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Elevator Fire Safety:
Elevator Recall and Elevator Power Shutdown

Disclaimer: This summary has been revised to cite model codes and standards current as of October 2010. The adoption of local codes or model codes with amendments may change these requirements. Also, not all jurisdictions use the most current codes and standards. The opinions herein are those of R.P. Schifiliti Associates, Inc. and are generalizations that may not apply to your specific situation. The examples and citations in this paper are for automatic elevators and only address recall, power shutdown and in-car warning. Requirements for "first responder use elevators", in-car communications and other safety features are not addressed in this paper. Prudent and responsible designers, installers, inspectors, owners and consultants will access and read all applicable codes, standards and regulations in their entirety. They are tools that you need to do your job correctly.

Background

Elevators are an extremely safe mode of transportation. The principle fire safety risk that they add is the possible transport of smoke and the possible entrapment of users due to control system failures or power shutdown. For this reason codes specify fire safety features to reduce the likelihood of smoke migration and to control elevators when they are threatened with fire or smoke.

In the late 1980s ASME sponsored a series of task group meetings to address elevator fire safety and to coordinate ASME A17.1[1] with building codes, NFPA 101 *Life Safety Code*[2], NFPA 13 *Standard for the Installation of Sprinkler Systems*[3] and NFPA 72 *National Fire Alarm Code*[4]. The task group included elevator safety experts, fire protection engineers, fire alarm and sprinkler experts, fire fighters, code experts and others. That work resulted in a framework that connects the various codes and standards. The requirements in the various codes and standards have evolved since then, but remain essentially the same with respect to the overall mission and methodologies.

The codes recognize that there is almost no risk of fire in a code compliant elevator or hoistway that would be mitigated by protection being required in those spaces. Therefore, building codes, life safety codes, fire codes, elevator safety codes and sprinkler and fire alarm standards have been coordinated to not require any special protection in properly constructed hoistways. The exception (see NFPA 13 below) is where hydraulic elevators use a combustible fluid. However, it was also acknowledged that sprinklers would often be required in elevator machine rooms and other control spaces and that there could be circumstances where sprinklers might be installed in hoistways. Therefore, the codes and standards were coordinated to protect elevator equipment and to remove elevator power (sometimes called shunting) before or immediately upon sprinkler discharge *if the sprinkler water might affect the elevator operation.*

The codes and standards also recognize the need for emergency control of elevators under certain conditions. Phase I Emergency Recall Operation provides the manual and automatic return of elevators to designated levels. Phase I recall provides a means for emergency responders to quickly verify that no one is trapped and ensures that no one other than emergency forces will be using the elevators that might be exposed to smoke or heat from a fire. Phase II Emergency In-car Operation provides a means for emergency forces to manually operate elevators even when Phase I recall has been initiated. The codes and standards are also coordinated to provide emergency forces using Phase II operation with an in-car warning when conditions threaten the safe operation of the elevator. Phase I recall can be initiated manually or automatically and firefighters can use Phase II operation to use elevators even when smoke is present. But, if the safe operation of the elevator is threatened, they will receive an in-car warning signal.

The safe operation of elevators requires compliance with all of the coordinated building codes, life safety codes, fire codes, elevator safety codes and sprinkler and fire alarm standards. This paper is intended only as a guide or roadmap to demonstrate how the various codes and standards are coordinated and dependent upon each other to achieve the overall goal.

Summary

This section of the paper summarizes the requirements to have, and the particular features of, elevator recall and power shutdown. Specific citations from the relevant codes and standards are found in later sections. In some locations of this paper a code paragraph or section number is preceded by the code number for clarity. For example, A17.1-2.27.3 or 72-23.8.5.1.2. In other locations, where the context is clear, the code number is left off.

The 2007 edition of ANSI/ASME A17.1 has been revised to incorporate several different terms for the space where elevators controls are located. The terms include machine room, machine space, control room and control space. This paper uses the terms interchangeably to mean all or any of these rooms and spaces.

There is no code requirement to recall elevators unless the hoistway or machine room is threatened or if there is smoke in an elevator lobby. Smoke in an elevator lobby threatens the hoistway and also threatens to expose people if an elevator opens to that lobby. Thus, the codes and standards work together to require automatic elevator recall only when detectors in the following areas are activated: 1) elevator lobbies, 2) elevator machine rooms, or 3) *if provided*, elevator hoistways. In most locations, but not all, the detectors are required to be smoke detectors. The codes do not require any other initiating devices (smoke detectors, heat detectors, manual fire alarm boxes, etc.) to initiate elevator recall. With respect to the third location in the list, smoke detectors are *not permitted* to be in an elevator hoistway, except under certain conditions.

Model building codes require hoistways to be constructed as fire resistive shafts – except in very special circumstances, such as certain parking garages. The exact fire rating of the hoistway/shaft required by the building code may vary from 1-hour to 2-hours or more depending on other characteristics of the building. The doors to the hoistway are a weak link for fire and smoke.

Therefore, smoke detection is needed near the doors to initiate Phase I recall. The sequence of Phase I recall also prevents a car from traveling to the floor where smoke is first detected. NFPA 72 is the document that provides the details for the location and operation of those detectors and the control circuits.

Similarly, the elevator controls are a point of common mode failure where smoke or heat could cause elevator failure. Therefore, smoke detection is needed in machine rooms and control spaces to initiate Phase I recall. NFPA 72 is the document that provides the details for the location and operation of those detectors and the control circuits.

Where complete coverage by sprinklers is provided or required in a building, elevator lobbies and elevator machine rooms are required by NFPA 13 to have them. Water discharge from machine room has sprinklers onto control equipment could cause erratic behavior or sudden failure of the elevators – as could smoke and heat. Therefore, smoke detection is needed, and required by code, to recall and safely park the elevator. To protect against failure caused by sprinkler water discharge onto control equipment, heat detection or a flow switch without any time delay mechanism is also needed and required by code to remove power before or at the instant water is discharged. NFPA 13 is the document that provides the details for the sprinkler design and installation. NFPA 72 is the document that provides the details for the selection, location and operation of the smoke detectors, heat detectors, waterflow switches and control circuits. A17.1 describes the requirements for power shutdown and for elevator recall and control.

There is no need and no code requirement to provide sprinkler protection anywhere in an elevator hoistway unless the hoistway or the elevator car fail to meet the non-combustibility requirements that they are required to meet. In other words, if the elevator car and hoistway meet code, NFPA 13 does not require sprinklers in the hoistway. There are two exceptions in NFPA 13. The first is if a hydraulic elevator uses a combustible fluid. Then, sprinklers are required in the pit. The second is if the elevator use polyurethane-coated steel belts or other similar combustible belt materials. Then, sprinklers are required the top and in the pit of the hoistway. There is no requirement to provide sprinklers in a pit to protect against fires involving trash and other debris that might accumulate in the pit. Such fires are generally more of a nuisance than any real threat to life and might not even activate the sprinklers.

