NFPA 130

Standard for Fixed Guideway Transit and Passenger Rail Systems

2000 Edition

NFPA®

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 130

Standard for

Fixed Guideway Transit and Passenger Rail Systems

2000 Edition

This edition of NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems,* was prepared by the Technical Committee on Fixed Guideway Transit Systems and acted on by the National Fire Protection Association, Inc., at its November Meeting held November 14–17, 1999, in New Orleans, LA. It was issued by the Standards Council on January 14, 2000, with an effective date of February 11, 2000, and supersedes all previous editions.

This edition of NFPA 130 was approved as an American National Standard on February 11, 2000.

Origin and Development of NFPA 130

The Fixed Guideway Transit Systems Committee was formed in 1975 and immediately began work on the development of NFPA 130. One of the primary concerns of the committee in the preparation of this document centered on the potential for entrapment and injury of large numbers of people who routinely utilize these mass transportation facilities.

During the preparation of this document, several significant fires occurred in fixed guideway systems where, fortunately, the loss of life was limited. The committee stated that the minimal loss of life was due primarily to chance events more than any preconceived plan or the operation of protective systems.

The committee developed material on fire protection requirements to be included in NFPA 130, *Standard for Fixed Guideway Transit Systems*. This was adopted by NFPA in 1983. The 1983 edition was partially revised in 1986 to conform with the NFPA *Manual of Style* and incorporated revisions including a new Chapter 8; new Appendix F, "Creepage Distance"; additional minor revisions to the first four chapters and Appendices A, B, C, and E; and a complete revision of Appendix D.

The scope of the 1988 edition was expanded to include Automated Guideway Transit (AGT) Systems. The sample calculations in Appendix C were revised and Appendix D was also completely revised in 1988.

The 1990 edition included additional minor changes to integrate provisions and special requirements for AGT Systems into the standard. Table 1 from Appendix D was moved into Chapter 4, "Vehicles," and new vehicle risk assessment material was added to Appendix D.

Definitions for *enclosed station* and *open station* were added in the 1993 edition, along with minor changes to Chapters 2 and 3.

There were minor changes in the 1995 edition in Chapters 1, 2, and 3.

A new chapter on emergency ventilation systems for transit stations and trainways was included in the 1997 edition. A new Appendix B addressing ventilation replaced the previous Appendix B titled "Air Quality Criteria in Emergencies." Also, the first three sections of Chapter 6 (renumbered Chapter 7 in the 1997 edition), "Emergency Procedures," were revised and several new definitions were added in this edition.

The 2000 edition of NFPA 130 now addresses fixed guideway transit and passenger rail systems. Changes have been made throughout the document to incorporate passenger rail requirements. Additionally, much of Chapter 2 was rewritten to incorporate changes that have been made to the egress calculations of NFPA *101*®, *Life Safety Code*®. The examples contained in Appendix C have been modified using the new calculation methods. The protection requirements for Chapter 3 have been modified, addressing emergency lighting and standpipes. Chapter 4 has also been modified to clarify and expand the emergency ventilation requirements.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This Committee shall have primary responsibility for documents on fire protection requirements for underground, surface, and elevated fixed guideway transit systems including trainways, vehicles, transit stations, and vehicle maintenance and storage areas; and for life safety from fire in transit stations, trainways, vehicles, and outdoor vehicle maintenance and storage areas. Transit stations shall pertain to stations accommodating only passengers and employees of the fixed guideway transit systems and incidental occupancies in the stations.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Appendix A.

Information on referenced publications can be found in Chapter 9 and Appendix F.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition.

Chapter 1 General

1-1 Scope.

1-1.1 This standard shall cover fire protection requirements for passenger rail, underground, surface, and elevated fixed guideway transit systems including trainways, vehicles, fixed guideway transit stations, and vehicle maintenance and storage areas; and for life safety from fire in fixed guideway transit stations, trainways, vehicles, and outdoor vehicle maintenance and storage areas. Fixed guideway transit stations shall pertain to stations accommodating only passengers and employees of the fixed guideway transit and passenger rail systems and incidental occupancies in the stations. This standard establishes minimum requirements for each of the identified subsystems.

1-1.2 This standard shall not cover requirements for the following:

(1) Conventional freight systems
(2) Buses and trolley coaches
(3) Circus trains
(4) Tourist, scenic, historic, or excursion operations
(5) Any other system of transportation not included in the definition of *fixed guideway transit system (see definition 1-5.19)*

To the extent where a system, including those listed in 1-1.2(1) through 1-1.2(5), introduces hazards of a similar nature to those addressed herein, this standard shall be permitted to be used as a guide.

1-1.3 Nothing in this standard is intended to prevent or discourage the use of new methods, materials, or devices, provided that sufficient technical data are submitted to the authority having jurisdiction to demonstrate that the new method, material, or device is equivalent to or superior to the requirements of this standard with respect to fire resistance and safety.

1-2 Purpose. The purpose of this standard is to establish minimum requirements that will provide a reasonable degree of safety from fire and its related hazards.

1-3 Characteristics of Fire Safety. Fire safety on fixed guideway transit and passenger rail systems shall be achieved through a composite of facility design, operating equipment, hardware, procedures, and software subsystems that are integrated to provide requirements for the protection of life and property from the effects of fire. The level of fire safety desired for the whole system shall be achieved by integrating the required levels for each subsystem.

1-4 Application.

1-4.1 This standard shall apply to new fixed guideway transit and passenger rail systems and to extensions of existing systems.

1-4.2 The portion of the standard dealing with emergency procedures shall apply to new and existing systems.

1-4.3 The standard also shall be used for purchases of new rolling stock and retrofitting of existing equipment or facilities except in those instances where compliance with the standard will make the improvement or expansion incompatible with the existing system.

1-5 Definitions.

1-5.1 Ancillary Area/Ancillary Space. The nonpublic areas or spaces of the stations usually used to house or contain operating, maintenance, or support equipment and functions.

1-5.2* **Approved.** Acceptable to the authority having jurisdiction.

1-5.3 Authority. The agency legally established and authorized to operate a fixed guideway transit and/or passenger rail system.

1-5.4* **Authority Having Jurisdiction.** The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

1-5.5 Backlayering. The reversal of movement of smoke and hot gases counter to the direction of the ventilation airflow.

1-5.6 Building. Any structure or group of structures in which fixed guideway transit and/or passenger rail vehicles are stored or maintained, including those in which inspection and service functions are performed, and other ancillary structures, such as substations and air conditioning or ventilation facilities.

1-5.7 Central Supervising Station. The operations center where the authority controls and coordinates the systemwide movement of passengers and trains from which communication is maintained with supervisory and operating personnel of the authority and with participating agencies when required.

1-5.7.1 Central Supervising Station, Alternate. A prearranged location that is equipped, or can be equipped quickly, to function as the central supervising station in the event the central supervising station is inoperative or untenable for any reason.

1-5.8 Combustible Load of a Vehicle. The total value of heat energy that can be released through complete combustion of the components of a vehicle or fuel expressed in British thermal units (Btus).

1-5.9 Command Post. The location for controlling and coordinating emergency operations, designated as such by the person in command during an emergency.

1-5.10 Communications. Radio, telephone, and messenger services throughout the system and particularly at the central supervising station and command post.

1-5.11 Computational Fluid Dynamics. A solution of fundamental equations of fluid flow using computer techniques allowing the engineer to identify velocities, pressures, temperatures, and so forth.

1-5.12* **Critical Radiant Flux.** The level of incident radiant heat energy on a floor covering system at the most distant flameout point. The unit of measurement of critical radiant flux is watts per square centimeter (W/cm^2).

1-5.13 Critical Velocity. The minimum steady-state velocity of the ventilation airflow moving toward the fire within a tunnel or passageway that is required to prevent backlayering at the fire site.

1-5.14 Effective Fire Load. The actual heat release under a given, specific fire scenario expressed in British thermal units (Btus) of a certain fuel package, which can include a transit and/or passenger rail vehicle(s), luggage, fuel, and/or wayside facilities or structures, that because of the fuel package configuration, separation, and combustion characteristics, would be expected to be released in a design fire incident.

1-5.15 Emergency Procedures Plan. A plan that is developed by the authority with the cooperation of all participating agencies and that details specific actions required by all those who will respond during an emergency.

1-5.16 Engineering Analysis (Fire Hazard/Fire Risk Assessment). An analysis that evaluates all the various factors that affect the fire safety of the system or component. A written report of the analysis shall be submitted to the authority indicating recommended fire protection method(s) that will provide a level of fire safety commensurate with this standard. The engineering analysis of the ventilation system shall include a validated subway analytical simulation program augmented as appropriate by a quantitative analysis of airflow dynamics produced in the fire scenario, such as would result from the application of validated computational fluid dynamics (CFD) techniques. The results of the analysis shall include the no-fire (or cold) air velocities that can be measured during commissioning to confirm that the ventilation system as built meets the requirements determined by the analysis.

1-5.17 Fire Emergency. The existence of, or threat of, fire and/or the development of smoke or fumes that calls for immediate action to correct or alleviate the condition or situation.

1-5.18 Fire Growth Rate. Rate of change of the heat release rate. Some factors that affect the fire growth rate are exposure, geometry, flame spread, and fire barriers.

1-5.19 Fixed Guideway Transit System. An electrified transportation system, utilizing a fixed guideway, operating on right-of-way for the mass movement of passengers within a metropolitan area, and consisting of its fixed guideways, transit vehicles, and other rolling stock; power system; buildings; maintenance facilities; stations; transit vehicle yard; and other stationary and movable apparatus, equipment, appurtenances, and structures.

1-5.19.1 Fixed Guideway Transit System, Automated. A fixed guideway transit system that operates fully automated, driverless vehicles along an exclusive right-of-way.

1-5.20 Fixed Guideway Transit Vehicle. An electrically propelled passenger-carrying vehicle characterized by high acceleration and braking rates for frequent starts and stops and fast passenger loading and unloading.

1-5.21 Flame Spread Index (I_S). Flame spread index (I_S) means, as defined in ASTM E 162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source,* a factor derived from the rate of progress of the flame front (F_S) and the rate of heat liberation by the material under test (Q), such that $I_S = F_S \times Q$.

1-5.22 Guideway. That portion of the transit or passenger rail line included within right-of-way fences, outside lines of curbs or shoulders, underground tunnels, cut or fill slopes, ditches, channels, and waterways, and including all appertaining structures.

1-5.23 Heat Release Rate. Energy evolved under a given fire scenario expressed as a function of time.

1-5.24 Incident Commander. The person who is responsible for managing and coordinating all facets of the fire and emergency responses during a fire incident. The incident commander can be a designated authority staff person or a responsible fire or police representative at the scene.

1-5.25 Incidental Occupancies in Stations. The use of the station by others who are neither transit system employees nor passengers.

1-5.26 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

1-5.27* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

1-5.28 Local Control. The point of control of the emergency ventilation system or ventilation plant that is remote from the central supervising station.

1-5.29 Noncombustible. A material that, in the form in which it is used and under the conditions anticipated, will not aid combustion or add appreciable heat to an ambient fire. Materials, where tested in accordance with ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C,* and conforming to the criteria contained in Section 7 of the referenced standard shall be considered as noncombustible.

1-5.30 Nontransit Occupancy. An occupancy not under the control of the system operating authority.

1-5.31 Participating Agency. A public, quasipublic, or private agency that has agreed to cooperate with and assist the authority during an emergency.

1-5.32 Passenger Rail System. A transportation system, utilizing a rail guideway, operating on right-of-way for the movement of passengers within and between metropolitan areas, and consisting of its rail guideways, passenger rail vehicles, and other rolling stock; power systems; buildings; maintenance facilities; stations; passenger rail vehicle yard; and other stationary and movable apparatus, equipment, appurtenances, and structures.

1-5.33 Passenger Rail Vehicle. A vehicle and/or power unit running on rails used to carry passengers and crew.

1-5.34 Point of Safety. An enclosed fire exit that leads to a public way or safe location outside the structure, or an at-grade point beyond any enclosing structure, or another area that affords adequate protection for passengers.

1-5.35 Power Station. An electric generating plant for supplying electrical energy to the system.

1-5.36 Power Substation. Location of electric equipment that does not generate electricity but receives and converts or transforms generated energy to usable electric energy.

1-5.37 Replace-in-Kind. As applied to vehicles and facilities, to furnish with new parts or equipment of the same type but not necessarily of identical design.

1-5.38 Retrofit. As applied to vehicles and facilities, to furnish with new parts or equipment to constitute a deliberate modification of the original design (as contrasted with an overhaul or a replacement-in-kind).

