure 1)—a 1-5 combination would not be permitted, since no more than four cars are allowed in a single hoistway.

Elevator car size is also regulated by the IBC and by ICC/ANSI A117.1. In the IBC, if an elevator is provided in a building that has four or more stories above or below the grade plane, then at least one elevator shall be sized to accommodate an ambulance stretcher that is 24 inches wide by 84 inches long with corners having radii of 5 inches or more. In ICC/ANSI A117.1, elevator cars shall have a clear dimension of 60 inches wide and 60 inches deep or 54 inches wide and 80 inches deep. Elevator cars with centered doors may be 51 inches deep (54 inches to the doors) and 80 inches wide, provided the door has a 42-inch minimum width. Additionally, elevator cars with 36-inch-wide side doors may be equally deep, but need only be 68 inches wide. Existing elevators are exempt from the previous size criteria, provided elevators cars have clear dimensions of 36 inches wide and 54 inches deep, and have a clear floor area of 16 sq. ft.

Elevator hoistways penetrating more than three stories are required to provide venting at the top of the hoistways to allow heat and smoke to escape. Except for Groups R-1, R-2, I-1, I-2, and other occupancies with sleeping units, venting is not required when the building is sprinklered throughout in accordance with NFPA 13 or 13R. When venting is required, the vents must open directly to the exterior or through noncombustible ducts that terminate at the exterior. The area of the vents shall be 3½% of the hoistway, but not less than 3 sq. ft. per elevator car. Of the total required venting area, not less than ⅓ of the area must be permanently open with the remaining area closed off with annealed glass not greater than ⅛ inch thick. Permanently opened venting is not required if automatic vents are installed that open when smoke is detected in the hoistway or in the elevator lobby (if lobbies are provided), upon power failure, or when activated by manual control.

Other considerations that go into planning and design for elevators—also affected by the codes—are machine rooms, elevator lobbies, pits and clearances, and car finishes. Machine rooms are regulated by both the IBC and ASME A17.1. Requirements for elevator lobbies are only located in the IBC, while pits and clearances are only regulated by ASME A17.1. Regarding elevator car finishes, the IBC is not very specific, but will likely consider elevators as enclosed spaces per Table 803.9. On the other hand, ASME A17.1 provides specific criteria for car finishes and may supersede IBC criteria.

Pits and Clearances

ASME A17.1 separates criteria for pits and clearances in hoistways between electric and hydraulic elevators in Parts 2 and 3, respectively. Typically, most of the requirements are in Part 2 and referenced by Part 3, except where specifically modified for hydraulic elevators. For both types of elevators, the pit depth is based on the required equipment plus the minimum bottom car clearance of 24 inches when the elevator rests on fully compressed buffers or bumpers. For top clearances, the requirements are basically the same, except the dimensions will likely vary between electric elevators (either counterweighted or uncounterweighted[4]) and hydraulic elevators. Therefore, for design purposes, consult manufacturers' design criteria for the types of elevators under consideration.

[4] Counterweighted elevators use ropes with weights to help offset the weight of the elevator car for ease in moving the car. Uncounterweighted elevators are identified by ASME A17.1 as screw column elevators and rack-and-pinion elevators that do not require counterweights.

Machine Rooms

ASME A17.1 provides the majority of the technical requirements for machine rooms and spaces, but defers fire-resistive requirements to the building code. The minimum clear headroom in a machine room per ASME A17.1 is 84 inches. If fire resistance of the machine is not required by the building code, ASME A17.1 requires that machine rooms be constructed of noncombustible materials to a minimum height of 79 inches. The IBC requires that machine rooms be of fire-resistive construction complying with the requirements for fire barriers, horizontal assemblies, or both. The rating must be equal to the rating of the hoistway. IBC Section 3002.1 requires that hoistways comply with Section 713 for shaft enclosures; therefore, if the shaft connects four or more stories, then the hoistway and the machine room must have a fire-resistance rating of 2 hours, or 1 hour if connecting fewer than four stories. However, two exceptions are provided in the IBC:

- If a fire-resistance rating of 2 hours is required, then only a 1-hour rating is required if the machine room is not directly adjacent to the hoistway and no openings are provided between the hoistway and machine room.
- If the building is four stories or less and the machine room is not directly adjacent to the hoistway and no openings are provided between the hoistway and machine room, then the machine room is not required to have a fire-resistance rating.