If sprinklers must be installed at the top of the hoistway, then smoke detection is also needed, and required by code, to recall and safely park the elevator. To protect against failure caused by sprinkler water discharge onto elevator brakes and other equipment in hoistway, heat detection or a flow switch without any time delay mechanism is also needed and required by code to remove power before or at the instant water is discharged. NFPA 13 is the document that provides the details for the sprinkler design and installation. NFPA 72 is the document that provides the details for the selection, location and operation of the smoke detectors, heat detectors, waterflow switches and control circuits. A17.1 describes the requirements for power shutdown and for elevator recall and control.

If sprinklers must be installed in a pit, NFPA 13 has specific height requirement that is coordinated with requirements in A17.1 for the location and protection of electrical equipment in the pit. The

two standards are coordinated to keep sprinkler water away from the elevator electrical circuits and equipment. When these installation requirements are met it should not be necessary to remove power before or upon sprinkler discharge. However, if the arrangement of electrical equipment and sprinklers is such that water discharge could cause unsafe elevator operation, then a heat detector or flow switch without any time delay mechanism is needed and required by code to remove power before or at the instant water is discharged. This might occur in retrofit situations where sprinklers are added at a latter date or where the two trades are not properly coordinated.

A17.1 requires that detection be provided to initiate Phase I recall whenever sprinklers are installed in a hoistway. This includes sprinkler in the pit, regardless of whether a power shutdown is required. The elevator code requires the detectors to be selected and installed per NFPA 72. Since an elevator pit is not a suitable space for using smoke detectors, heat detectors are permitted by NFPA72 to initiate Phase I recall. NFPA 72 is the document that provides the details for the selection, location and operation of the heat detectors and control circuits. A17.1 describes the requirements for elevator recall and control.

The remaining sections of this paper provide code citations and additional discussion to support the generalizations listed above.

Elevator Control (Requirements to Have)

The requirements for elevator control start with a local law, regulation or code. Typically a local law or regulation is passed to adopt a building code, fire code, or life safety code. The legislation might instead appoint some local authority and empower them to write or adopt one or more of these codes. These codes might then require compliance with the ANSI/ASME elevator code or some local elevator code. In some cases, an elevator code is adopted directly by a law or regulation. Here are some examples of code text requiring elevator control:

2009 International Building Code[5] (IBC):

> [F] 3003.2 Fire-fighters' emergency operation. Elevators shall be provided with Phase I emergency recall operation and Phase II emergency in-car operation in accordance with ASME A17.1/CSA B44.
> (Note: The "[F]" in front of the paragraph number indicates that this paragraph is under the jurisdiction of the International Fire Code Development Committee.)

2009 International Fire Code[6] (IFC):

> 607.1 Emergency operation. Existing elevators with a travel distance of 25 feet (7620 mm) or more shall comply with the requirements in Chapter 46. New elevators shall be provided with Phase I emergency recall operation and Phase II emergency in-car operation in accordance with ASME A17.1.
>
> 4603.2 Elevator operation. Existing elevators with a travel distance of 25 feet (7620 mm) or more above or below the main floor or other level of a building and intended to serve the needs of emergency personnel for fire-fighting or rescue purposes shall be provided with emergency operation in accordance with ASME A17.3.

2009 NFPA 101, Life Safety Code[7] (LSC):

> 9.4.3 Fire Fighters' Emergency Operations.
> 9.4.3.1 All new elevators shall conform to the Fire Fighters' Emergency Operations requirements of ASME A17.1/CSA B44, Safety Code for Elevators and Escalators.
> 9.4.3.2 All existing elevators having a travel distance of 25 ft (7620 mm) or more above or below the level that best serves the needs of emergency personnel for fire-fighting or rescue purposes shall conform to the Fire Fighters' Emergency Operations requirements of ASME A17.3, Safety Code for Existing Elevators and Escalators.

2009 NFPA 5000, Building Construction and Safety Code[8] (BCSC):

> 54.2 Installation. Except as modified herein, elevators, escalators, dumbwaiters, and moving walks shall be installed in accordance with the requirements of ASME A17.1/CSA B44, Safety Code for Elevators and Escalators.

Note that if a jurisdiction adopts the IBC, LSC or the BCSC for new construction, there is no qualifier for travel distance. However, A17.1 does have some qualifiers that establish whether emergency operation is required.

2007 ASME/ANSI Safety Code for Elevators and Escalators A17.1[9]:

For electric elevators:

> 2.27.3 Firefighters' Emergency Operation: Automatic Elevators
> Firefighters' Emergency Operation shall apply to all automatic elevators except where the hoistway or a portion thereof is not required to be fire-resistive construction (see 2.1.1.1), the rise does not exceed 2 000 mm (80 in.), and the hoistway does not penetrate a floor.

For hydraulic elevators:

> 3.27 Emergency Operation and Signaling Devices:
> Emergency operation and signaling devices shall conform to 2.27, except as modified by the following: The requirements of 3.26.9 and 3.18.2.7 shall be modified when Phase I Emergency Recall Operation and Phase II Emergency In-Car Operation are in effect, as specified in 3.27.1 through 3.27.4.
>
> [NOTE: The modifications cited in 3.27 do not affect fire protection requirements or operating features.]

Elevator Recall (Required Features and Operation)

Excerpts from ANSI/ASME A17.1, *Safety Code for Elevators and Escalators*

Section of 2.27.3.1, Phase I Emergency Recall Operation, of A17.1 describes how the elevator is to operate during Phase I recall, whether initiated manually or automatically. The specific requirements for automatic recall are in section of 2.27.3.2, titled Phase I Emergency Recall Operation by Fire Alarm Initiating Devices.

2.27.3.2.1 In jurisdictions not enforcing the NBCC, fire alarm initiating devices used to initiate Phase I Emergency Recall Operation shall be installed in conformance with the requirements of NFPA 72, and shall be located
(a) at each floor served by the elevator
(b) in the associated elevator machine room, control space, or control room
(c) in the elevator hoistway, when sprinklers are located in those hoistways

[NOTE: NBCC refers to the National Building Code of Canada. Requirements for jurisdictions enforcing the NBCC are not listed in this paper.]

Note that the A17.1 code requires recall only from detectors "at each floor served by the elevator", elevator machine room detectors and, where provided, elevator hoistway detectors. The elevator code does not require recall from any other fire alarm initiating devices. A17.1 does not specify what type of detectors or the specific location, spacing or installation requirements. Instead, it references NFPA 72. The intent, and the consensus reached by the experts taking part in the code development, is that there is no need to recall the elevators until the elevators are threatened at the weak points – the doors to the hoistway and the machinery/control spaces. Therefore, for the floor level detectors required by A17.1-2.27.3.2.1 (a), NFPA 72 requires only elevator lobby detectors to initiate recall. Again, note that there is no requirement for detectors in hoistway – anywhere – unless sprinklers are present in the hoistway.

Paragraph A17.1-2.27.3.2.3 then requires the fire alarm initiating devices at any floor (only the detectors in the elevator lobbies per NFPA 72), other than at the designated level, to recall the elevators that serve that floor, and any associated elevators in a common group, to be returned to the designated level. If the lobby detector on the designated level activates, recall must be to the alternate level (A17.1-2.27.3.2.4). The designated and alternative levels are defined in A17.1:

designated level: the main floor or other floor level that best serves the needs of emergency personnel for firefighting or rescue purposes identified by the building code or fire authority.

alternate level: a floor level identified by the building code or fire authority, other than the designated level.