1-5.39 Specific Optical Density (D_S). Means, as defined in ASTM E 662, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*, the optical density measured over unit path length within a chamber of unit volume, produced from a specimen of unit surface area, that is irradiated by a heat flux of 2.5 W/cm^2 for a specified period of time.

1-5.40 Station. A place designated for the purpose of loading and unloading passengers, including patron service areas and ancillary spaces associated with the same structure.

1-5.40.1 Station, Enclosed. A station or portion thereof that does not meet the definition of an *open station.*

1-5.40.2 Station, Open. A station that is constructed in such a manner that it is open to the atmosphere, and smoke and heat are allowed to disperse directly into the atmosphere.

1-5.41 Station Platform. The area of a station used primarily for loading and unloading transit vehicle passengers.

1-5.42 Structure, Elevated. Any structure not otherwise defined as a surface or underground structure.

1-5.43 Structure, Surface. Any at-grade or unroofed structure other than an elevated or underground structure.

1-5.44 System. See appropriate fixed guideway transit system or passenger rail system definition.

1-5.45 Tenable Environment. An environment that supports human life for a specific period of time.

1-5.46 Tourist, Scenic, Historic, or Excursion Operations. Railroad operations that carry passengers, often using antiquated equipment, with the conveyance of the passengers to a particular destination not being the principal purpose.

1-5.47 Trainway. That portion of the guideway in which the fixed guideway transit or passenger rail vehicles operate.

1-5.48 Underground System. The system or that part of the system located beneath the surface of the earth or of the water.

Chapter 2 Stations

2-1 General.

2-1.1* Application. This chapter shall apply to all fixed guideway transit stations whether they are entirely or in any part below, at, or above grade.

2-1.2 Occupancy.

2-1.2.1 The primary purpose of a station is for the use of the transit passengers who normally stay in a station structure for a period of time no longer than that necessary to wait for and enter a departing transit vehicle or to exit the station after arriving on an incoming transit vehicle. Where contiguous commercial occupancies are in common with the station, or where the station is integrated into a building of nontransit occupancy, special considerations beyond this standard will be necessary.

2-1.2.2 A station is also for the use of employees whose work assignments require their presence in the station structures.

2-2 Construction.

2-2.1 Construction Materials. Building construction for all new rapid transit stations shall be not less than Type I- or Type II- or combinations of Type I- and Type II-approved noncombustible construction as defined in NFPA 220, *Standard on Types of Building Construction*, as determined by an engineering analysis of potential fire exposure hazards to the structure.

2-2.2 Safeguards During Construction. During the course of construction or major modification of any structure, provisions of NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, shall apply.

2-2.3 Compartmentation and Fire Separation.

2-2.3.1 Stair and Escalator Enclosure. Stairs and escalators regularly used by passengers shall not be required to be enclosed. Such stairs and escalators shall be included in exit capacity calculations as defined in 2-5.3 and 2-5.4.

2-2.3.2 Ancillary Spaces. In all stations, fire resistance ratings of separations between occupancies shall be established as required by the local building code in accordance with NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials.*

Exception No. 1: All power substations shall have a fire separation of at least 3 hours from all other occupancies.

Exception No. 2: Electrical control rooms, auxiliary electrical rooms, and associated battery rooms shall have a fire separation of at least 2 hours from all other occupancies.

Exception No. 3: Trash rooms shall have a fire separation of at least 2 hours from all other occupancies.

Exception No. 4: Train control rooms and associated battery rooms shall have a fire separation of at least 2 hours from all other occupancies.

Exception No. 5: All public areas shall have a fire separation of at least 2 hours from nonpublic areas.

2-2.3.3 Doors and Openings. Doors and other openings through the separations identified in 2-2.3.2, including Exceptions 2 through 5, shall be protected by fire door assemblies having a protection rating of $1^1/_2$ hours.

Exception: Exception No. 1 identified in 2-2.3.2 shall be protected by fire door assemblies having a protection rating of 3 hours.

2-2.3.4 Agents' and Information Booths. Agents' or information booths shall be constructed of approved noncombustible materials.

2-2.3.5* Fire Separation. All station public areas shall have a fire separation of at least 3 hours from all nontransit occupancies. The fire separation for stations shall be permitted to be modified based on an engineering analysis of potential fire exposure hazards.

2-2.3.6 Openings. All openings (e.g., private entrances) from station public areas to all nontransit occupancies shall be protected by approved fire-protective assemblies with an appropriate rating for the location in which they are installed. Where a fire door is required to be open, it shall be automatic closing, activated by listed smoke detectors, or, where a separate smoke barrier is provided, the operation can be by fusible links. Fire doors shall be installed in accordance with NFPA 80, *Standard for Fire Doors and Fire Windows.*

2-2.4 Automatic Sprinkler System Requirements. See 2-7.3.

2-3 Ventilation. Emergency ventilation shall be provided in enclosed stations in accordance with Chapter 4.

2-4 Wiring Requirements.

2-4.1 All wiring materials and installations within stations other than for traction power shall conform to requirements of NFPA 70, *National Electrical Code®*, and, in addition, shall satisfy the requirements of 2-4.2 through 2-4.9.

2-4.2 Materials manufactured for use as conduits, raceways, ducts, boxes, cabinets, equipment enclosures, and their surface finish materials shall be capable of being subjected to temperatures up to 932°F (500°C) for 1 hour and shall not support combustion under the same temperature condition. Other materials when encased in concrete shall be acceptable.

2-4.3 All conductors shall be insulated. Ground wires shall be permitted to be bare. All thicknesses of insulation and all thicknesses of jackets shall conform to NFPA 70, *National Electrical Code.*

2-4.4 All insulations shall conform to Article 310 of NFPA 70, *National Electrical Code,* and shall be moisture- and heat-resistant types carrying temperature ratings corresponding to the conditions of application and in no case lower than 194°F (90°C).

2-4.5 Wire and cable constructions intended for use in operating vital train signal circuits, power circuits to emergency lights, and so forth shall pass the flame-propagating criteria of IEEE Standard 383, *Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations. National Electrical Code*–type (*NEC*-type) listed cables suitable for use in plenums shall be permitted to be used in train signal circuits.

2-4.6 All conductors, except radio antennas, shall be enclosed in their entirety in armor sheaths, conduits, or enclosed raceways, boxes, and cabinets except in ancillary areas or other nonpublic areas. Conductors in conduits or raceways shall be permitted to be embedded in concrete or run in concrete electrical duct banks, but they shall not be installed exposed or surface-mounted in air plenums that might carry air at the elevated temperatures accompanying fire-emergency conditions.

2-4.7 Overcurrent elements that are (1) designed to protect conductors serving emergency equipment motors (i.e., pumps, etc.), emergency lighting, and communications equipment, and (2) located in spaces other than the main electrical distribution system equipment rooms shall not depend on thermal properties for operation.

2-4.8 Conductors for emergency lighting, communications, and so forth shall be protected from physical damage by transit vehicles or other normal transit system operations and from fires in the transit system by suitable embedment or encasement, or by routing such conductors external to the interior underground portions of the transit system facilities.

2-4.9 Power Supply for Emergency Ventilation Fans. See Chapter 4 for power supply for emergency ventilation fans.

2-5 Means of Egress. See Appendix C.

2-5.1 General. To provide minimum criteria for design of egress facilities, a station shall comply with the provisions of NFPA *101®, Life Safety Code®,* Chapter 5, "Means of Egress," and Chapter 8, "New Assembly Occupancies," except as herein modified.

2-5.1.1* For a station, the design of the means of egress shall be based on an emergency condition requiring evacuation of the train(s) and station occupants to a point of safety.

2-5.2 Occupant Load. See Appendix C.

2-5.2.1 The occupant load for a transit station shall be determined based on the emergency condition requiring evacuation of that station to a point of safety. The occupant load shall be based on the calculated train load of trains simultaneously entering the station on all tracks in normal traffic direction during the peak 15-minute period plus the simultaneous entraining load awaiting a train. As a basis for computing the detraining load during an emergency, not more than one train will unload at any one track to a platform during an emergency.

2-5.2.1.1 The required egress capacity in stations shall be based on evacuation of the occupant load calculated in accordance with 2-5.2.5.

Exception: As required by Section 2-5.2.4.

2-5.2.1.2 The basis for calculating the platform occupant load shall be the peak hour patronage figures as projected for design of a new transit system or as updated for an operating system.

2-5.2.2 Special consideration shall be given to station(s) servicing areas where events that occur establish occupant loads not included in normal passenger loads, which include such areas as civic centers, sports complexes, and convention centers. Consideration of control of access to platforms might be necessary to provide the appropriate level of safety.

2-5.2.3 At multiplatform stations, each platform shall be considered separately, and the arrival of trains from all normal traffic directions plus entraining loads shall be considered. At concourses, mezzanines, or multilevel stations, simultaneous loads shall be considered for all exit lanes passing through that area.

2-5.2.4 Where an area within a station is intended for use by other than transit patrons or employees, the occupant load for that area shall be determined in accordance with the provisions of NFPA *101*, *Life Safety Code*, as appropriate for the class of occupancy. That additional occupant load shall be included in determining the required egress from that area.

Exception: The additional occupant load need not be added to the station occupant load when the area has independent means of egress of sufficient number and capacity.

2-5.2.5 Calculation of Platform Occupant Load. The platform occupant load for each platform in a station shall be the greater of the peak period loads calculated as follows.

2-5.2.5.1 The peak period occupant load for each platform shall be based on the simultaneous evacuation of the entraining load and the train load for that platform in the peak period.

2-5.2.5.2 The entraining load for each platform shall be the sum of the entraining loads for each track serving that platform. The entraining load for each track shall be based on the entraining load per train headway multiplied by the following:

(1) *The system surge factor, and

(2) In the peak direction for each route, an additional factor of 2 to account for one missed headway

2-5.2.5.3 The train load for each platform shall be the sum of the train loads for each track serving that platform. The train load for each track shall be the train load per train headway multiplied by the following:

(1) *The system surge factor, and
(2) In the peak direction for each route, an additional factor of 2 to account for one missed headway

2-5.2.5.4* The maximum train load at each track shall be the maximum passenger train capacity.

2-5.3 Number and Capacity of Exits.

2-5.3.1 There shall be sufficient exit lanes to evacuate the station occupant load as defined in 2-5.2 from the station platforms in 4 minutes or less. The maximum travel distance to an exit from any point on the platform shall not exceed 300 ft (91.4 m).

Exception: Modification of the evacuation time shall be permitted based on an engineering analysis by evaluating material heat release rates, station geometrics, and emergency ventilation systems.

2-5.3.2 The station also shall be designed to permit evacuation from the most remote point on the platform to a point of safety in 6 minutes or less.

Exception: Modification of the evacuation time shall be permitted based on an engineering analysis by evaluating material heat release rates, station geometrics, and emergency ventilation systems.

2-5.3.2.1 In at-grade or elevated structures where the station platform is open to the elements and where the concourse is below or protected from the platform by distance or materials as determined by an appropriate engineering analysis, that concourse shall be permitted to be defined as a point of safety.

2-5.3.3 Exit Lanes, Doors, and Gates. The capacity in persons per inch per minute (pim), passenger travel speeds in feet per minute (fpm), and for gates in people per minute (ppm) shall be as follows.

2-5.3.3.1 Platforms, Corridors, and Ramps of 4 Percent Slope or Less. Exit corridors and ramps shall be a minimum of 5 ft 8 in. (1.73 m) wide. In computing the capacity available, 1 ft 0 in. (304.8 mm) shall be deducted at each side wall and 1 ft 6 in. (457.2 mm) at platform edges.

Capacity — 2.27 pim

Travel Speed — 200 fpm (61 m/min)

2-5.3.3.2* Stairs, Stopped Escalators, and Ramps of Over 4 Percent Slope. Exit stairs shall be a minimum of 44 in. (1.12 m) wide. Stopped escalators shall be permitted to be considered as emergency exits. Exit ramps shall be a minimum of 6 ft 0 in. (1.83 m) wide.

Escalators shall not account for more than half of the units of exit at any one level.

Up Direction

Capacity — 1.59 pim

Travel Speed — 50 fpm (15.24 m/min) (indicates vertical component of travel speed)

Per Exit Lane Down Direction

Capacity — 1.82 pim

Travel Speed — 60 fpm (18.3 m/min) (indicates vertical component of travel speed)

2-5.3.3.3 Doors and Gates. Exit doors and gates shall be a minimum of 36 in. (914.4 mm) wide.

Capacity — 2.27 pim

2-5.3.3.4 Fare Collection Gates. Fare collection gates, when deactivated, shall provide a minimum 20-in. (508-mm) clear unobstructed aisle. Consoles shall not exceed 40 in. (1016 mm) in height.