The IBC simply states that machine rooms are to have an approved means of access; thus, the detailed criteria in ASME A17.1 will establish the minimum requirements for the means of access. If the machine room is elevated above the floor or roof surface, then a permanent and noncombustible set of stairs or ladder, along with a landing at the top, is required to reach the machine room door. The landing must be sized to allow the full swing of the door plus 24 inches if the door swings outward, or 29.5 inches if the door swings inward. Although ASME A17.1 allows doors to machine rooms to have a width of 29.5 inches, the IBC requires a minimum clear width of 32 inches.

If access to the machine room is across a roof, a stairway with a swing door shall be provided to the roof from the floor below—roof access hatches are not permitted. If the roof slopes more than 15 degrees or the roof does not have a minimum 42-inch-high parapet or guardrail around the roof or passageway to the machine room, then a walkway must be provided. The walkway must be 24 inches wide with railings 42 inches high consisting of a top rail, an intermediate rail or solid panel, and 4-inch-high toe-boards.

Elevator Lobbies

Elevator lobbies are required on each floor where an elevator shaft enclosure (*i.e.* hoistway) connects three or more stories. The exceptions to the code do not require lobbies under the following conditions or locations:

- On the level of exit discharge if the level is sprinklered in accordance with NFPA 13.
- Elevators not required to be enclosed in a shaft per IBC Section 712.1.
- When hoistway openings are provided with additional doors that comply with smoke and draft control requirements of IBC Section 716.5.3.1 and tested per UL 1784, *Air Leakage Tests of Door Assemblies*, without a bottom seal.
- When the building is sprinklered throughout in accordance with NFPA 13 or 13R. However, this exception is not permitted in Groups I-2 and I-3 and in high-rise buildings[5].
- Elevator hoistways pressurized in accordance with IBC Section 909.21.

[5] High-rise buildings are defined as buildings with an occupied floor located more than 75 feet above the lowest level of fire department vehicle access.

- Elevators only serving open parking garages.

When required or provided, elevator lobbies shall be enclosed with walls complying with the requirements for fire partitions. Since elevator lobbies must have at least one means of egress, doors in elevator lobby enclosure walls shall comply with requirements for doors in corridors. Ducts and air transfer openings in elevator lobby enclosures shall also be protected as required for corridors. Elevator lobby enclosures may be constructed as smoke partitions per Section 710 in lieu of fire partitions, provided the building is sprinklered throughout in accordance with NFPA 13 or 13R. If smoke partitions are provided, then doors need to comply with requirements for smoke and draft control.

Elevator lobbies are also required in the following special conditions and must comply with the requirements unique to each condition:

- Underground buildings where the elevator or elevators are shared by both smoke compartments[6].
- Elevators designated as fire service access elevators.
- Elevators designated as occupant evacuation elevators.
- Elevator lobbies serving as areas of refuge.

Elevator Finishes and Materials

The IBC states that interior finishes for enclosed spaces must be of Class C or B materials, depending on whether the space is sprinklered or not. However, that is not a decision that needs to be determined since ASME A17.1 requires finishes to be of Class B materials (a flame spread index less than or equal to 75 and a smoke developed index less than or equal to 450) when tested in accordance with ASTM E 84, *Test Methods for Surface Burning Characteristics of Building Materials*, or UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*.

If carpet or fabric (napped, tufted, woven, or looped) is used on elevator car walls, the material must be tested using the method specified in Section 8.3.7 of ASME A17.1. The material shall not have a burn length greater than 8 inches, the flame shall extinguish within 15 seconds after removal of the flame source, and drippings shall not burn for more than 5 seconds. Floor coverings, underlayments, and adhesives must have a critical radiant flux of not less than 0.45 W/cm^2 when tested in accordance with ASTM E 648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source*. Handrails are permitted, but not required, inside elevator cars.

Glazing is permitted in elevator cars and hoistways per IBC Section 2409 and ASME A17.1. When installed in elevator hoistways, glass shall be laminated safety glazing complying with 16 CFR 1201 Category II or ANSI Z97.1 Class A. If the hoistway is required to be fire-resistance rated, then the glazing must also comply with IBC Section 716 for opening protectives. Since Section 716 is referenced, glazing tested in accordance with ASTM E 119, *Test Methods for Fire Tests of Building Construction and Materials*, or UL 263, *Standard for Fire Tests of Building Construction and Materials*, may be used in lieu of complying with the limitations of Section 716.