If a detector in an elevator machine room, control space, or control room activates, the elevator must be recalled to the designated level – unless the alarm is from a space on the designated level, in which case recall is to the alternate level.

If a detector installed in a hoistway activates, recall is to the designated level. The exception would be where the detector is below the lowest recall level (designated or alternate), in which case recall is to the highest recall level. Again, note that detectors are not required by A17.1 or NFPA 72 in hoistways unless sprinklers are installed in the hoistway. So, if sprinklers are installed in a pit because of combustible hydraulic fluid or combustible belts, heat detection would be used to send the elevator to the highest recall level.

Activation of any recall detector in a hoistway or machine room must also activate the in-car warning signal in any elevator served by those spaces (A17.1-2.27.3.2.6). Detectors installed in hoistways to initiate power shutdown do not have to activate the in-car warning signal.

<u>Sprinkler Requirements for Hoistways and Machine Rooms</u> –
Excerpts from NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2010 and ANSI/ASME A17.1, *Safety Code for Elevators and Escalators*

A17.1 and NFPA 72 require detection in a hoistway *if* sprinklers are present. Therefore, it is important to know the circumstances that would result in sprinklers being required in the hoistway.

Similar to the requirements for elevator control, requirements to have sprinkler protection in a building start with a local law, regulation or code. Typically a local law or regulation is passed to adopt a building code, fire code, or life safety code. The legislation might instead appoint a local authority and empowered to write or adopt one or more of these codes. These codes might require compliance with the NFPA 13 sprinkler standard. In some cases, NFPA 13 is adopted directly by a law or regulation. For most new construction, where a code requires sprinkler protection, it requires complete coverage per NFPA 13. For existing retrofits, a code may specify specific areas or spaces that require sprinklers. Unless otherwise specified by the referencing code or regulation, section 8.15.5 of NFPA 13 addresses sprinklers in elevator hoistways and machine rooms.

> 8.15.5 Elevator Hoistways and Machine Rooms.
>
> 8.15.5.1* Sidewall spray sprinklers shall be installed at the bottom of each elevator hoistway not more than 2 ft (0.61 m) above the floor of the pit.
>
> [Note: The * indicates that there is an associated paragraph in Annex A.]
>
> > A.8.15.5.1 The sprinklers in the pit are intended to protect against fires caused by debris, which can accumulate over time. Ideally, the sprinklers should be located near the side of the pit below the elevator doors, where most debris accumulates. However, care should be taken that the sprinkler location does not interfere with the elevator toe guard, which extends below the face of the door opening.
> >
> > ASME A17.1, *Safety Code for Elevators and Escalators*, allows the sprinklers within 2 ft (0.65 m) of the bottom of the pit to be exempted from the special arrangements of inhibiting waterflow until elevator recall has occurred.
>
> 8.15.5.2 The sprinkler required at the bottom of the elevator hoistway by 8.15.5.1 shall not be required for enclosed, noncombustible elevator shafts that do not contain combustible hydraulic fluids.
>
> 8.15.5.3* Automatic sprinklers in elevator machine rooms or at the tops of hoistways shall be of ordinary- or intermediate temperature rating.
>
> > A.8.15.5.3 ASME A17.1, *Safety Code for Elevators and Escalators*, requires the shutdown of power to the elevator upon or prior to the application of water in elevator machine rooms or hoistways. This shutdown can be accomplished by a detection system with sufficient sensitivity that operates prior to the activation of the sprinklers *(see also NFPA72, National Fire Alarm and Signaling Code*). As an alternative, the system can be arranged using devices or sprinklers capable of effecting power shutdown immediately upon sprinkler activation, such as a waterflow switch without a time delay. This alternative arrangement is intended to interrupt power before significant sprinkler discharge.

8.15.5.4* Upright, pendent, or sidewall spray sprinklers shall be installed at the top of elevator hoistways.

A.8.15.5.4 Passenger elevator cars that have been constructed in accordance with ASME A17.1, *Safety Code for Elevators and Escalators,* Rule 204.2a (under A17.1a-1985 and later editions of the code) have limited combustibility. Materials exposed to the interior of the car and the hoistway, in their end-use composition, are limited to a flame spread index of 0 to 75 and a smoke developed index of 0 to 450, when tested in accordance with ASTM E 84, *Standard Test Method of Surface Burning Characteristics of Building Materials*.

8.15.5.5 The sprinkler required at the top of the elevator hoistway by 8.15.5.4 shall not be required where the hoistway for passenger elevators is noncombustible or limited-combustible and the car enclosure materials meet the requirements of ASME A17.1, *Safety Code for Elevators and Escalators*.

8.15.5.6 Sprinklers shall be installed at the top and bottom of elevators that utilize polyurethane-coated steel belts or other similar combustible belt material.

In the hoistway pit, sprinklers are required only if a combustible hydraulic fluid is used or if combustible belts are used. Since 13-8.15.5.2 provides and exemption unless a combustible hydraulic fluid is used, there is no requirement to provide sprinklers in a pit to protect against fires involving trash and other debris that might accumulate in the pit – regardless of the contrary comment in the annex text. Paragraph 13-8.15.5.6 was added in the 2010 edition of NFPA 13 to address the use of combustible traction belts. If sprinklers are installed in the hoistway pit, they must be within 2 feet of the bottom of the pit. This is coordinated with A17.1 requirements for electrical equipment and wiring:

A17.1-2.8.3.3.2 In jurisdictions not enforcing the NBCC, where elevator equipment is located or its enclosure is configured such that application of water from sprinklers could cause unsafe elevator operation, means shall be provided to automatically disconnect the main line power supply to the affected elevator and any other power supplies used to move the elevator upon or prior to the application of water.
(a) This means shall be independent of the elevator control and shall not be self-resetting.
(b) Heat detectors and sprinkler flow switches used to initiate main line elevator power shutdown shall comply with the requirements of NFPA 72.
(c) The activation of sprinklers outside of such locations shall not disconnect the main line elevator power supply. See also 2.27.3.3.6.

A17.1-2.8.3.3.3 Smoke detectors shall not be used to activate sprinklers in these spaces or to disconnect the main line power supply.

A17.1-2.8.3.3.4 In jurisdictions not enforcing the NBCC, when sprinklers are installed not more than 600 mm (24 in.) above the pit floor, 2.8.3.3.4(a) and (b) apply to elevator electrical equipment and wiring in the hoistway located less than 1 200 mm (48 in.) above the pit floor, except earthquake protective devices conforming to 8.4.10.1.2(d); and on the exterior of the car at the point where the car platform sill and the lowest landing hoistway door sill are in vertical alignment.
(a) Elevator electrical equipment shall be weatherproof (Type 4 as specified in NEMA 250).
(b) Elevator wiring, except traveling cables, shall be identified for use in wet locations in accordance with the requirements in NFPA 70.