Capacity — 50 ppm per gate

A turnstile-type fare collection gate is one that consists of a minimum of 18-in. (457.2-mm) aisle and maximum of 36-in. (914.4-mm) height of the turnstile bar. When deactivated, the turnstile bar shall free wheel in the exit direction.

Capacity — 25 ppm per gate

2-5.3.4 Emergency exit gates shall be in accordance with NFPA *101, Life Safety Code.* Gate-type exits shall be provided for at least 50 percent of the required emergency exit capacity unless fare collection equipment provides unobstructed exiting under all conditions.

2-5.3.5 A second means of egress at least 44 in. (1120 mm) wide shall be provided from each station platform and shall be remote from the major egress route.

2-5.4 Escalators. See also C-2.

2-5.4.1 Escalators equipped to operate in both directions shall be acceptable as emergency exits.

2-5.4.1.1 Escalators running in the exit direction shall be permitted to be left in operating mode. Escalators running reverse to the exiting direction shall be capable of being stopped remotely, manually, or automatically. *(See C-2.)*

2-5.4.1.2 Because of the possibility of maintenance or malfunction, one escalator at each station shall be considered as being out of service in calculating egress requirements. The escalator chosen shall be the one having the most adverse effect upon exiting capacities.

2-5.4.2 Escalators with or without intermediate landings shall be acceptable as emergency exits, regardless of vertical rise.

2-5.4.3 If escalators are exposed to the outdoor environment, the landing and floor plates shall have a nonslip surface, and if they also are exposed to freezing temperatures, the landing and floor plates and steps shall be heated to keep those areas free of ice and snow.

2-5.4.4* Escalators used as a means of egress shall be constructed of noncombustible materials.

2-5.5 Fare Collection Gates or Turnstiles. The following design features shall be provided to facilitate the exit of patrons in the event of an emergency.

2-5.5.1 The fare gates or turnstiles shall assume an emergency exit mode in the event of loss of power to the fare gates or turnstiles or upon actuation of a manual or remote control.

2-5.5.2 Fare collection gates or turnstiles shall be designed so that their failure to operate properly will not prohibit movement of passengers in the direction of the emergency egress.

2-6 Emergency Lighting.

2-6.1 Stations shall be provided with a system of emergency lighting in accordance with NFPA *101, Life Safety Code,* except as otherwise noted herein.

2-6.2 Emergency lighting for stairs and escalators shall be designed to emphasize illumination on the top and bottom steps and landings. All newell- and comb-lighting on escalator steps shall be on emergency power circuits.

2-7 Fire Protection.

2-7.1 Protective Signaling Systems.

2-7.1.1 Stations equipped with fire alarm devices shall be protected by a proprietary system as defined in NFPA 72, *National Fire Alarm Code®*.

2-7.1.2* Each station having alarm detector devices shall be provided with a fire alarm annunciator panel at a suitable location that is accessible to the authority having jurisdiction. Annunciator panels shall announce by audible alarm the activation of any heat or smoke detector in the station and visually display the location of the actuated detector or alarm.

2-7.1.3 All fire alarm, smoke detection, valve switches, and water flow indicator signals — when activated — shall be transmitted simultaneously to the local station and to the central supervising station.

2-7.1.4* Separate zones shall be established on local station annunciator panels to monitor water flow on sprinkler systems and supervise main control valves.

2-7.1.5 Automatic fire detection shall be provided in all ancillary spaces by the installation of listed combination fixed-temperature and rate-of-rise heat detectors or listed smoke detectors except where protected by automatic sprinklers.

2-7.2 Emergency Communication.

2-7.2.1 A public address (PA) system and emergency voice alarm reporting devices, such as emergency telephones, conforming to NFPA 72, *National Fire Alarm Code,* or local (interior) fire alarm pull boxes shall be required in transit stations.

2-7.2.2 The central supervising station and each passenger station shall be equipped with suitable devices (i.e., PA systems) so that appropriate announcements can be made regarding fire alarms, including provisions for giving necessary information and directions to the public upon receipt of any manual or automatic fire alarm signal. These devices shall be placed in suitable locations at each facility.

2-7.2.3 Emergency alarm reporting devices shall be located on passenger platforms and throughout the passenger station such that the travel distance from any point in the public area shall not exceed 300 ft (91.4 m) unless otherwise approved by the authority having jurisdiction. Such emergency devices shall be distinctive in color and their location shall be plainly indicated by appropriate signs.

2-7.3 Automatic Sprinkler Systems.

2-7.3.1 An automatic sprinkler protection system shall be provided in areas of transit stations used for concessions, storage areas, trash rooms, and in the steel truss area of all escalators in a single entry station and other similar areas with combustible loadings, except trainways.

Exception: Areas of open stations remotely located from public spaces.

2-7.3.2 Installation of sprinkler systems shall comply with NFPA 13, *Standard for the Installation of Sprinkler Systems,* or applicable local codes as required.

2-7.3.3 A sprinkler system water flow alarm and supervisory signal service shall be installed.

2-7.3.4 Other approved fire suppression systems shall be permitted to be substituted for automatic sprinkler systems in the areas listed in 2-7.3.1 with the approval of the authority having jurisdiction.

2-7.4 Standpipe and Hose Systems.

2-7.4.1 Each underground transit station shall be equipped with a standpipe system of either Class I- or Class III-type, as defined in NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems.* Class of service shall be determined by the authority having jurisdiction. *(See A-2-7.4.3.)*

2-7.4.2 The authority having jurisdiction shall be consulted as to location, spacing, and number of standpipe hose outlets and valves and shall determine the need for provision and type of hose.

2-7.4.3* Fire department connections for fire department use in supplying the standpipe system shall be located within 100 ft (30.5 m) of vehicular access and within operating distance of fire hydrants as determined by the local authority having jurisdiction. In addition to the usual identification required on fire department connections for standpipes, there shall also be appropriate wording to identify the fire department connection as part of the transit station system in order to avoid confusion with any nearby fire department connections for other buildings.

2-7.4.4 Where underground transit stations include more than one platform level (such as crossover subway lines), there shall be a cross-connection pipe of a minimum size of 4 in. (101.6 mm) in diameter between each standpipe system, so that supplying water through any fire department connection will furnish water throughout the entire system.

2-7.5 Portable Fire Extinguishers. Portable fire extinguishers — in such number, size, type, and location as determined by the authority having jurisdiction — shall be provided.

Chapter 3 Trainways

3-1 General.

3-1.1* This chapter considers all fixed guideway transit trainways whether they are entirely or in any part below, at, or above grade.

3-1.2 Occupancy. It is anticipated that passengers will enter the trainways only in the event that it becomes necessary to evacuate a disabled train. Such evacuation shall take place only under the guidance and control of authorized, trained, transit system employees or other authorized personnel as warranted under an emergency situation.

3-1.3 Warning Signs. Warning signs shall be posted on entrances to the trainway (e.g., station platforms and portals), on fences or barriers adjacent to the trainway, and at such other places where nontransit authority employees might trespass. The warning signs shall clearly state the hazard (e.g., DANGER HIGH VOLTAGE — 750 VOLTS) with letter sizes and colors in conformance with NFPA 70, *National Electrical Code,* and OSHA requirements.

3-1.4 Emergency Telephone. An emergency telephone (ETEL) shall be provided along the trainway at each blue light station and at other locations deemed necessary by the authority having jurisdiction.

3-1.5 Blue Light Station.

3-1.5.1 A location along the trainway, indicated by a blue light, where emergency service or authorized personnel can communicate with the central supervising stations and disconnect traction power.

Traction power disconnect devices shall allow quick removal of power from power zones. Emergency shutoff of traction power shall be achieved by activation of remote manual-control devices, which, in turn, cause the operation of substation circuit breakers and associated trackway disconnect devices.

3-1.5.2 Adjacent to each blue light station, information shall be provided that identifies the location of that station and the distance to an exit in each direction.

3-1.5.3* Blue light stations shall be provided at the following locations:

(1) Ends of station platforms
(2) Cross passages *(see 3-2.4.3)*
(3) Emergency access points
(4) Traction power substations

3-2 Underground (Subways).

3-2.1 Construction Materials.

3-2.1.1 Where line sections are to be constructed by the cut-and-cover method, perimeter walls and related construction shall be not less than Type I- or Type II- or combinations of Type I- or Type II-approved noncombustible construction as defined in NFPA 220, *Standard on Types of Building Construction,* as determined by an engineering analysis of potential fire exposure hazards to the structure.

3-2.1.2 Where line sections are to be constructed by a tunneling method through earth, unprotected steel liners, reinforced concrete, shotcrete, or equivalent shall be used.

Exception: Rock tunnels shall be permitted to utilize steel bents with concrete liner if lining is required.

3-2.1.3 Walk surfaces designated for evacuation of passengers shall be constructed of noncombustible materials. Walk surfaces shall have a slip-resistant design.

3-2.1.4 Underwater Tubes. Underwater tubes shall be not less than Type II- (000) approved noncombustible construction as defined in NFPA 220, *Standard on Types of Building Construction,* as applicable.

3-2.1.5 Noncombustible rail ties shall be used in underground locations except at switch or crossover locations, where fire-retardant, pressure-treated ties shall be permitted to be used.

3-2.1.6 Structures such as remote vertical exit shafts and ventilation structures shall be not less than Type I- (332) approved noncombustible construction as defined in NFPA 220, *Standard on Types of Building Construction.*

3-2.1.7 Ancillary areas shall be separated from trackway areas within underwater line sections by a minimum of 3-hour fire-resistive construction. Ancillary areas shall be separated from trackway areas within underground line sections by a minimum of 2-hour fire-resistive construction.

3-2.2 Ventilation. Emergency ventilation shall be provided in enclosed trainways in accordance with Chapter 4.

3-2.3 Wiring Requirements. See Section 2-4.

3-2.3.1 All wiring materials and installations within trainways, other than for traction power, shall conform to the requirements of NFPA 70, *National Electrical Code,* and, in addition, shall satisfy the requirements of 3-2.3.2 through 3-2.3.9.

3-2.3.2 Materials manufactured for use as conduits, raceways, ducts, boxes, cabinets, equipment enclosures, and their surface finish materials shall be capable of being subjected to temperatures up to 932°F (500°C) for 1 hour and shall not support combustion under the same temperature condition. Other materials, where encased in concrete or suitably protected, shall be acceptable.

3-2.3.3 All conductors shall be insulated. Ground wires shall be permitted to be bare. All thicknesses of insulation and all thicknesses of jackets shall conform to NFPA 70, *National Electrical Code.*

3-2.3.4 All insulations shall conform to Article 310 of NFPA 70, *National Electrical Code,* and shall be moisture- and heat-resistant types carrying temperature ratings corresponding to the conditions of application and in no case lower than 194°F (90°C).

3-2.3.5 Wire and cable constructions intended for use in operating vital train circuits and power circuits to emergency lights and so forth shall pass the flame-propagating criteria of IEEE Standard 383, *Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.*

3-2.3.6* All conductors, except radio antennas, shall be enclosed in their entirety in armor sheaths, conduits, or enclosed raceways, boxes, and cabinets. Conductors in conduits or raceways shall be permitted to be embedded in concrete or run in protected electrical duct banks, but shall not be installed exposed or surface-mounted in air plenums that could carry air at the elevated temperatures accompanying fire emergency conditions.

3-2.3.7 Overcurrent elements that are (1) designed to protect conductors serving emergency equipment motors (i.e., pumps, etc.), emergency lighting, and communications equipment, and (2) located in spaces other than the main electrical distribution system equipment rooms shall not depend on thermal properties for operation.

3-2.3.8 Conductors for emergency lighting, communications, and so forth shall be protected from physical damage by transit vehicles or other normal transit system operations and from fires in the transit system by suitable embedment or encasement, or by routing such conductors external to the interior underground portions of the transit system facilities.

3-2.3.9 Power Supply for Emergency Ventilation. See Chapter 4 for power supply for emergency ventilation fans.

3-2.4 Emergency Exit Details.

3-2.4.1 Emergency exits shall be provided from tunnels to a point of safety.

3-2.4.2 Emergency exit stairways shall be provided throughout the tunnels and spaced so that the distance to an emergency exit shall not be greater than 1250 ft (381 m) unless otherwise approved by the authority having jurisdiction. The stairway shall be designed in accordance with NFPA *101, Life Safety Code,* Class A designation. The stairway shall be enclosed and shall lead directly to the outdoors or to a safe refuge area.