In hoistway doors, glass shall comply with the same criteria for hoistways, except that ASME A17.1 permits wire glass in vision panels without reference to any safety glazing standards; however, the IBC will permit wire glass provided that the glass complies with the safety glazing standards previously mentioned. With the exception of vision panels, glazing in hoistway doors must not be less than 60% of

[6] Underground buildings as buildings with an occupied floor more than 30 feet below the lowest level of exit discharge. Requirements for underground buildings are located in Section 405 of the IBC. Underground buildings with floors more than 60 feet below the level of exit discharge must be divided into two smoke compartments, each with access to an elevator unless the elevator or elevators are shared by both compartments.

the total visible door surface area; likewise, car doors must have the same minimum area for glass as viewed from the car side. There is no requirement that glass, if provided, must be used in both the car and hoistway doors, nor is it required that the areas of glazing in each be equal.

When glass is installed as part of the elevator car enclosure, ASME A17.1 requires laminated safety glazing complying with 16 CFR 1201 and that it be mounted so that the assembly will pass the elevator tests without damage. Additionally, ASME A17.1 requires that a handrail or other framing be provided if the glass panels are wider than 12 inches. The IBC further requires that glass used within an elevator, either as a wall lining or as part of the enclosure, comply with 16 CFR 1201 Category II or ANSI Z97.1 Class A. Since ANSI Z97.1 is not referenced by ASME A17.1, then, to comply with both codes, only materials complying with 16 CFR 1201 Category II should be used.

Both the IBC and ASME A17.1 allow tempered glass when used as a lining for elevator car walls. If used, tempered glass must be bonded to a coating, sheeting, or film backing to hold fragments in place if broken. The tempered glass cannot be sandblasted, etched, heat treated, painted, or have received any other treatment that would affect the characteristics of the glass. Finally, the IBC requires that tempered glass comply with 16 CFR 1201 Category II or ANSI Z97.1 Class A, which is more specific than the safety glazing requirements specified by ASME A17.1.

Elevators as Accessible Means of Egress

Elevators required or provided as an accessible means of egress must comply with requirements in IBC Section 1007.4. To be considered an accessible means of egress, elevators must be provided with standby power in accordance with NFPA 110, *Emergency and Standby Power Systems*, or NFPA 111, *Stored Electrical Energy Emergency and Standby Power Systems*. NFPA 110 provides requirements for generators, whereas NFPA 111 provides requirements for stored energy type systems, such as batteries.

As previously mentioned, elevator lobbies may serve as a required area of refuge for elevators used as an accessible means of egress. Elevators are not required to be accessed by an area of refuge when buildings are sprinklered throughout with a system complying with NFPA 13 or 13R, when elevators are not required to be enclosed in a shaft, and when elevators are accessed by a horizontal exit. If used as an area of refuge, elevator lobbies must be enclosed with smoke barriers and provided with two-way communication to the fire command center or other location approved by the fire department. Also, elevator lobbies used as areas of refuge must accommodate one 30- by 48-inch wheelchair space for every 200 occupants served by the area of refuge. The wheelchair spaces cannot reduce the required means of egress width.

Fire Service Access and Occupant Evacuation Elevators

Fire service access and occupant evacuation elevators were introduced in the 2009 IBC and modified in the 2012 IBC. As mentioned earlier, buildings with an occupied floor more than 120 feet above the lowest level of fire department vehicle access must provide two elevators designated as fire service access elevators. Passenger elevators in high-rises are permitted to be used as occupant evacuation elevators. Additionally, in high-rise buildings greater than 420 feet in height, elevators complying with the requirements for occupant evacuation may be used in lieu of the required third stairway.

Fire service access elevators were added to the IBC in Section 3007 as a result of research conducted following the World Trade Center tragedy of September 11, 2001. According to the code change proposal, these requirements were recommended to "provide a reasonable degree of safety for firefighters" when "staging firefighters and equipment one or two floors below the fire." Elevators used for fire service access are required to be identified by a pictorial symbol representing a firefighter's

helmet that shall be mounted on the face of hoistway door frame that is perpendicular to the hoistway door.

Fire service access elevators must have access to a fire service access elevator lobby on each floor, except at the level of exit discharge. Each lobby shall have direct access to an interior exit stairway, which shall be provided with a Class I standpipe. If a fire service access elevator has two entrances to a floor, the second entrance is permitted to have access to a standard elevator lobby as described earlier. Fire service access elevator lobbies must be enclosed with smoke barriers. Doorways to a fire service access lobby shall be fire door assemblies having a ¾-hour rating and complying with smoke and draft control requirements of Section 716.5.3.1. The size of a fire service access elevator lobby must be a minimum 150 sq. ft. in floor area with no dimension less than 8 feet.