NFPA 13 requires sprinklers to be no more than 24 inches from the bottom of the pit. A17.1 requires any electrical equipment located below 48 inches to be in weatherproof enclosures (NEMA

Type 4) and wiring below 48 inches to be identified for use in wet locations in accordance with the requirements in NFPA 70, the National Electrical Code (NEC)[10]. NFPA 13, A17.1 and the NEC combine to separate the sprinklers and electrical equipment and protect the electrical installation that is exposed to sprinkler discharge. Where these conditions are met, shutdown of elevator power would not be required. This is an opinion based on discussions in early task group meetings and on wording used in editions of A17.1 prior to 2007 that explicitly said power shutdown would not be required where the 24 inch and 48 inch requirements of NFPA 13 and A17.1 were met. The newer performance-based language of A17.1-2.8.3.3.2 is less clear. However, there might be circumstances where the separation is not possible and where electrical equipment already installed is not properly rated. In those situations, the ability to remove power before or upon sprinkler discharge is explicitly required. A17.1 references NFPA 72 for the proper use of heat detectors or flow switches to accomplish the power shutdown.

The elevator machine room will always require sprinkler protection if the building requires coverage per NFPA 13. Note that NFPA 13 cites only the "machine room" and has not been revised to incorporate the different terms added to A17.1 for the space where elevators controls are located. Nevertheless, the intent of NFPA 13 is to include machine rooms, machine spaces, control rooms and control spaces.

At the top of the hoistway, sprinklers are only required if the hoistway fails to meet the noncombustible or limited-combustible requirements or if the elevator car enclosure materials fail to meet the meet the requirements of A17.1.

Detection and Control Requirements

Excerpts from NFPA 72, *National Fire Alarm and Signaling Code*, 2010

The ASME/ANSI A17.1 code references NFPA 72 for the selection, location and operation of the initiating devices used for both elevator recall and for power disconnection. Initiating devices include smoke detectors, heat detectors and waterflow switches. Section 21.3 of NFPA 72 is the appropriate section[11] for elevator recall and 21.4 is the section that covers elevator shutdown[12].

The section in NFPA 72 for elevator recall starts by requiring initiating devices used to initiate recall to be connected to the building's fire alarm system (72-21.3.1). If the building does not have to have a fire alarm system, the code requires use of a dedicated function control unit designated as an "elevator recall control and supervisory control unit" (72-21.3.2). The use of a dedicated function system does not invoke any other fire detection and alarm system requirements. The only added feature that would be required is a smoke detector for protection of the control unit (72-10.15). There are no requirements to add occupant notification, duct smoke detectors, off premises signaling or any other system features.

Paragraph 21.3.3 of NFPA 72 is the first location where the initiating devices for recall are required to be smoke detectors.

> 21.3.3 Unless otherwise required by the authority having jurisdiction, only the elevator lobby, elevator hoistway, and elevator machine room smoke detectors, or other automatic fire detection as permitted by 21.3.7, and initiating devices used to initiate shutdown of elevator power in accordance with Section 21.4 shall be used to recall elevators for fire fighters' service.

The paragraph references 72-23.7 that permits the use of heat detectors where conditions are not suitable for smoke detectors. This is how designers are permitted to use heat detectors in sprinklered hoistway pits to send the elevator to the highest recall level. This allowance also permits the use of heat detectors in unheated elevator lobbies or at elevator landings that are open to outside ambient conditions and weather.

That same paragraph (72-21.3.3) is where the detectors required by A17.1 "at each floor served by the elevator" are specified as being only in the elevator lobbies.

The last part of 72-21.3.3 indicates that initiating devices that are used for power shutdown should also initiate recall. That provision has actually been rejected as a requirement of A17.1 and should be removed from NFPA 72. The conflict is that A17.1 and NFPA 72 require power to be shutdown immediately upon actuation of the initiating device. Programming that same detection device to also initiate recall would have no effect since the elevator will not have power.

On systems that use initiating device circuits, depending on the panel design and the system design and installation, it is possible for an alarm on an initiating device circuit to prevent other devices on the same circuit from operating. For a system that only needs to signal an alarm, that is not a problem since the first device to activate will do that job. However for a system that needs to control something, such as elevators, as smoke migrates towards an elevator lobby, it is important that detectors and relays remain operational (72-21.3.4) even after others on the same circuit have already operated. Most systems today do not have any problem meeting this requirement. However, designs that used initiating device circuits with detectors having integral relays would have to be properly designed to provide external power for the proper operation of the detectors and relays.

Where should elevator lobby detectors be located? How many are needed? Should there be one for each elevator? All detectors have a circle of coverage, which is defined as 0.7 times the listed or required spacing (72-17.6.3.1.1 and 72-17.7.3.2.3.5). NFPA 72 requires that a detector be within that range of the elevator door.

> 21.3.5* A lobby smoke detector shall be located on the ceiling within 21 ft (6.4 m) of the centerline of each elevator door within the elevator bank under control of the detector.
> *Exception: For lobby ceiling configurations exceeding 15 ft (4.6 m) in height or that are other than flat and smooth, detector locations shall be determined in accordance with Chapter 17.*
> [Note: The * indicates that there is an associated paragraph in Annex A. In this case it is not relevant to the discussion and is not cited here.]

This paragraph permits a single detector to provide recall for a bank of elevators, provided that it is within 21 feet of each of the elevator doors. Twenty-one feet is 0.7 times the nominal 30 foot spacing required by NFPA 72 for smoke detectors (72-17.7.3.2.3.1). Figure 1 is a partial plan of a

building with a small elevator lobby. In this application, the smoke detector also serves as detection for the entire floor lobby space. The shaded area shows the coverage circle (21 foot radius) for the smoke detector. The detector is less than 21 feet from the centerline of the elevator door. Therefore, it meets the requirements of 72-21.3.5.

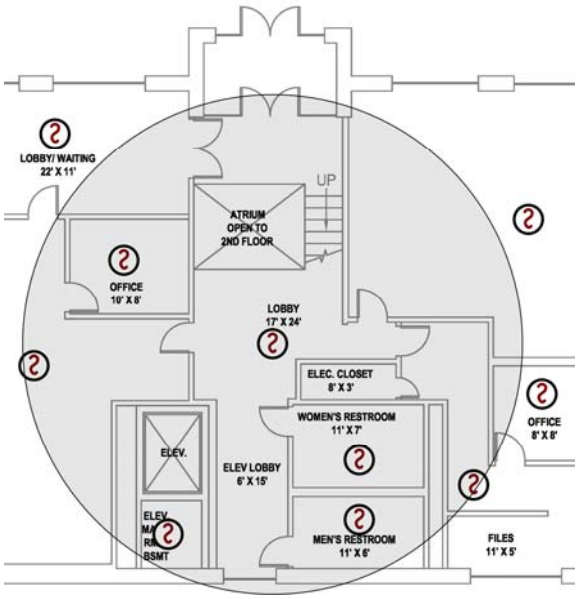

Figure 1 - Elevator Lobby Smoke Detection

Although 72-21.3.5 says the detector must be mounted on the ceiling within 21 feet of the centerline of the elevator door, wall mounting in accordance with Chapter 17 would also be permitted. If it is wall mounted, Chapter 17 would require the detector to be located on the wall down from the ceiling no more than 12 inches to the top of the detector. Note that the requirement to be at least four inches down – the "dead air space" – has been removed in the 2010 edition for smoke detector applications based on recent research.

The exception listed in 72-21.3.5 was written to address situations such as atriums or other high ceiling spaces. This was done explicitly to permit the recall smoke detector to be located on the wall immediately above the elevator doors, even where there is no ceiling. Mounting the detector on a high ceiling or the wall just below a high ceiling would not serve its intended purpose.