3-2.4.3 Where trainways in tunnels are divided by a minimum of 2-hour–rated fire walls or where trainways are in twin bores, such an arrangement shall be deemed to afford adequate protection for the passengers via cross passageways between the trainways and, therefore, shall be permitted to be utilized in lieu of emergency exit stairways to the surface. In this situation, or in the event that a ventilation system fails to provide a sufficient amount of noncontaminated air to the passengers in a path of egress, the following shall apply:

(1) Cross passageways shall not be farther than 800 ft (244 m) apart.
(2) Openings in open passageways shall be protected with fire door assemblies having a fire protection rating of $1^1/_2$ hours with a self-closing fire door.
(3) A noncontaminated environment shall be provided in that portion of the trainway that is not involved in an emergency and that is being used for evacuation.
(4) A ventilation system for the contaminated tunnel shall be designed to control smoke in the vicinity of the passengers.
(5) A suitable method shall be provided for evacuating passengers in the uncontaminated trainway, for protecting passengers from oncoming traffic, and for evacuating the passengers to a nearby station or other emergency exit.

3-2.4.4 Doors. Doors to the exit access shall open in the direction of exit travel, except in the case of cross passageway closures, and shall be equipped with hardware in accordance with NFPA *101*, *Life Safety Code.* The force required to open the doors fully when applied to the latch side shall be as low as possible, not exceeding 50 lb (222 N). In addition, doors and hardware shall be adequate to withstand positive and negative pressures created by passing trains.

3-2.4.5 Exit Hatches. Exit hatches at exit discharge shall be equipped with hardware or latches that can be readily opened from the side of egress. The force required to open the hatch when applied at the latch side shall not exceed 30 lb (133 N). The hatch shall be equipped with a hold-open device that shall automatically latch the door in the open position to preclude accidental closure. Hatches shall be capable of being opened from the outside by authorized personnel.

3-2.4.6 Emergency exit facilities shall be suitably identified and maintained to allow for their intended use.

3-2.4.7 Emergency Lighting.

3-2.4.7.1 The requirements of 3-2.4.7 shall apply to all underground or enclosed trainways that are greater than 50 ft (15.25 m) or 1 car length, whichever is greater.

3-2.4.7.1.1 Emergency lighting systems shall be installed and maintained in accordance with NFPA 70, *National Electrical Code.*

3-2.4.7.1.2 Exit lights, essential signs, and emergency lights shall be included in the emergency lighting system and shall be powered by a standby power supply or a supply independent of the traction power system. Emergency fixtures, exit lights, and signs shall be wired separately from emergency distribution panels.

3-2.4.7.1.3 The illumination levels of underground or enclosed trainway walkways and walking surfaces (i.e., trackway or bench wall walkway) shall not be less than 0.25 ft-candles (2.69 lx) at the walking surface.

3-2.5 Traction Power.

3-2.5.1* Application. This section describes life safety and fire protection criteria for the traction power subsystem installed in the subway trainway. The life safety and fire protection requirements for the traction power substations, tie breaker stations, and power distribution and control cabling are described in other parts of this standard.

Specifically, traction power as used in this subsection includes the wayside pothead, the cable between the pothead and the contact (third) rail or overhead contact system (OCS), the contact rail or OCS supports, and special warning and identification devices, as well as electrical appurtenances associated with overhead trolley systems.

3-2.5.2 Traction Power Contact Rail Protection. To provide safety isolation from the contact rail, the following shall be implemented.

3-2.5.2.1 Power rail conductor (dc or ac, that supply power to the vehicle for propulsion and other loads) shall be secured to suitable insulating supports, properly bonded at joints, and properly protected to prevent contact with personnel. In particular, the design shall consider measures to prevent inadvertent contact with the live power rails where such power rails are adjacent to emergency or service walkways and where walkways cross over trainways.

3-2.5.2.2 Coverboards, where used, shall be capable of supporting a vertical load of 250 lb (1112 N) at any point with no visible permanent deflection.

3-2.5.2.3 Coverboard or protective material shall have a flame spread rating of not more than 25 when tested in accordance with NFPA 255 (ASTM E 84), *Standard Method of Test of Surface Burning Characteristics of Building Materials.*

3-2.5.2.4 Insulating material for the cable connecting power to the rail shall meet the requirements of IEEE Standard 383, *Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations,* Section 2.5.

3-2.5.3 Traction Power Overhead Contact System Protection. To provide isolation from the overhead contact system, the following shall be provided.

3-2.5.3.1 Power conductor(s) (dc or ac, that supply power to the vehicle for propulsion and other loads) shall be secured to suitable insulating supports, properly bonded at joints, and properly protected to prevent contact with personnel.

3-2.5.3.2 Insulating material for the cable connecting power to the overhead contact system shall meet the requirements of IEEE Standard 383, *Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations*, Section 2.5.

3-2.6 Egress for Passengers. The system shall incorporate means for passengers to evacuate a train at any point along the trainway and reach a safe area. System egress points shall be illuminated.

3-2.6.1 An effective emergency egress pathway shall be provided.

3-2.6.2 Walking surfaces shall have a uniform, slip-resistant design.

3-2.6.3 In areas where crosspassages are provided, walkways shall be provided on the crosspassage side of the trainway for unobstructed access to the crosspassage.

3-2.6.4 Raised walkways, ramps, and stairs shall be provided with a handrail that shall not obstruct egress from the train.

3-2.6.5 Crosswalks shall be provided at track level to assure walkway continuity. Crosswalks shall have uniform walking surface at top of rail.

3-2.6.6 Walkway continuity shall be maintained at special track sections (e.g., crossovers, pocket tracks, etc.).

3-2.7 Protection.

3-2.7.1 Automatic Fire Detection. Heat and smoke detectors shall be installed at traction power substations and shall be connected to the central supervising station. Signals received from such devices shall be readily identifiable as to origin of signals.

3-2.7.2 Standpipe and Hose Systems. Standpipes for Class I or Class III service, as described in NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems,* shall be installed in all underground or enclosed trainways according to the following calculation. Due to the nature and length of underground or enclosed trainways, standpipes shall be permitted to be of the dry type with the approval of the authority having jurisdiction.

3-2.7.2.1 A fire standpipe system shall be provided for all underground or enclosed trainways if the length of the trainway, L_T, is greater than the length allowable for participating agency personnel to reach every conceivable fire location within the trainway, according to the following calculated length:

$$L_T > L_H - D_P$$

where:

L_H = maximum length of fire hose permitted by the authority having jurisdiction

D_P = maximum of the distances (measured along the route of the hose) from each trainway portal to the nearest fire hydrant or approved water source

3-2.7.2.2 Underground or enclosed trainway standpipe lines shall be a minimum size of 4 in. (101.6 mm) in diameter, or sized by hydraulic calculations, and shall be increased in diameter as the length of pipe increases in order to deliver the rate of water flow at proper pressure, as specified by the authority having jurisdiction.

3-2.7.2.3 Identification numbers and letters conforming to the sectional identification numbers and letters of the fixed guideway transit or passenger rail track system shall be provided at each surface fire department connection and at each hose valve on the standpipe lines. Such identifying numbers and letters shall be on conspicuous, durable, and legible signs affixed to, or immediately adjacent to, ground level fire department connections. In underground or enclosed trainway, the identifying signs shall be affixed to underground or enclosed trainway walls at each hose outlet valve or shall be painted directly on the standpipe in white letters next to each hose outlet valve. Exposed tunnel standpipe lines and identification signs shall be painted as required by the local authority having jurisdiction.

3-2.7.3 Standpipe Installations in Tunnels under Construction.

3-2.7.3.1 A standpipe system, either temporary or permanent in nature, shall be installed in tunnels under construction before the tunnel has exceeded a length of 200 ft (61 m) beyond any access shaft and shall be extended as tunnel work progresses.

3-2.7.3.2 Permanent standpipes shall conform to NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems,* as outlined in 3-2.7.2.

3-2.7.3.3 Temporary standpipes, which might be used by contractors to furnish water for construction purposes, shall be equipped with hose outlets and valves with $2^1/_2$-in. (63.5-mm) hose thread conforming to NFPA 1963, *Standard for Fire Hose Connections,* and shall have suitable reducers or adapters attached for connection of the contractor's hose. Such reducers or adapters shall be readily removable through the use of a fire fighter's hose spanner wrench.

3-2.7.3.4 Permanent standpipes or temporary standpipes installed in tunnels during construction shall be provided with risers to the ground surface level. Such risers shall be equipped with approved fire department connections, which shall be identified with appropriate signs as outlined in 3-2.7.2.3 of this standard, and shall be readily accessible for fire department use and protected from accidental damage. There shall be a check valve and ball drip or a valved drain in the riser near the connection to the standpipe.

3-2.7.3.5 Permanent or temporary standpipes installed during the construction phase shall be securely and adequately supported and shall be of sufficient strength to withstand the pressure and thrust forces to which they might be subjected.

3-2.7.3.6 Temporary standpipes shall remain in service until the permanent standpipe installation is complete.

3-2.7.4 Portable Fire Extinguishers. Portable fire extinguishers shall be provided in such numbers, sizes, and types and at such locations in tunnels as determined by the authority having jurisdiction.

3-2.8 Flammable and Combustible Liquids Intrusion. This subsection deals with the prevention of accidental intrusion of flammable and combustible liquids due to spills.

3-2.8.1 Vehicle Roadway Terminations. Vent or fan shafts utilized for ventilation of subway tunnels shall not terminate at grade on any vehicle roadway.

3-2.8.2 Median and Sidewalk Terminations. Vent and fan shafts shall be permitted to terminate in median strips of divided highways or on sidewalks designed to accept such shafts or in open space areas, provided that the grade level of the median strips or sidewalk or open space is at a higher elevation than the surrounding grade level and is separated from the roadway by a concrete curb at least 6 in. (152.4 mm) in height.

3-2.8.3 Aboveground Atmospheric Storage Tanks. Aboveground atmospheric storage tanks storing, handling, or processing

Class I flammable liquid or Class II or Class III combustible liquids and related piping shall not be located directly over a subsurface structure or within 25 ft (7.6 m) measured horizontally from the outside wall of such subsurface structure unless provided with an approved leak detection system.

3-2.8.4 Underground Storage Tanks. Underground storage tanks for Class I flammable or Class II or Class III combustible liquids and related piping shall not be permitted directly over a subsurface structure or within 25 ft (7.6 m) measured horizontally from the outside wall of such subsurface structure. *(See 3-2.8.6 for tanks in or under existing buildings.)*

3-2.8.4.1 Underground storage tanks and related piping for Class I flammable or Class II or Class III combustible liquids located in the area between 25 ft (7.6 m) and 100 ft (30.5 m) (measured horizontally) from the outside wall of the subsurface structure and within that same area, such tanks and related piping within 2 ft (0.61 m) (measured vertically) below the lowest point of subsurface structure excavation, shall be constructed and installed by one of the methods described in (a) or (b).

(a) Tanks shall be of double wall construction. Tanks shall be equipped with an approved automatic leak detection and monitoring system. Tanks shall be provided with an approved corrosion protection system. Installation, maintenance, and inspection shall conform to the requirements specified by the authority having jurisdiction.

(b) Tanks shall be installed in a cast-in-place reinforced concrete vault large enough to hold and retain the entire contents of the tank. The storage tank shall be completely encompassed by not less than 24 in. (610 mm) of well-tamped, noncorrosive inert material within the vault. An approved method for monitoring of, or testing for, product and enclosure leakage shall be incorporated into the enclosure design. The vault lid shall be designed and constructed to withstand anticipated surface loadings and shall not be less than 6 in. (152.4 mm) of reinforced concrete. Vault, tank, and piping shall be protected from corrosion.

3-2.8.4.2 All tanks, vaults, and appurtenances used to store Class I flammable and Class II and Class III combustible liquids shall be compatible with the materials stored and shall conform to the provisions of NFPA 30, *Flammable and Combustible Liquids Code.*

3-2.8.5 Service Stations. Service stations dispensing Class I flammable liquids and Class II and Class III combustible liquids, and located in the area within 100 ft (30.5 m) (measured horizontally) from the outside wall of the subsurface structure, shall be required to comply with 3-2.8.5.1 through 3-2.8.5.4.

3-2.8.5.1 The surface around pump islands shall be graded or drained in a manner to divert possible spills away from the subway vent gratings or subway entrances or exits.

3-2.8.5.2 Appropriate continuous drains across driveways, ramps, or curbs of at least 6 in. (152.4 mm) in height shall separate service station properties from adjacent subway property.

3-2.8.5.3 No connection (such as venting or drainage) of any storage tanks and related piping of Class I flammable liquids and Class II and Class III combustible liquids to a subsurface fixed guideway transit structure shall be permitted.

3-2.8.5.4 Dispensing pumps for Class I flammable liquids and Class II and Class III combustible liquids shall not be located less than 25 ft (7.6 m) from the face of such pump to the nearest side of a subway vent grating or subway entrance or exit.