Other unique criteria apply to fire service access elevators. For example, sprinklers are not permitted in machine rooms, machine spaces, and hoistways of fire service access elevators, and water from sprinklers outside the fire service access elevator shall be prevented by approved means from entering the fire service access elevator hoistway. Fire service access elevators and associated equipment shall be supplied by normal and standby power. Wires and cables from outside the fire service access elevator that provide power, communications, fire detection, and control signals for the elevator must be protected by construction having a fire-resistance rating of not less than 2 hours.

Occupant evacuation elevators were added to the IBC in Section 3008 to provide occupant self-evacuation. Prior to the introduction of occupant evacuation elevators in the 2009 IBC, elevators were not permitted to be used by building occupants for means of egress. These provisions are voluntary, but, if provided, all public passenger elevators must comply with the provisions. For the most part, occupant evacuation elevators must comply with the same requirements for fire service access elevators in regard to the fire sprinkler prohibition, prevention of outside sprinkler water from entering the hoistway, and protection of wires and cables.

Elevator lobbies serving occupant evacuation elevator have requirements identical to fire service access elevator lobbies, such as smoke barrier enclosure construction (except at level of exit discharge), doorways, and access to an interior exit stairway; however, occupant evacuation elevator lobbies have additional provisions. Doors, in addition to the fire-resistive requirements, must also have vision panels consisting of fire-protection-rated glazing and be automatic closing by fire alarm signal if kept open by magnetic or other hold-open devices. The size of the occupant evacuation elevator lobby shall be a minimum of 3 sq. ft. per occupant based on not less than 25% of the floor occupant load served by the lobby. Furthermore, a 30- by 48-inch wheelchair space is required for every 50 occupants of the occupant load of the floor area served by the lobby. The lobby shall also be provided with two-way communication identical to that required for areas of refuge.

Occupant evacuation elevators shall be identified as such on all floors with an approved sign located adjacent to each call station. Lobbies serving occupant evacuation elevators must provide a status indicator that shows by green illumination that elevators are available for occupant evacuation when elevators are in normal service and the fire alarm system has indicated an alarm. If the elevators have been switched to emergency recall service by the fire department, the status indicator should show by red illumination that elevators are not available for evacuation and that stairs should be used. At all other times, no illumination or message should be indicated.

Structural Integrity for High-Rise Elevator Hoistways

If high-rise buildings are classified as Risk Category III or IV[7] in accordance with Section 1604.5, or if the building has a height greater than 420 feet, then elevator hoistway enclosures must comply with the requirements for structural integrity per Section 403.2.3. These provisions were introduced in the 2009 IBC as a result of recommendations developed following the World Trade Center tragedy. The intent is to provide increased resistance to structural damage from external impacts.

The wall assembly surrounding a hoistway must comply with Soft Body Impact Classification Level 2 as determined by ASTM C 1629/C 1629M, *Standard Classification for Abuse-Resistant Nondecorated Interior Gypsum Panel Products and Fiber-Reinforced Cement Panels*, which requires the entire assembly to withstand an impact of a 195 pound force. The exterior face of the hoistway (the wall surface not facing the stairway) must consist of either two layers of material complying with Hard Body Impact Classification Level 2, or one layer of material complying with Hard Body Impact Classification Level 3. Additionally, any materials that, when combined and tested together, comply with Hard Body Impact Level 3 shall be permitted. Concrete and masonry construction are deemed to comply with the requirements for the Soft Body and Hard Body Classification requirements and are not required to be tested.

This article does not attempt to address all the requirements relating to elevators. Most of the requirements associated with elevators—essentially those in ASME A17.1—pertain to the fabrication of elevators and associated equipment and accessories, of which elevator manufacturers are acutely aware. Specifications for elevators in the construction documents should require compliance with ASME A17.1 and with ICC/ANSI A117.1, the *2010 ADA Standards*, or both. Since elevators vary among manufacturers, design professionals should consult manufacturer representatives when designing and specifying elevators, especially if custom designs are proposed for elevator cars, entrances, call stations, and hall signals.

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[7] Risk Category III buildings are those "that represent a substantial hazard to human life in the event of failure," and Risk Category IV buildings are those "designated as essential facilities." Refer to Table 1604.5 for specific uses identified for each category.