> 17.7.3.1.3 If the intent is to protect against a specific hazard, the detector(s) shall be permitted to be installed closer to the hazard in a position where the detector can intercept the smoke.
> 17.7.3.1.4* If the intent is to initiate action when smoke/fire threatens a specific object or space, the detector shall be permitted to be installed in close proximity to that object or space.
> A.17.7.3.1.4 There are some applications that do not require full area protection, but do require detection, to initiate action when specific objects or spaces are threatened by smoke or fire, such as at elevator landings that have ceilings in excess of 15 ft (4.6 m) and for protection of fire alarm control units. In high-ceiling areas, to achieve the desired initiation, such as for elevator recall and protection of fire alarm control units (FACUs), detection should be placed on the wall above and within 60 in. (1.52 m) from the top of the elevator door(s) or FACU.

How can the smoke detector operate if it is on the wall 10, 15, 20 or even 30 feet below the ceiling? The answer is that it will operate when smoke reaches it. Remember that this particular detector is not a fire detector purposed with sounding an evacuation alarm. Its main job is to detect smoke at the weak point to the elevator hoistway – the door opening – and to send the elevator car away from that opening and lock it out (Phase I recall) so that only firefighters can use it (Phase II override).

A17.1 also requires recall to be initiated by detectors in the hoistway *if* sprinklers are installed in the hoistway (A17.1-2.27.3.2.1(c)). NFPA 72 reminds everyone that detectors should not be installed in the hoistway unless required because of the presence of sprinklers or if they are required for smoke control.

> 21.3.6 Smoke detectors shall not be installed in unsprinklered elevator hoistways unless they are installed to activate the elevator hoistway smoke relief equipment.

If sprinklers are required at the top of a hoistway, then a smoke detector would be provided to initiate recall. If sprinklers are provided in the hoistway pit, detection is required to send the cab to the recall level that is farthest from the pit. The regular presence of dust, dirt and debris in the pit create conditions not suitable for the use of smoke detectors. NFPA 72 permits the use of heat detectors for that application:

> 21.3.7* If ambient conditions prohibit installation of automatic smoke detection, other automatic fire detection shall be permitted.
>
> A.21.3.7 The objective of Phase I Emergency Recall Operation is to have the elevator automatically return to the recall level before fire can affect the safe operation of the elevator. This includes both the safe mechanical operation of the elevator, as well as the delivery of passengers to a safe lobby location. Where ASME A17.1, Safety Code for Elevators and Escalators, specifies the use of smoke detectors, these devices are expected to provide the earliest response to situations that would require Phase I Emergency Recall Operations. The use of other automatic fire detection is only intended where smoke detection would not be appropriate due to the environment. Where ambient conditions prohibit the installation of smoke detectors, the selection and location of other automatic fire detection should be evaluated to ensure the best response is achieved. When heat detectors are used, consideration should be given to both detector temperature and time lag characteristics. The consideration of a low temperature rating alone might not provide the earliest response.

The annex text also points out the need to consider the relative thermal sensitivity of heat detectors and sprinklers. This is characterized as a Response Time Index (RTI). Since sprinkler operation could prevent the operation of a heat detector, it is important that the heat detector operate before the sprinkler so that it can initiate recall. If two heat actuated devices (sprinkler and heat detector) have the same operating temperature, the one with the lower RTI will operate first. In fact, it is possible for a device with a higher operating temperature to operate before one with a lower operating temperature if its RTI is sufficiently less than that of the lower temperature device. For this reason, a heat detector used in a sprinklered hoistway must have *both* a lower temperature rating and a lower RTI. The concept of requiring heat detection to respond before sprinklers goes back to the days before flow switches when heat detectors were used to call the fire department[13]. If

the sprinkler operated before the heat detection system, the fire might be suppressed, but water would continue to flow with no alarm.

NFPA 72 requires detectors that initiate recall to also annunciate at the required control unit. However, if permitted by the authority having jurisdiction, the response would not have to be treated as a typical "alarm":

> 21.3.10 Where approved by the authority having jurisdiction, the detectors used to initiate elevator recall shall be permitted to initiate a supervisory signal in lieu of an alarm signal.

Regardless of whether the signal is called an alarm signal or a supervisory signal, it is important that the signal initiate whatever response is intended. In most cases, the required response includes occupant notification (alarm) as well as the initiation of Phase I recall. However, some authorities have required hoistway smoke detectors to be treated as supervisory signals that do not operate occupant notification appliance. This has been done in situations where the smoke detector initiates nuisance alarms due to dust and dirt. In most cases the problem can be solved by removing the detector and the sprinklers because they are not required by the codes and standards.

If detectors are required in the hoistway, it is because sprinklers are required, which is because there is a significant presence of potential fuel in the hoistway. See Sprinkler Requirements for Hoistways and Machine Rooms above. If a hoistway detector operates, it might be due to a fire in the hoistway, which threatens the safe use of the elevator even by firefighters using Phase II Emergency In-car Operation. Similarly, a fire in the machine room could threaten safe of the elevator. Therefore, A17.1 and NFPA 72 combine to require hoistway and machine room detectors to initiate Phase I recall and to operate an in-car warning signal:

> 21.3.9 Actuation from the elevator hoistway, elevator machine room, elevator machinery space, elevator control space, or elevator control room smoke detectors, or other automatic fire detection as permitted by 21.3.7, shall cause separate and distinct visible annunciation at the building fire alarm control unit, or the fire alarm control unit described in 21.3.2, and at required annunciators to alert fire fighters and other emergency personnel that the elevators are no longer safe to use.
>
> 21.3.12.3* Visual Warning. For each elevator or group of elevators, an output(s) shall be provided for the elevator visual warning signal in response to the following:
> (1) Activation of the elevator machine room, elevator machinery space, elevator control space, or elevator control room initiating devices identified in 21.3.12.1(2) or 21.3.12.2(2)
> (2) Activation of the elevator hoistway initiating devices identified in 21.3.12.1(3) or 21.3.12.2(3)
>
> > A.21.3.12.3 ASME A17.1, Safety Code for Elevators and Escalators, requires differentiation between separate hoistways that share a common elevator machine room. For instance, in a situation where there is more than one single hoistway sharing the same elevator machine room, a separate signal must be derived from each hoistway.