3-2.8.6 Existing Storage Tanks in or under Buildings.

3-2.8.6.1 Existing storage tanks for Class I flammable liquids and Class II and Class III combustible liquids located in or under buildings, and located directly above a subsurface transit structure or within 25 ft (7.6 m) (measured horizontally) from the outside wall of the subsurface transit structure, shall be removed and relocated outside the prohibited area.

3-2.8.6.2 Where it is not possible to remove and relocate tanks for Class I flammable and Class II combustible liquids due to limited space, such underground tanks shall be abandoned in accordance with the provisions of Appendix C of NFPA 30, *Flammable and Combustible Liquids Code.*

3-2.8.6.3 Where it is not possible to remove and relocate tanks for Class III combustible liquids located in buildings, such tanks shall be provided with leak detection and a secondary containment system of adequate capacity to contain the contents of the tank. Otherwise it shall be abandoned in accordance with the provisions of Appendix C of NFPA 30, *Flammable and Combustible Liquids Code.*

3-2.8.6.4 Where it is not possible to remove and relocate tanks for Class III combustible liquids located under a building, such tanks shall be UL-listed double wall or installed in a cast-in-place reinforced concrete vault and shall be provided with an approved leak detection system. Otherwise, it shall be abandoned in accordance with the provisions of Appendix C of NFPA 30, *Flammable and Combustible Liquids Code.*

3-3 Surface.

3-3.1 General. Applies to any at-grade or unroofed structure other than elevated structures.

3-3.2 Construction Materials. Construction materials shall be not less than Type II- (000) approved noncombustible material as defined in NFPA 220, *Standard on Types of Building Construction,* as determined by an engineering analysis of potential fire exposure hazards to the structure.

3-3.3* Traction Power. This subsection describes life safety and fire protection criteria for the traction power subsystem installed in the trainway. The life safety and fire protection requirements for the traction power substations, tie breaker stations, and power distribution and control cabling are described in other parts of this standard.

3-3.3.1 Specifically, traction power as used in this section shall include the wayside pothead, the cable between the pothead and the contact (third) rail or overhead wire, the contact rail supports, and special warning and identification devices.

3-3.3.2 Life safety and fire protection criteria for the subsystem installed in the trainway shall conform to the requirements for underground trainways that are listed in 3-2.5.2.

3-3.4 Electrical Wiring and Cable Requirements. All wiring materials and installations other than those for traction power shall conform to the requirements of NFPA 70, *National Electrical Code.*

3-3.5 Emergency Access.

3-3.5.1 Access gates shall be provided in security fences, as deemed necessary by the authority.

3-3.5.2 The gates shall be a minimum of two exit units wide and shall be of the hinged or sliding type. Gates shall be placed as close as practical to the portals to permit easy access to tunnels.

3-3.5.3 Information that clearly identifies the route and location of each gate shall be provided on the gates or adjacent thereto.

3-3.6 Egress for Passengers. The system shall incorporate means for passengers to evacuate a train at any point along the trainway and reach a point of safety. System egress points shall be illuminated.

3-4 Elevated.

3-4.1 General. Elevated structures are all structures not defined in this standard as surface or underground structures.

3-4.2 Construction Materials. All structures necessary for line way support shall be of not less than Type I- or Type II- (000) or combinations of Type I- or Type II-approved noncombustible construction as defined in NFPA 220, *Standard on Types of Building Construction,* as determined by an engineering analysis of potential fire exposure hazards to the structure.

3-4.3* Traction Power. This subsection describes life safety and fire protection criteria for the traction power subsystem installed in the trainway. The life safety and fire protection requirements for the traction power substations, tie breaker stations, and power distribution and control cabling are described in other parts of this standard.

3-4.3.1 Specifically, traction power as used in this subsection shall include the wayside pothead, the cable between the pothead and the contact (third) rail or overhead wire, the contact rail supports walkways, and special warning and identification devices.

3-4.3.2 Life safety and fire protection criteria for the subsystem installed in the trainway shall conform to the requirements for underground trainways that are listed in 3-2.5.2.

3-4.4 Electric Wire and Cable Requirements. All wiring materials and installations other than for traction power shall conform to the requirements of NFPA 70, *National Electrical Code.*

3-4.5 Emergency Access. Access to the trainway shall be from stations or by mobile ladder equipment from roadways adjacent to the trackway. If no adjacent or crossing roadways exist, access roads at a maximum of 2500-ft (762-m) intervals shall be required.

3-4.5.1 If security fences are used along the trackway, gates shall be provided to permit access. *(See 3-3.5.2.)*

3-4.5.2 Information shall be provided adjacent to each blue light station that identifies the route and location of the access. The graphics shall be legible from the ground level outside the trackway.

3-4.6 Egress for Passengers. The transit system shall incorporate a walk surface or other suitable means for passengers to evacuate a train at any point along the trainway so that they can proceed to the nearest station or other point of safety. System egress points shall be illuminated.

Chapter 4 Emergency Ventilation System

4-1 General.

4-1.1 This chapter defines the requirements for the environmental conditions and the mechanical ventilation systems used to meet those requirements for a fire emergency in a station or trainway as required by Section 2-3 and 3-2.2. Appendix B provides information on types of mechanical systems for normal ventilation of fixed guideway transit systems and information for determining a tenable environment.

4-1.2 The requirement for a mechanical system intended for the purpose of emergency ventilation shall be determined in accordance with 4-1.2.1 through 4-1.2.4.

4-1.2.1 A mechanical emergency ventilation system shall be provided in the following locations:

(1) In an enclosed fixed guideway transit station
(2) In a fixed guideway transit underground or enclosed trainway that is greater in length than 1000 ft (304.8 m)

4-1.2.2 A mechanical emergency ventilation system shall not be required in the following locations:

(1) In an open fixed guideway transit station
(2) Where the length of an underground trainway is less than or equal to 200 ft (61 m)

4-1.2.3 An engineering analysis to determine the need for a mechanical emergency ventilation system shall be conducted where the length of the underground or enclosed trainway is less than or equal to 1000 ft (304.8 m) and greater than 200 ft (61 m).

4-1.2.4 In the event that an emergency analysis is not conducted for the configurations described in 4-1.2.3, a mechanical emergency ventilation system shall be provided.

4-1.3 Where required by 4-1.2, the mechanical emergency ventilation system shall make provisions for the protection of passengers, employees, and emergency personnel from fire and smoke during a fire emergency and shall be designed to maintain the required airflow rates for a minimum of 1 hour but not less than the anticipated evacuation time.

4-2 Design.

4-2.1 The emergency ventilation system shall be designed to do the following:

(1) Provide a tenable environment along the path of egress from a fire incident in enclosed stations and enclosed trainways
(2) Produce airflow rates sufficient to prevent backlayering of smoke in the path of egress within enclosed trainways
(3) Be capable of reaching full operational mode within 120 seconds

4-2.2 The design shall encompass the following:

(1) The heat release rate produced by the combustible load of a vehicle and any combustible materials that could contribute to the fire load at the incident site
(2) The fire growth rate
(3) Station and trainway geometries
(4) A system of fans, shafts, and devices for directing airflow in stations and trainways
(5) A program of predetermined emergency response procedures capable of initiating prompt response from

the central supervising station in the event of a fire emergency

4-3 Emergency Ventilation Fans.

4-3.1 The ventilation system fans that are designated for use in fire emergencies shall be capable of satisfying the emergency ventilation requirements in either the supply or exhaust mode. Individual emergency ventilation fan motors shall be designed to achieve their full operating speed in no more than 30 seconds from a stopped position when started across the line and in no more than 60 seconds for variable speed motors.

4-3.2 Emergency ventilation fans, their motors, and all related components exposed to the exhaust airflow shall be designed to operate in an ambient atmosphere of 482°F (250°C) for a minimum of 1 hour with actual values to be determined by design analysis. In no case shall the operating temperatures be less than 300°F (149°C). Fans shall be rated in accordance with the ANSI/AMCA 210-85, *Laboratory Methods of Testing Fans for Rating,* AMCA 300-96, *Reverberant Room Method for Sound Testing of Fans,* and the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), *Handbook Fundamentals.*

4-3.3 Local fan motor starters and related operating control devices shall be located away from the direct airstream of the fans to the greatest extent practical. Thermal overload protective devices on motor controls of fans used for emergency ventilation shall not be permitted.

4-3.4 Fans associated only with patron or employee comfort and that are not designed to function as a part of the emergency ventilation system shall shut down automatically on identification and initiation of a fire emergency ventilation program so as not to jeopardize or conflict with emergency airflows. Nonemergency ventilation airflows that do not impact the emergency ventilation airflows shall be permitted to be left operational where identified in the engineering analysis.

4-3.5 Critical fans required in battery rooms or similar spaces where hydrogen gases or other hazardous gases might be released shall be designed to meet the ventilation requirements of NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.* These fans and other critical fans in automatic train control rooms, communications rooms, and so forth shall be identified in the engineering analysis and shall remain operational as required during the fire emergency.

4-4 Devices.

4-4.1 Devices that are interrelated with the emergency ventilation fans and that are required to meet the emergency ventilation system airflows shall be structurally capable of withstanding both maximum repetitive and additive piston pressures of moving trains and emergency airflow velocities.

4-4.2 Devices shall be constructed of noncombustible, fire-resistant materials capable of functioning at anticipated operating temperatures.

Exception: Finishes applied to noncombustible devices.

4-4.3 Device controls shall be protected against fire in the immediate area to the greatest extent practical.

4-5 Shafts. Shafts that penetrate the surface and that are used for intake and discharge in fire or smoke emergencies shall be positioned or protected to prevent recirculation of smoke into the system through surface openings. If this is not possible, surface openings shall be protected by other means to prevent smoke from re-entering the system. Adjacent structures and property uses also shall be considered.

4-6 Emergency Ventilation System Control/Operation.

4-6.1 Operation of the emergency ventilation system components shall be initiated from the central supervising station. The central supervising station shall receive verification of proper emergency ventilation fan(s) and interrelated device(s) response. Local controls shall be permitted to override the central supervising station in all modes in the event the central supervising station becomes inoperative or where the operation of the emergency ventilation system components is specifically redirected to another site.

4-6.2 Operation of the emergency ventilation system shall not be discontinued until directed by the incident commander.

4-7 Power and Wiring.

4-7.1 The power for the emergency ventilation fan plants shall originate from two separate and distinct utility sources. The feeders from those sources to the individual components shall be isolated from one another to the greatest degree possible. If a second feeder is not available, an emergency backup system shall be permitted to provide the second power source if designed to meet the demands of the emergency modes. Where an emergency backup system is utilized, it shall comply with the provisions of NFPA 110, *Standard for Emergency and Standby Power Systems.*

4-7.2 All wiring materials and installations shall conform to the requirements of NFPA 70, *National Electrical Code,* and, in addition, shall satisfy the requirements of 4-7.3 through 4-7.8.

4-7.3 Materials manufactured for use as conduits, raceways, ducts, boxes, cabinets, equipment enclosures, and their surface finish materials shall be capable of being subjected to temperatures up to 932°F (500°C) for 1 hour and shall not support combustion under the same temperature condition. Other materials, when encased in concrete, shall be acceptable.

4-7.4 All conductors shall be insulated. Ground wires shall be permitted to be bare. All thicknesses of jackets shall conform to NFPA 70, *National Electrical Code.*

4-7.5 All insulations shall conform to Article 310 of NFPA 70, *National Electrical Code,* and be moisture- and heat-resistant types carrying temperature ratings corresponding to the conditions of application and in no case lower than 194°F (90°C).

4-7.6 Wire and cable constructions intended for use in control circuits and power circuits to related emergency devices shall pass the flame-propagating criteria of IEEE Standard 383, *Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.*

4-7.7* All conductors for emergency ventilation fans and related emergency devices shall be protected from physical damage by transit vehicles or other normal transit system operations and from fires in the transit system by suitable embedment, encasement, or location. Encased conductors shall be enclosed in their entirety in armor sheaths, conduits, or enclosed raceway boxes and cabinets, except in ancillary areas or other nonpublic areas. Conductors in conduits or raceways shall be permitted to be embedded in concrete or to run in concrete electrical duct banks but shall not be installed exposed or surface-mounted in air plenums that might carry elevated temperatures accompanying fire emergency conditions.

4-7.8 Overcurrent elements that are designed to protect conductors serving motors for both emergency fans and related emergency devices that are located in spaces other than the main electrical distribution system equipment rooms shall not depend on thermal properties for operation.

Chapter 5 Vehicles

5-1 Applicability.

5-1.1 New Vehicles. All new fixed guideway transit and passenger rail vehicles shall be, at a minimum, designed and constructed to conform with the requirements set forth in this chapter.