With respect to elevator recall, the fire alarm or dedicated function control unit must provide three relays for connection to the elevator controller: 1) designated level recall, 2) alternate level recall, and 3) the in-car warning signal discussed above. Because these are provided by and programmed by the alarm system contractor, NFPA 72 reiterates the specific recall requirements:

> 21.3.12.1 Designated Level Recall. For each elevator or group of elevators, an output shall be provided to signal elevator recall to the designated level in response to the following:
> (1) Activation of smoke detectors, or other automatic fire detection as permitted by 21.3.7, located at any elevator lobby served by the elevator(s) other than the lobby at the designated level
> (2) Activation of smoke detectors, or other automatic fire detection as permitted by 21.3.7, located at any elevator machine room, elevator machinery space, elevator control space, or elevator control room serving the elevator(s), except where such rooms or spaces are located at the designated level
> (3) Activation of smoke detectors, or other automatic fire detection as permitted by 21.3.7, located in the elevator hoistway serving the elevator where sprinklers are located in the hoistway, unless otherwise specified in 21.3.12.2(3)
>
> 21.3.12.2 Alternate Level Recall. For each elevator or group of elevators, an output shall be provided to signal elevator recall to the alternate level in response to the following:
> (1) Activation of smoke detectors, or automatic fire detection as permitted by 21.3.7, located at the designated level lobby served by the elevator(s)
> (2) Activation of smoke detectors, or other automatic fire detection as permitted by 21.3.7, located in the elevator machine room, elevator machinery space, elevator control space, or elevator control room serving the elevator(s) if such rooms or spaces are located at the designated level
> (3)*Activation of the initiating devices identified in 21.3.12.1(3) if they are installed at or below the lowest level of recall in the elevator hoistway and the alternate level is located above the designated level
>
> > A.21.3.12.2(3) Where initiating devices are located in the elevator hoistway at or below the lowest level of recall, ASME A17.1, Safety Code for Elevators and Escalators, requires that the elevator be sent to the upper recall level. Note that the lowest level of recall could be the "designated level" or "alternate level" as determined by the local authority for the particular installation. Also note that the elevator hoistway, as defined in ASME A.17.1, includes the elevator pit.

As previously discussed, *if* the operation of sprinklers could cause unsafe elevator operation, A17.1 requires that a "means shall be provided to automatically disconnect the main line power supply to the affected elevator and any other power supplies used to move the elevator upon or prior to the application of water" (A17.1-2.8.3.3.2).

A17.1 requires compliance with NFPA 72 for the heat detectors and sprinkler flow switches that might be used to perform this service. NFPA 72 permits two methods for initiating the power shutdown. The first is to use heat detectors:

> 21.4.1* Where heat detectors are used to shut down elevator power prior to sprinkler operation, the detector shall have both a lower temperature rating and a higher sensitivity as compared to the sprinkler.
>
> > A.21.4.1 When determining desired performance, consideration should be given to the temperature and time lag characteristics of both the sprinkler head and the heat detector to ensure as much as possible that the heat detector will operate prior to the sprinkler head, because a lower temperature rating alone might not provide earlier response. The listed spacing rating of the heat detector should be 25 ft (7.6 m) or greater.

> 21.4.2* If heat detectors are used to shut down elevator power prior to sprinkler operation, they shall be placed within 24 in. (610 mm) of each sprinkler head and be installed in accordance with the requirements of Chapter 17. Alternatively, engineering methods, such as those specified in Annex B, shall be permitted to be used to select and place heat detectors to ensure response prior to any sprinkler head operation under a variety of fire growth rate scenarios.
>
> > A.21.4.2 Upon activation of the heat detector used for elevator power shutdown, there should be a delay in the activation of the power shunt trip. This delay should be the time that it takes the elevator cab to travel from the top of the hoistway to the lowest recall level.

The requirement to have a heat detector within 24 inches of each sprinkler is based on calculations using a range of possible fire growths. The code points out that the detectors must have *both* a lower temperature rating and a lower RTI to ensure operation of the heat detector before the sprinkler. (See previous discussion of RTI.) The modeling calculations used a range of RTIs and temperatures to arrive at the maximum 24 inch separation.

The annex text suggesting a time delay before power removal was added in 2002 and is not a requirement. The text was proposed as a requirement, but moved by the technical committee to the annex so that it would only be a suggestion. However, the technical committee statement in the Report on Proposals[14] indicated that their intent was to require immediate power shutdown. Hence, the suggested text is in direct conflict with the intent of the body of the code. The submitter's substantiation was that the delay would minimize the chance of an occupant being trapped in the elevator. The elevator safety task group that drafted the original framework and the coordinated requirements in the various codes and standards debated the relative risks involved with trying to ensure safe parking of the elevator car before removing power. The elevator experts convinced the group that the application of water before removing power can be a higher risk than the possibility of entrapment – assuming compliance with the requirements for initiating Phase I recall by smoke detectors. The group was also concluded that operation of a sprinkler in a machine space or hoistway (particularly at the top) would most likely mean that there was a fire, which could cause unpredictable operation of electronic controllers with results that might be worst than the risk of entrapment. The idea of delaying the water discharge until it could be confirmed that the elevator was parked has also been debated and rejected in part due to the increased complexity adding additional failure mechanisms as well as the unpredictable effects of the unsuppressed fire on the elevator equipment.

The use of time delays and pre-action sprinkler systems would require considerable engineering and engineering coordination of four systems: 1) elevator controllers, 2) sprinklers, 3) fire alarm and 4) electrical. The problem with these proposed methods is that there are no data on the actual statistical need, the failure and success rates and the various hazards that might be created. To some extent, this is also true of the more simple approach currently required by the coordinated set of codes and standards. Nevertheless, the elevator safety experts, fire protection engineers, fire alarm and sprinkler experts, fire fighters, code experts and others who have worked on the coordinated codes and standards have settled on the simpler approach.

The second method permitted by NFPA 72 for initiating the power shutdown is to use a sprinkler waterflow switch.

> 21.4.3* If pressure or waterflow switches are used to shut down elevator power immediately upon, or prior to, the discharge of water from sprinklers, the use of devices with time-delay switches or time-delay capability shall not be permitted.
>
> > A.21.4.3 Care should be taken to ensure that elevator power cannot be interrupted due to water pressure surges in the sprinkler system. The intent of the Code is to ensure that the switch and the system as a whole do not have the capability of introducing a time delay into the sequence. The use of a switch with a time delay mechanism set to zero does not meet the intent of the Code, because it is possible to introduce a time delay after the system has been accepted. This might occur in response to unwanted alarms caused by surges or water movement, rather than addressing the underlying cause of the surges or water movement (often due to air in the piping). Permanently disabling the delay in accordance with the manufacturer's printed instructions should be considered acceptable. Systems that have software that can introduce a delay in the sequence should be programmed to require a security password to make such a change.

Fire alarm and signaling system relays are not used to directly control the elevator power circuits – the load is too great. Shunt trip breakers are circuit breakers with a magnetic coil that can be used to automatically trip the breaker when the coil is energized. The fire alarm and signaling system relays are used to actuate the magnetic coil of the shunt trip breaker.

> 21.4.4* Control circuits to shut down elevator power shall be monitored for the presence of operating voltage. Loss of voltage to the control circuit for the disconnecting means shall cause a supervisory signal to be indicated at the control unit and required remote annunciators.
> [The associated annex text shows a diagram of how the control circuit, relays, power and shunt trip breaker can be wired.]

The fire alarm or signaling system would provide a relay to initiate the power shutdown and would also provide a means to monitor the power circuit used to trip the shunt trip breaker. Monitoring the shunt trip power circuit is done using a relay and either an initiating device circuit or a monitor module on an addressable signaling line circuit. NFPA 72 shows a typical arrangement for shunt trip breakers in 72-A.21.4.4. Also, there are very specific installation and wiring requirements for elevator circuits. In the National Electrical Code, NFPA 70, 2011 edition, they are found in Article 620: Elevators, Dumbwaiters, Escalators, Moving Walks, Platform Lifts, and Stairway Chairlifts.