5-1.2 Retrofit. Where existing fixed guideway transit and passenger rail vehicles are to be retrofitted, the appropriate sections of this standard shall apply only to the extent of such retrofit.

5-2 Construction.

5-2.1 Application. This standard is prepared with the intent to provide minimum requirements for those instances where *noncombustible materials* (as defined in 1-5.30) are not used due to other considerations in the design and construction of the vehicle.

5-2.2 Testing. It is recognized that the tests cited in this chapter might not accurately predict the behavior of materials under hostile fire conditions. Therefore, the use of tests that evaluate materials in subassemblies and full-scale configurations shall be encouraged where such tests are more representative of the fire source–heat flux levels and surface area-to-volume ratios.

5-2.3 Structural Fire Resistivity. Portions of the vehicle body separating major ignition, energy, or fuel-loading sources from the passenger compartment including equipment-carrying portions of vehicle roofs shall have sufficient resistance to fire penetration to the interior of the vehicle by an external fire for a period consistent with the safe evacuation of a full load of passengers from the vehicle in the worst-case situation. Design of floor systems shall take into account the potential fire hazard associated with under-floor operating components, items carried onto a vehicle by riders, and the use and right-of-way characteristics that affect evacuation time of the vehicle.

5-2.3.1 Component Test Criteria.

5-2.3.1.1 Where the floor is separating the major ignition, energy, or fuel-loading sources from the passenger compartment, the floor assembly shall, at the end of 15 minutes, when subjected to the fire exposure as defined in NFPA 251 (ASTM E 119), *Standard Methods of Tests of Fire Endurance of Building Construction and Materials,* meet the following criteria:

(a) Transmission of heat through the floor assembly shall not be sufficient to raise the temperature on its unexposed surface more than 250°F (139°C) average and 325°F (181°C) single point.

(b) The floor assembly shall have withstood the fire exposure without the passage of flame or gases hot enough to ignite cotton waste on the unexposed surface of the specimen.

(c) The floor assembly shall be tested with a representative loading consistent with the vehicle design.

(d) At a minimum, the size of the exposed portion of the floor assembly shall be 10 ft (3.1 m) long by the normal vehicle-floor-width wide. The assembly shall be configured to have at least one representative floor joint and one of each type of typical floor penetration (e.g., air duct, wiring conduit, etc.).

5-2.3.1.2 Tests for portions of the vehicle body, other than the floor, shall be permitted to use the test criteria defined for floors or criteria appropriate to the physical locations and magnitude of the major ignition, energy, or fuel-loading sources and shall have sufficient resistance to fire penetration to the interior of the vehicle by an external fire for a period consistent with the safe evacuation of a full load of passengers from the vehicle in the worst-case situation.

5-2.3.2 Where vehicles are powered by overhead supply (e.g., trolley wire, catenary, etc.), roof design consideration shall be given to the prevention of arc penetration and to the susceptibility of ignition in materials in the roof assembly.

5-2.3.3 All floor, wall, and roof openings and penetrations shall be adequately sealed or protected in order to maintain the fire and smoke integrity of the structure, in addition to mechanical considerations (e.g., waterproofing). Test assemblies shall be representative of vehicle construction including penetrations.

5-2.4 Interior Fire Propagation Resistance. Materials and finishes installed in the vehicle shall have sufficient resistance to fire propagation in the interior of the vehicle by an internal fire for a period consistent with the safe evacuation of a full load of passengers from the vehicle. The aforementioned materials and finishes shall be evaluated under a fire hazard assessment for vehicles including material characteristics other than fire propagation resistance; such as smoke emission, ease of ignition, rate of heat, and smoke release. Two methods for assessing the fire hazard for materials and finishes used in a vehicle interior are to do a hazard load analysis *(see Appendix D)* or use appropriate material properties *(see Table 5-2.4).* The aforementioned materials and finishes shall include interior walls and ceiling linings, floor coverings, ceiling, seats, sleeping accommodation, and food service–related components, shades, drapes, curtains, glazing, transparencies, partitions, elastomer(s), and nonelectrical insulation.

Table 5-2.4 contains test procedures and minimum performance requirements for interior materials.

Exception: Materials used in small parts, such as knobs, rollers, fasteners, adhesives, clips, grommets, small electrical parts, and other small miscellaneous parts, which can be shown to not contribute to fire propagation and smoke release.

Table 5-2.4 Test Procedures and Minimum Performance Requirements for Testing the Flammability and Smoke Emission Characteristics of Rail Transit Vehicle Materials

Category	Function of Material	Test Procedure	Performance Criteria
Vehicle Seating, Sleeping Accommodation, and Food Service–Related Components	Cushions, mattresses[1,2,5,9]	ASTM D 3675 ASTM E 662	$I_s \le 25$ $D_s(1.5) \le 100$; $D_s(4.0) \le 175$
	Seat and/or bed frame[1,5,8]	ASTM E 162 ASTM E 662	$I_s \le 35$ $D_s(1.5) \le 100$; $D_s(4.0) \le 200$
	Seat shroud, toilet, and trays[1,5]	ASTM E 162 ASTM E 662	$I_s \le 35$ $D_s(1.5) \le 100$; $D_s(4.0) \le 200$
	Upholstery, mattress ticking covers, curtains, drapes, and shades[1,2,3,5]	FAR 25.853*a* (Vertical) ASTM E 662	Flame time ≤ 10 sec; burn length ≤ 6 in. $D_s(4.0) \le 200$
Panels	Wall[1,5,10]	ASTM E 162 ASTM E 662	$I_s \le 35$ $D_s(1.5) \le 100$; $D_s(4.0) \le 200$
	Ceiling[1,5,10]	ASTM E 162 ASTM E 662	$I_s \le 35$ $D_s(1.5) \le 100$; $D_s(4.0) \le 200$
	Partition, tables, and shelves[1,5,10]	ASTM E 162 ASTM E 662	$I_s \le 35$ $D_s(1.5) \le 100$; $D_s(4.0) \le 200$
	Windscreen[1,5]	ASTM E 162 ASTM E 662	$I_s \le 35$ $D_s(1.5) \le 100$; $D_s(4.0) \le 200$
	HVAC ducting[1,5]	ASTM E 162 ASTM E 662	$I_s \le 35$ $D_s(4.0) \le 100$
	Window[4,5]	ASTM E 162 ASTM E 662	$I_s \le 100$ $D_s(1.5) \le 100$; $D_s(4.0) \le 200$
	Light diffuser[5]	ASTM E 162 ASTM E 662	$I_s \le 100$ $D_s(1.5) \le 100$; $D_s(4.0) \le 200$
Flooring	Structural[6]	ASTM E 119	Pass
	Covering[7]	ASTM E 648 ASTM E 662	C.R.F. ≥ 0.5 W/cm^2 D_s $(1.5) \le 100$ D_s $(4.0) \le 200$
Insulation	Thermal[1,2,5]	ASTM E 162 ASTM E 662	$I_s \le 25$ $D_s(4.0) \le 100$
	Acoustic[1,2,5]	ASTM E 162 ASTM E 662	$I_s \le 25$ $D_s(4.0) \le 100$
Elastomers	Window gaskets, door nosing, and roof mats[1,10]	ASTM C 1166 ASTM E 662	Pass $D_s(1.5) \le 100$; $D_s(4.0) \le 200$
Equipment boxes and covers[1,5]	Exterior shells, diaphragms, and articulation bellows[1,5]		
	Equipment boxes and covers[1,5]	ASTM E 162 ASTM E 662	$I_s \le 35$ $D_s(1.5) \le 100$; $D_s(4.0) \le 200$

[1]Materials tested for surface flammability shall not exhibit any flaming running or flaming dripping.
[2]The surface flammability and smoke emission characteristics of a material shall be demonstrated to be permanent by washing, if appropriate, according to Federal Test Method Standard 191A, *Textile Test Method 5830*.
[3]The surface flammability and smoke emission characteristics of a material should be demonstrated to be permanent by dry cleaning, if appropriate, according to ASTM D 2724, *Standard Test Method for Bonded, Fused, and Laminated Apparel Fabrics*. Materials that cannot be washed or dry cleaned should be so labeled and shall meet the applicable performance criteria after being cleaned as recommended by the manufacturer.
[4]For double window glazing, only the interior glazing shall meet the material requirements specified herein; the exterior need not meet those requirements.
[5]The ASTM E 662, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*, maximum test limits for smoke emission (specific optical density) shall be measured in either the flaming or nonflaming mode, depending on which mode generates the most smoke.
[6]Structural flooring assemblies shall meet the performance criteria during a nominal test period determined by the transit agency. The nominal test period shall not be less than 15 minutes. Only one specimen needs to be tested. A proportional reduction can be made in dimensions of the specimen provided that it represents a true test of its ability to perform as a barrier against undercar fires. Penetrations (e.g., ducts, etc.) shall be designed against acting as conduits for fire and smoke.
[7]Carpeting shall be tested in accordance with ASTM E 648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source*, and be tested with its padding, if the padding is used in actual installation.
[8]Arm rests, if foamed plastic, are tested as cushions.
[9]Testing is performed without upholstery.
[10]Carpeting and elastomers installed on walls, ceilings, and partitions shall be considered wall and ceiling panel materials, respectively.

5-2.5 Electrical Insulation. Control wire and power cable shall be capable of passing the following tests.

(a) Wires for control and other low voltage (i.e., less than 100 V ac and 150 V dc) functions shall meet the requirements of ICEA S-19/NEMA WC3, *Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy,* (with Amendment FR-1) paragraph 6.19.6; or of UL 44, *Standard for Safety Rubber-Insulated Wires and Cables*, for thermosetting insulation and UL 83, *Standard for Safety Thermoplastic-Insulated Wires and Cables,* for thermoplastic insulation.

(b) Power cable shall meet the requirements of IEEE Standard 383, *Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations,* Section 2.5, with the additional requirement that circuit integrity continue for 5 minutes after the start of the test.

5-2.6 Equipment Arrangement.

5-2.6.1 Vehicle design shall arrange equipment apparatus external to the passenger and crew compartment, where practical, to isolate potential ignition sources from fuel and combustible material and to control fire and smoke propagation. Where it is necessary to install equipment in vehicles, suitable shields or enclosures shall be provided to isolate the equipment from passenger and crew compartment.

5-2.6.2 Materials used for ducting and plenums serving the car interior shall be noncombustible.

Exception: Materials used for HVAC ducting that meet the requirements of Table 5-2.4.

5-2.6.3 Fuel tanks shall be designed to minimize passenger and crew exposure to fuel hazards.

5-3 Electrical Fire Safety Requirements.

5-3.1 General Construction. All motors, motor control, current collectors, and auxiliaries shall be of a type and construction suitable for use on fixed guideway transit and passenger rail vehicles.

5-3.2 Gap and Creepage.

5-3.2.1 Electrical Circuit. Electrical circuits and associated cabling shall be designed with gap and creepage distance between voltage potentials and car body ground considering the environmental conditions to which the circuits and cabling will be subjected.

5-3.2.2 Air Gap. The air gap distances between voltage potentials (up to 2000 V) and ground shall comply with the following formula:

$$\text{Gap (in.)} = 0.125 + (0.0005 \times \text{nominal voltage})$$

In selecting air gap distances, special consideration shall be given to the presence of contaminants encroaching upon the air gaps.

5-3.2.3 Creepage Distance. Creepage distance for voltage potentials (up to 2000 V) to ground in ordinary enclosed environments shall comply with the following formula:

$$\text{Creepage (in.)} = 0.125 + (0.001875 \times \text{nominal voltage})$$

In other than ordinary enclosed environments, creepage distances shall be modified according to the anticipated severity of the environment. Appropriate creepage distances can be selected from Appendix E.

5-3.3 Propulsion Motors. Rotary motors shall be rated and tested per IEEE Standard 11, *Standard for Rotating Electric Machinery for Rail and Road Vehicles.*

Motor leads shall have an insulation suitable for the operating environment and shall be supported and protected to offer the least possible chance of mechanical damage. Motor leads, where entering the frame, shall be securely clamped and shall fit snugly to prevent moisture from entering the motor case. Drip loops shall be formed in motor leads to minimize water running along the lead onto the motor case. The current value used in determining the minimum size of motor leads shall be not less than 50 percent of the maximum load current seen under the most severe normal duty or as determined by root-mean-square (RMS) calculation, whichever is greater.

Other car-borne propulsion configurations shall be designed and constructed to provide a similar level of rating and testing as that for rotary motors.

5-3.4 Motor Control. Motor control shall be rated and tested per IEEE Standard 16, *American Standard for Electric Control Apparatus for Land Transportation Vehicles.*

Control equipment enclosures shall be arranged and installed to provide protection against moisture and mechanical damage.

Metal enclosures that surround arcing devices shall be lined with insulating material approved by the authority having jurisdiction. Adequate shields or separations shall be provided to prevent arcing to adjacent equipment and wiring.

Exception: Where the arc chutes extend through the enclosure and vent the arc to the outside air, lining shall not be required.

5-3.5 Propulsion and Braking System Resistors. Self-ventilated propulsion and braking resistors shall be mounted with air space between resistor elements and combustible materials. Heat-resisting barriers of at least $^1/_4$-in. (6.35-mm) noncombustible insulating material, or sheet metal not less than 0.04-in. (1.02-mm) thickness, shall be used extending horizontally beyond resistor supports to ensure protection from overheated resistors. Forced ventilated resistors shall be mounted in ducts, enclosures, or compartments of noncombustible material and shall be mounted with air space between the resistor enclosure and combustible materials. Provisions shall be made to filter the air where the operating environment is severe.

Power resistor circuits shall incorporate protective devices for the following failures:

(1) Ventilation airflow, if appropriate
(2) Temperature controls, if appropriate
(3) Short circuit in supply wiring, if appropriate

Resistor elements shall be electrically insulated from resistor frames, and frames shall be electrically insulated from supports. The insulation shall be removed from resistor leads a minimum of 3 in. (75 mm) back from their terminals except where such removal introduces potential grounding conditions. Where forced ventilation is provided, the resistor leads shall be separated, secured, and cleated for protection in the event of loss of air circulation of the ventilating system. Leads shall be so routed or otherwise protected from resistor heat.

The current value used in determining the minimum size of resistor leads shall not be less than 110 percent of the load current seen by the lead under the most severe duty cycle or as determined by RMS calculation.

5-3.6 Current Collectors. The minimum size of current collector leads shall be determined by adding the maximum auxiliary loads to the propulsion motor loads. The equivalent regenerative load shall be included in the propulsion system equipped with regenerative capability. For vehicles that have more than one current collector, all current-carrying components shall be sized for continuous operation in the event power collection to the vehicle is restricted to a single collector.

5-3.7 Wiring.

5-3.7.1 Minimum Wire Size. In no case shall wire smaller than the sizes listed as follows be used:

(1) No. 14 AWG: for wire that is pulled through conduits or wireways or installed exposed between enclosures
(2) No. 22 AWG: for wire used on electronic units, cards, and card racks
(3) No. 18 AWG: for all other wire including wire laid in (rather than pulled through) wireways

5-3.7.2 Cable and Wire Sizes. Conductor sizes shall be selected on the basis of current-carrying capacity, mechanical strength, temperature and flexibility requirements, and maximum allowable voltage drops. Conductors shall be no smaller than minimum sizes specified in 5-3.7.1.

Conductors shall be derated for grouping and shall be derated for ambient temperature greater than the manufacturer's design value in accordance with criteria specified by the authority having jurisdiction.

5-3.7.3 Wiring Methods. Conductors of all sizes shall be provided with mechanical and environmental protection and shall be installed, with the exception of low-voltage dc circuits, in any one of or combination of the following ways:

(1) In raceways: metallic and nonmetallic, rigid or flexible
(2) In enclosures, boxes, or cabinets for apparatus housing
(3) Exposed: cleated, tied, or secured by other means

Firestops shall be provided in raceways to control the spread of fire. Wires connected to different sources of energy shall not be cabled together or be run in the same conduit, raceway, tubing, junction box, or cable unless all such wires are insulated for the highest rated voltage in such locations. Wires connected to electronic control apparatus shall not touch wires connected to a higher voltage source of energy than control voltage.

Conduits, electrical metallic tubing, nonmetallic ducts or tubing, and all wires with their outer casings shall be extended into devices and cases where practicable. They shall be rigidly secured in place by means of cleats, straps, or bushings to prevent vibration or movement and to give environmental protection. They shall be run continuously into junction boxes or enclosing cases and be securely fastened to these devices. Splices outside of junction boxes shall not be permitted except as specifically approved by the authority. Connections and terminations shall be made in a manner to ensure their tightness and integrity.

Conductors and enclosures of any kind shall be protected from the environment and from mechanical damage including damage from other larger conductors.

5-3.8 Overload Protection.

5-3.8.1 Propulsion Line Breaker. A main, automatic circuit line breaker or line switch and overload relay for the protection of the power circuits shall be provided. The circuit breaker arc chute shall be vented directly to the outside air.

5-3.8.2 Main Fuse Protection. If cartridge-type fuses are used in addition to the automatic circuit breaker, they shall be installed in approved boxes or cabinets. If railway-type ribbon fuses are used, they shall be in boxes designed specifically for this purpose and shall be equipped with arc blow-out aids. Third rail shoe fuses mounted on the shoe beams shall be so mounted as to direct the arc away from grounded parts.

5-3.8.3 Auxiliary Circuits. Circuits used for purposes other than propelling the vehicle shall be connected to the main cable at a point between the current collector and the protective device for the traction motors. Each circuit or group of circuits shall be provided with at least one circuit breaker or a fused switch or fuse located as near as practicable to the point of connection of the auxiliary circuit, except that such protection shall be permitted to be omitted in circuits controlling safety devices.

5-3.9 Battery Installation. The design of battery installation and circuitry shall include the following:

(1) Minimal use of organic material, particularly those having hygroscopic properties
(2) Fire-retardant treatment for necessary organic materials used
(3) Battery chargers designed for protection against overcharging
(4) Use of smoke and heat detectors, if appropriate
(5) Use of an emergency battery cut-off switch, if appropriate
(6) Isolation of battery compartment from car interior using noncombustible materials as defined in 1-5.30, if appropriate

5-4 Ventilation. Vehicles shall have provisions to deactivate all ventilation systems remotely or automatically.

5-5 Emergency Egress Facilities.

5-5.1 Each vehicle shall be provided with emergency exit facilities on the sides or at the end(s). Alternate emergency exit facilities, as necessary for the type of vehicle, shall be approved by the authority having jurisdiction.

5-5.2 A means to allow passengers to evacuate the vehicle safely to a walk surface or other suitable area under the supervision of authorized employees in case of an emergency shall be provided.

5-5.3 Emergency Lighting. Emergency lighting facilities shall be provided. The level of illumination of means of egress and power sources shall conform with NFPA *101, Life Safety Code*.

Exception: Emergency lighting facilities shall be arranged to maintain the specified degree of illumination as determined by the authority having jurisdiction in the event of failure of the normal lighting. The power for the emergency lighting system shall be automatically obtained from the storage batteries for a period of time to permit evacuation but in no case for less than 1 hour.

5-6 Protection.

5-6.1 General. During normal vehicle operation, protective devices shall not introduce new hazards.

5-6.2 Communications.

5-6.2.1 Each manually operated vehicle shall be equipped with a communication system consisting of the following:

(1) A PA system whereby the train, crew personnel, and, at the option of the authority, the central supervising station can make announcements to the passengers

(2) A radio system whereby the train operator can communicate with the central supervising station
(3) An intercommunication system whereby the train crew can communicate with one another

At the option of the authority, each vehicle shall be equipped with a device that can be used by passengers to alert the operator of an emergency.

5-6.2.2 Each automated guideway transit (AGT) system vehicle shall be equipped with a communication system consisting of the following:

(1) A PA system whereby the central supervising station can make announcements to the passengers
(2) A system whereby the passengers can communicate with the central supervising station

5-6.2.3 Unauthorized opening of doors or emergency exit facilities on vehicles shall be communicated to the central supervising station or train operator.

5-6.3 Portable Fire Extinguishers. Each vehicle or operator's cab shall be equipped with an approved portable fire extinguisher. Portable fire extinguishers shall be selected, inspected, and maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers.*

Exception: Portable extinguishers shall not be required in the vehicle or cab where sufficient wayside extinguishers, standpipe systems, or other fire-fighting equipment are available.

5-6.4 Lightning Protection.

5-6.4.1 Each vehicle that is supplied power from the overhead electrical contact wire shall be provided with a suitable and effective lightning arrester for the protection of all electrical circuits.

5-6.4.2 Lightning arresters on vehicles shall have an adequate grounding connection of not less than No. 6 AWG and be run in as straight a line as possible to the ground and shall be properly protected against mechanical injury. The grounding conductor shall not be run in metal conduit unless such conduit is bonded to the grounding conductor at both ends.

5-6.5 Heater Protection. All heater elements shall incorporate protective devices for the following failures:

(1) Ventilation airflow, if appropriate
(2) Temperature controls, if appropriate
(3) Short circuits and overloads in supply wiring

Heater-forced air distribution ducts and plenums shall incorporate overtemperature sensors, fusible links, airflow devices, or other means to detect overtemperature or lack of airflow.

5-6.6 Testing and Maintenance.

5-6.6.1 Testing. Qualification testing shall be performed by the equipment manufacturer in accordance with IEEE Standard 16, *American Standard for Electric Control Apparatus for Land Transportation Vehicles;* IEEE Standard 11, *Standard for Rotating Electric Machinery for Rail and Road Vehicles;* and any additional tests specified by the authority having jurisdiction.

5-6.6.2 Maintenance. Periodic maintenance shall be performed in accordance with maintenance manuals furnished by the equipment manufacturer. The degree and frequency of maintenance shall be based on operating experience as determined by the authority.

5-7 Vehicle Support and Guidance System. The vehicle support and guidance system (i.e., wheels, tires, magnetic or pneumatic levitation) shall be capable of safely supporting and guiding the vehicle in normal service. Failure of support, guidance, or levitation system shall not result in a condition that is unsafe to passengers. Under loss of guideway clearance, the system shall be capable of safe operation until such time that the failure is detected by operation or maintenance personnel and the vehicle is taken out of service.

Chapter 6 Vehicle Storage and Maintenance Areas

6-1 General. The following requirements are directed toward maintaining adequate fire protection in all vehicle storage and maintenance areas. Implementation of these requirements shall be according to the authority having jurisdiction and applicable local codes.

6-2 Open Areas.

6-2.1 Water Supply. An adequate, reliable water supply shall be available for fire protection, including a sufficient number of properly located hydrants, in accordance with NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances.*

6-2.2 Emergency Access. Where the authority having jurisdiction deems it necessary, fire lane areas shall be laid out to permit access by mechanized fire-fighting equipment. Such access shall include the establishment of clearly marked fire lanes and the provision of a number of entrance gates into the property as determined by the authority having jurisdiction. Fire lanes, where provided, shall be at least 15 ft (4.6 m) wide.

6-2.3 Fire Extinguishers. Fire extinguishers of adequate size and rating shall be provided, suitably housed and spaced in accordance with NFPA 10, *Standard for Portable Fire Extinguishers,* and as required by the authority having jurisdiction.

6-2.4 Communications. Provisions shall be made within the property to summon the local fire department and to summon employees to assist in immediate fire fighting and in removal of vehicles in accordance with provisions contained in NFPA 72, *National Fire Alarm Code.*

6-3 Structures.

6-3.1 Structural Requirements. Structures shall be of noncombustible construction in accordance with NFPA 220, *Standard on Types of Building Construction.*

6-3.2 Drainage Systems. All drainage systems shall be designed to reduce fire and explosion hazards by the use of noncombustible piping. Where piping is not enclosed, as direct a routing as possible to a safe outside location shall be provided.

6-3.2.1 Oil separators, grease traps, and sand traps shall be installed on all floor drainage systems that service maintenance and vehicle storage areas to provide for the extraction of oil, grease, sand, and other substances that are harmful or hazardous to the structure or public drainage systems. Separators and grease traps shall be of approved design and of sufficient capacity to meet the level of waste discharged from the areas. The separator storage capacity shall be of sufficient size to retain all the sludge between cleanings.

6-3.2.2 Periodic maintenance checks and flushing shall be conducted on all drains, oil separators, and grease traps to ensure that they are clear of obstructions and that they perform their designed function. Any flammable liquids and greases shall be removed to an area approved for disposal.

6-3.3 Floors. The surface of the grade floor of storage or maintenance areas shall be of noncombustible material.

6-3.4 Roofs. Roof deck coverings shall be tested in accordance with NFPA 256, *Standard Methods of Fire Tests of Roof Coverings,* shall be Class A or Class B and shall be listed.

6-3.5 Electrical Requirements.

6-3.5.1 Application. The installation of electric wiring for structure light and power and the installation of all electrical devices not supplying traction power shall be in accordance with NFPA 70, *National Electrical Code;* ANSI C2, *National Electrical Safety Code;* and applicable local codes as called for by the authority having jurisdiction.

6-3.5.2 Traction Power.