Example 1

Figure 2 is an elevation view of a simple building with a traction elevator. The building is fully sprinklered per NFPA 13 including the elevator machine room. Sprinklers are not required in the hoistway pit. This example shows the machine room directly over the hoistway. In many cases the room for the controller(s) is larger may be separated from the hoistway. Figure 3 is a partial input/out matrix showing the elevator control functions for the signaling system.

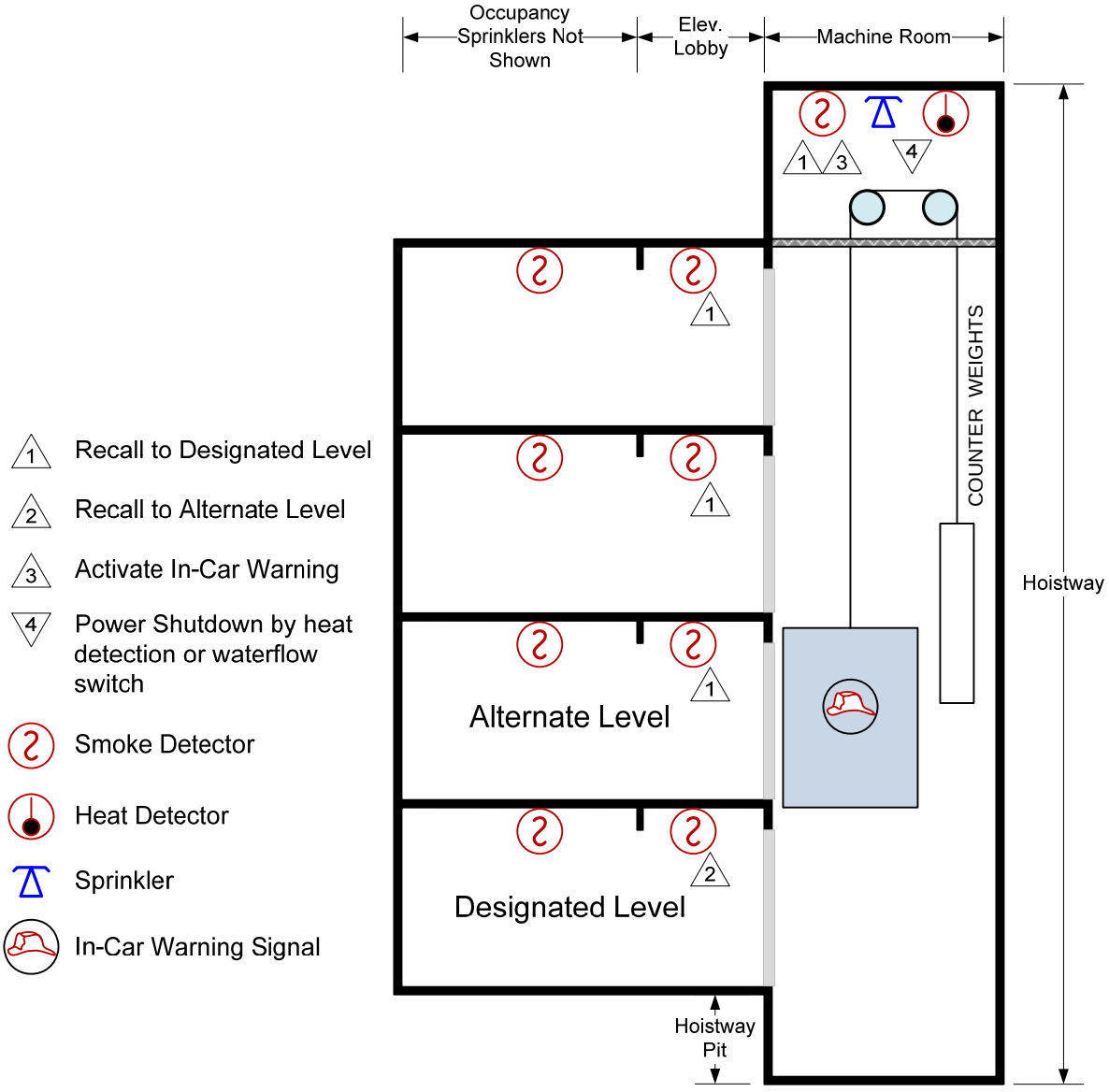

Figure 2 – Typical Traction Elevator

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		System Outputs					
		Occupant Notification Appliances	Signal to Supervising Station (if used)	Elev. Recall to Designated Level	Elev. Recall to Alternate Level	Elev. Warning Signal	Elev. Power Shutdown
	Input	A	B	C	D	E	F
1	1st Floor Initiating Devices	●	●				
2	2nd Floor Initiating Devices	●	●				
3	3rd Floor Initiating Devices	●	●				
4	4th Floor Initiating Devices	●	●				
5	1st Elev. Lobby SD	●	●		●		
6	2nd Elev. Lobby SD	●	●	●			
7	3rd Elev. Lobby SD	●	●	●			
8	4th Elev. Lobby SD	●	●	●			
9	Elevator Machine Rm SD	●	●	●		●	
10	* Elevator Machine Rm HD	●	●				●
11	* Elev. Machine Rm Spr. Flow Sw.	●	●				●
	* One or the other is required, not both.						

Figure 3 – Input/Output Matrix for Example 1

Example 2

Figure 4 is an elevation view of a building with an elevator that uses a combustible hydraulic fluid. The building is fully sprinklered per NFPA 13, including the elevator machine room and pit. As previously noted (see discussion above), if the sprinklers are not more than 24 inches from the bottom and all electrical equipment and wiring is properly rated, shutdown of elevator power should not be required. Nevertheless, heat detectors are required to initiate recall. Figure 5 is a partial input/out matrix showing the elevator control functions for the signaling system.

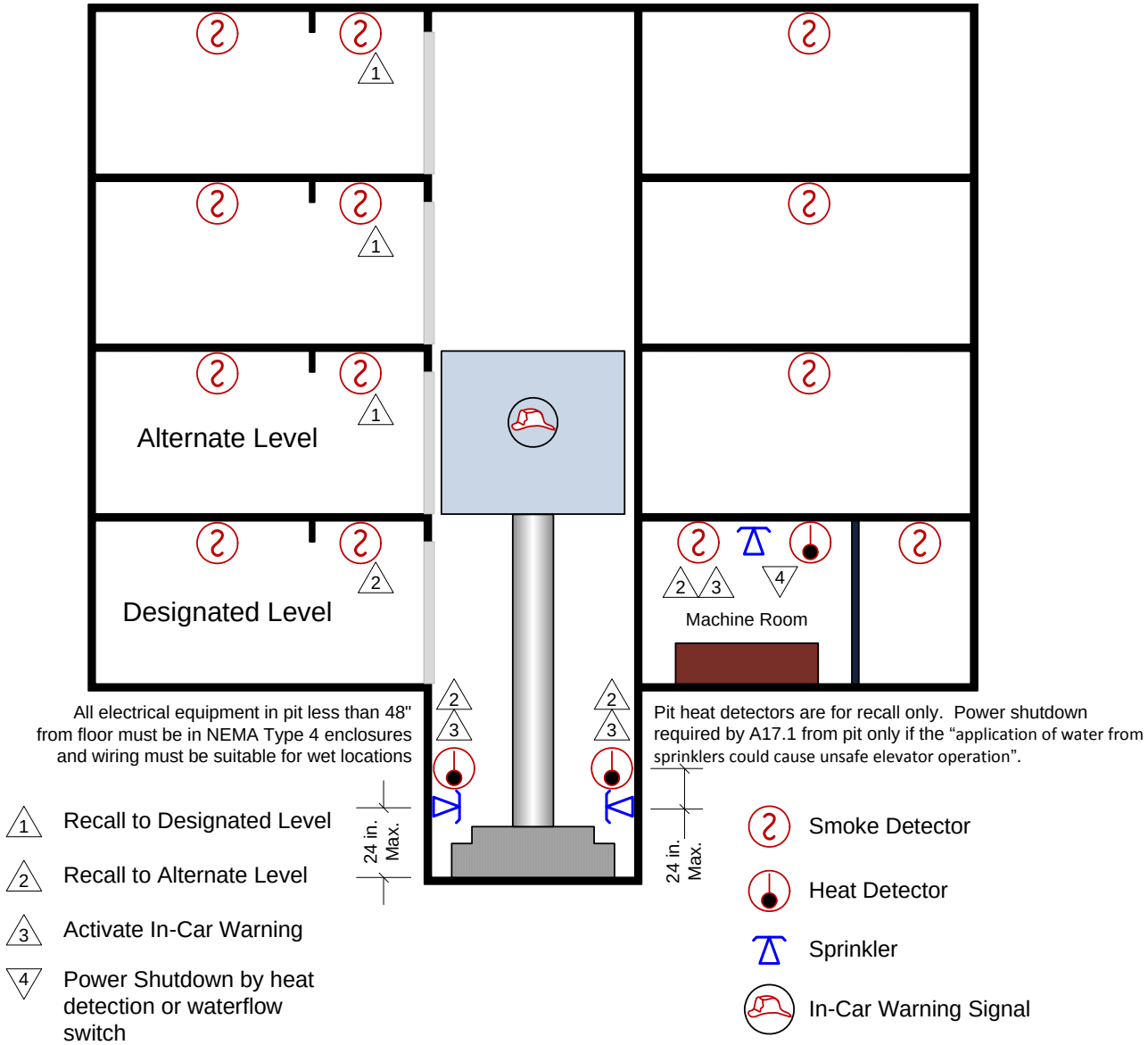

Figure 4 - Typical Hydraulic Elevator

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		System Outputs					
		Occupant Notification Appliances	Signal to Supervising Station (if used)	Elev. Recall to Designated Level	Elev. Recall to Alternate Level	Elev. Warning Signal	Elev. Power Shutdown
	Input	A	B	C	D	E	F
1	1st Floor Initiating Devices	●	●				
2	2nd Floor Initiating Devices	●	●				
3	3rd Floor Initiating Devices	●	●				
4	4th Floor Initiating Devices	●	●				
5	1st Elev. Lobby SD	●	●		●		
6	2nd Elev. Lobby SD	●	●	●			
7	3rd Elev. Lobby SD	●	●	●			
8	4th Elev. Lobby SD	●	●	●			
9	Elevator Pit HD	●	●		●	●	
10	Elevator Pit Spr. Flow Sw.	●	●				
11	Elevator Machine Rm SD	●	●		●	●	
12	* Elevator Machine Rm HD	●	●				●
13	* Elev. Machine Rm Spr. Flow Sw.	●	●				●
	* One or the other is required, not both.						

Figure 5 - Input/Output Matrix for Example 2

Conclusion

Various task groups and committees have worked on elevator safety requirements since the late 1980s and have crafted a set of coordinated codes and standards that minimize the risk of entrapment of occupants during normal elevator use and that minimize the risk of entrapment of emergency forces using Phase II override. However, the specific requirements must be located in different codes and standards for application by different engineering disciplines and trades. As is often the case with any complex system, failure of one system can affect other systems as well as the overall mission. In fact, failure of one system can sometimes cause the subsequent disruption of other systems resulting in a cascading failure of the overall system[15]. Any deviation from the requirements of the coordinated codes and standards should be avoided unless a thorough Failure Modes and Effects Analysis (FMEA) is conducted by a qualified engineering and safety team.

Finally, because elevator recall and power shutdown involve many codes, standards, disciplines and trades there are many possible failure scenarios. Integrated testing and commissioning of the completed systems is very important for mission success[16]. Integrated testing involves the coordinated, end-to-end testing of the combined systems. Commissioning starts when the building and elevator system is first being planned. It helps to ensure that all stakeholders are involved and communicating throughout the project to ensure proper coordination and success of the project.

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[1] ANSI/ASME A17.1, Safety Code for Elevators and Escalators, American Society of Mechanical Engineers, New York, NY.
[2] NFPA 101, Life Safety Code, 2009 edition, National Fire Protection Association, Quincy, MA.
[3] NFPA 13, Standard for the Installation of Sprinkler Systems, 2010 edition, National Fire Protection Association, Quincy, MA.
[4] NFPA 72, National Fire Alarm and Signaling Code, 2010 edition, National Fire Protection Association, Quincy, MA.
[5] 2009 International Building Code, International Code Council, Inc., Country Club Hills, IL 60478.
[6] 2009 International Fire Code, International Code Council, Inc., Country Club Hills, IL 60478.
[7] Chapter 9, Building Service and Fire Protection Equipment NFPA 101, Life Safety Code, National Fire Protection Association, Quincy, MA 02269.
[8] Chapter 54, Elevators and Conveying Systems, NFPA 5000, Building Construction and Safety Code, National Fire Protection Association, Quincy, MA 02269.
[9] Part 2, Electric Elevators, Section 2.27, and Part 3, Hydraulic Elevators, Section3.27, Emergency Operation and Signaling Devices, ANSI/ASME A17.1, Safety Code for Elevators and Escalators, American Society of Mechanical Engineers, New York, NY.
[10] NFPA 70, National Electrical Code, 2011 edition, National Fire protection Association, Quincy, MA.
[11] Section 21.3, Elevator Recall for Fire Fighters' Service, NFPA 72, National Fire Alarm and Signaling Code, 2010 edition, National Fire protection Association, Quincy, MA.
[12] Section 21.4, Elevator Shutdown, NFPA 72, National Fire Alarm and Signaling Code, 2010 edition, National Fire protection Association, Quincy, MA.
[13] A Partial Record of the Transactions at the Third Annual Meeting of the National Fire Protection Association, Boston, MA, June 13 – 15, 1899, Standard Publishing Company, 1899.
[14] See Proposal 72-301 in NFPA Annual Meeting 2002 Report on Proposals, National Fire protection Association, Quincy, MA, 2001.
[15] R.P. Schifiliti, "Engineering Failure, or Failure to Engineer?," NEMA Supplement in Fire Protection Engineering, Society of Fire Protection Engineers, Bethesda, MD 20814, Winter, 2003.
[16] R.P. Schifiliti, "Mission Effectiveness," NEMA Supplement in Fire Protection Engineering, Society of Fire Protection Engineers, Bethesda, MD 20814, Summer, 2002.