6-3.5.2.1 Overhead Conductors. Nonconducting material shall be used as a runway on which to mount overhead feed trolley wires. Overhead trolley power installations shall have a minimum height of 10 ft (3.05 m) for isolation of the power lines from shop and storage activity unless an enclosed feed rail system is used with portable cord connectors that have insulated plugs and similar safety features. Electrical supply for other than traction power shall be in accordance with NFPA 70, *National Electrical Code,* and ANSI C2, *National Electrical Safety Code.*

6-3.5.2.2 Power Rail Conductors. Power rails (i.e., dc or ac power supplied to the vehicle for propulsion and other loads) shall be secured to suitable insulating supports, properly bonded at joints, and properly guarded to prevent contact with personnel. Electrical supply for other than propulsion and other vehicle power loads shall be in accordance with NFPA 70, *National Electrical Code,* and ANSI C2, *National Electrical Safety Code.*

6-3.5.2.3 Emergency Power Shutoff. All traction power conductors shall have emergency power shutoff devices or means in accessible locations.

6-3.6 Maintenance Pit Areas.

6-3.6.1 The authority having jurisdiction shall determine whether pit areas and associated access areas below floor level must be designed on the basis that flammable liquids and vapor will be present at times. In any case, materials shall be noncombustible and equipment shall be made of noncombustible construction. *(See also 6-3.8.1.)*

6-3.6.2 Walls, floors, and piers shall be constructed of masonry or concrete.

6-3.6.3 Pits shall have at least two exits. Steps shall be noncombustible and constructed with no free space underneath.

6-3.6.4 Pits and subfloor work areas shall be kept clean. Smoking shall be prohibited in pits and subfloor maintenance areas.

6-3.7 Overhead Cranes. All overhead cranes installed in the maintenance area shall adhere to the standard for cranes and monorails as required by NFPA 70, *National Electrical Code.*

6-3.8 Ventilation.

6-3.8.1 Underfloor Ventilation. In all pit areas where undercar maintenance can generate fumes of a combustible nature (e.g., blowdowns of transit vehicles), a positive mechanical exhaust ventilation system shall be provided capable of air changes at the rate of 10 per hour or 1 cfm/ft^2 [(1 m^3/min)/ 3.28 m^2] of pitfloor area, whichever is greater, during normal operation and shall be designed to discharge to the outside atmosphere.

6-3.8.2 Abovefloor Ventilation. Where a mechanical ventilating system is employed in shop maintenance areas, the ventilating system shall be installed in accordance with NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems.* Where blower and exhaust systems are installed for vapor removal, the systems shall be installed in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids.*

6-3.9* Draft Stops. Permanent draft stops in sprinklered buildings shall be installed in structures having a height of over 25 ft (7.6 m) to the top of roof trusses. Draft stops shall be constructed of rigidly supported noncombustible material. The authority having jurisdiction shall be consulted regarding the exact location of these draft stops.

6-4 Fire Protection Suppression Systems.

6-4.1 Automatic Suppression Systems. An approved automatic sprinkler system shall be installed in all areas of enclosed structures used for storage and maintenance of vehicles. The sprinkler system shall be of a closed-head type for ordinary hazard classification and shall be installed in accordance with NFPA 13, *Standard for the Installation of Sprinkler Systems.* A sprinkler system water flow alarm and supervisory signal service shall be installed in accordance with NFPA 72, *National Fire Alarm Code.*

6-4.2 Protective Signaling Systems. Nonsprinklered covered vehicle storage areas shall be equipped with an automatic fire detection system. A signal of a fire shall be relayed to the supervising station or directly to the fire department. The system shall comply with NFPA 72, *National Fire Alarm Code.*

6-4.3 Standpipe and Hose Systems. Where standpipes and connections are required, the complete installation, including water supply, shall comply with NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems.*

6-4.4 Portable Fire Extinguishers.

6-4.4.1 General. Fire-extinguishing equipment and devices shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers,* subject to the provisions of 6-4.4.2 through 6-4.4.4.

6-4.4.2 Offices and Storerooms. Offices and storerooms, other than those containing flammable liquids and greases, shall be provided with a sufficient number of listed extinguishers designed for Class A fires. The number and capacity of such units shall be determined by the authority having jurisdiction.

6-4.4.3 Hazardous Areas. Areas in which flammable or combustible liquids, greases, or chemicals are used or stored shall be provided with approved extinguishers designed for Class A, Class B, and Class C fires. The number and capacity of such units shall be determined by the authority having jurisdiction.

6-4.4.4 Additional Locations. Where cranes or monorails are installed inside structures for hoisting or transporting heavy rail equipment, fire extinguishers suitable for Class B and Class C fires shall be located as defined by the authority having jurisdiction.

6-5 Operations and Maintenance.

6-5.1 Vehicle Placement. Vehicles shall be placed and tracks shall be arranged to allow a minimum clearance of 36 in. (914 mm) between the sides of adjacent vehicles. The ability to evacuate personnel from the structure in an emergency shall be a prime consideration and shall be in accordance with NFPA *101, Life Safety Code*.

6-5.2 Vehicle Maintenance.

6-5.2.1 Vehicle Electrical Systems. Vehicle electrical systems, including battery circuits, shall be de-energized except in those cases in which an energized circuit is necessary to accomplish the required maintenance.

6-5.2.2 Batteries. Vehicle batteries shall be disconnected or removed during maintenance operations that require the de-energizing of all electrical circuits.

Exception: Where the vehicle is equipped with a battery cutout switch that fully isolates the battery and is physically located immediately adjacent to the battery.

When moving batteries, including removal and replacement, precautions shall be taken to prevent short circuits that can result in fires or explosions.

6-5.2.2.1 Areas wherein batteries are charged shall be well ventilated to the outside to ensure that the maximum hydrogen/air mixture that might be generated during charging is held below the lower explosive limits. In addition, where mechanical ventilation systems are required, they shall be installed in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids*. The battery exhaust ventilation system shall be provided with electrical power and airflow interlocks that will prevent operation of the battery charger if the ventilation fan motor is not energized or the air velocity in the exhaust duct is less than the designed velocity. The entire electrical system shall be in accordance with NFPA 70, *National Electrical Code*.

6-5.2.2.2 Batteries shall be charged at a rate (i.e., amperage and length of charge) that will not produce a dangerous concentration of hydrogen or excessive heat. In addition, the following safety practices shall be followed.

(a) Access to battery rooms shall be limited to qualified personnel only.

(b) Smoking shall be prohibited and open flames, sparks, arcs, and other sources of ignition shall be kept away from the immediate vicinity of batteries that are being charged. Appropriate warning signs shall be displayed prominently.

(c) Precautions shall be observed while working near battery terminals. Wrenches and other hand tools shall be used carefully to avoid short circuits.

(d) Brushes used to clean batteries shall have neither a metal frame nor wire bristles.

6-5.3 Painting/Cleaning/Paint Removal.

6-5.3.1 In selecting materials for cleaning and paint removal purposes, nonflammable materials shall be specified wherever possible. The use of flammable or combustible cleaning agents shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

6-5.3.2 A location in which painting or cleaning is to be done shall be chosen that will provide good general ventilation, ease of clean-up, and convenience.

6-5.3.3 Where major cleaning, painting, and paint removal operations are being conducted, no concurrent potentially hazardous operations shall be conducted within 50 ft (15.2 m) of the area being worked on. For touch-up operations, any ignition sources within the areas being worked on shall be eliminated; such areas shall be maintained hazard-free during the work period.

6-5.3.4 The use of heat lamps to accelerate the drying of painted surfaces shall be prohibited unless used as part of an approved drying booth or enclosure in accordance with NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials*.

6-5.3.5 Where cleaning or paint removal agents are applied through spray nozzles under pressure, the nozzle shall be of the self-closing type so that when the hand of the operator is removed the nozzle will close automatically.

6-5.4 Storage of Painting/Cleaning Liquids. Storage of painting/cleaning liquids shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

6-5.5 Welding.

6-5.5.1 All welding operations performed on component vehicle parts on the vehicle shall be in accordance with NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work*.

6-5.5.2 Welding shall not be done in an area that contains fuel or other flammable or combustible liquids or vapors. No other work shall be permitted within a 35-ft (10.7-m) radius of the location of any gas-shielded arc welding operation unless the welding area is vented and enclosed in an approved manner to prohibit flammable and combustible vapors from entering the work area.

6-5.5.3 Welding equipment shall have no electrical components other than flexible lead cables within 18 in. (457 mm) of the floor.

6-5.5.4 Only qualified welders, trained in the techniques and familiar with the hazards involved, shall be permitted to do this work.

6-5.6 Industrial Trucks. Industrial trucks shall mean fork trucks, tractors, platform lift trucks, and other specialized industrial trucks; and their operation and usage shall be in accordance with NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation;* ANSI B56.1, *Safety Standard for Low Lift and High Lift Trucks;* and as determined by the authority having jurisdiction.

6-5.6.1 Fuel Handling. The storage and handling of liquefied petroleum gas (LP-gas) shall be in accordance with NFPA 58, *Liquefied Petroleum Gas Code*.

6-5.6.2 The storage and handling of liquid fuels (e.g., gasoline and diesel) shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code,* and with local codes.

Chapter 7 Emergency Procedures

7-1 General. The authority that is responsible for the safe and efficient operation of a fixed guideway transit or passenger rail system shall anticipate and plan for emergencies that could involve the system. Participating agencies shall be invited to assist with the preparations of the emergency procedure plan.

7-2 Emergency Management. Operational procedures for the management of emergency situations shall be predefined for situations both within the fixed guideway transit or passenger rail system. These procedures shall be recorded, be readily accessible, and be managed from a dedicated source at the central supervising station. Special note shall be taken to keep patrons advised and informed appropriately to discourage panic or stress during adverse circumstances. It is also necessary that personnel whose duties take them onto the operational system be trained for emergency response pending the arrival of jurisdictional personnel and that the training be kept current through periodic drills and review courses.

7-3 Emergencies. The following types of emergencies shall be considered as requiring development and implementation of emergency procedure plans specific to the resolution of the type of emergency.

(a) Fire or smoke conditions within the system structures including stations, guideways (revenue or nonrevenue), and support facilities

(b) Collision or derailment involving the following:

(1) Rail vehicles on the guideway
(2) Rail vehicles with privately owned vehicles
(3) Intrusion into the right-of-way from adjacent roads or properties

(c) Loss of primary power source resulting in stalled trains, loss of illumination, and availability of emergency power

(d) Evacuation of passengers from a train to all right-of-way configurations under circumstances where assistance is required

(e) Passenger panic

(f) Disabled, stalled, or stopped trains due to adverse personnel/patron emergency conditions

(g) Tunnel flooding from internal or external sources

(h) Disruption of service due to disasters or dangerous conditions adjacent to the system, such as hazardous spills on adjacent roads or police activities or pursuits dangerously close to the operational system

(i) Structural collapse or imminent collapse of the authority property or adjacent property, which threatens safe operations of the system

(j) Hazardous materials accidentally or intentionally being released into the system

(k) Serious vandalism or criminal acts, including terrorism

(l) First aid or medical care for patrons on trains and in stations

(m) Extreme weather conditions, such as heavy snows, high or low temperatures, sleet, ice, and so forth

(n) Earthquake

7-4 Emergency Procedures. An emergency procedure shall be developed to address specifically the various types of emergencies that might be experienced on the system and shall include, but not be limited to, the following.

(a) Identification of the type of emergency, name of authority, and the date the plan was adopted (reviewed/revised, as applicable)

(b) Policy, purpose, scope, and definitions

(c) Participating agencies and area of responsibility including governing officials and signatures of executives signing for each agency

(d) Safety procedures to be implemented specific to each type of emergency operation

(e) Purpose and operations of the central supervising station and alternate central supervising station, as applicable

(f) Command post and auxiliary command post, their purpose and operational procedures, as applicable

(g) Communications, types of communications available, procedures to maintain safe operation, and equipment to interface with responding agencies

(h) Fire and smoke emergencies shall include information and procedures defining the following:

(1) Location of fire in station or support facility
(2) Location of train in tunnel and fire location on train
(3) Fire detection systems/zones in stations
(4) Fire protection systems and devices and their location/point of initiating operation
(5) Exit/entrance locations to the incident site, including vehicular routes
(6) Emergency ventilation system components, locations of equipment and local controls
(7) Special equipment locations/cabinets
(8) Agency(ies) to be notified and their phone numbers
(9) Agency in command prior to and after the arrival of the local jurisdiction emergency response personnel
(10) The ventilation system preplanned mode of fan operation (exhaust or supply)
(11) Preplanned patron evacuation direction as coordinated with fan mode operation
(12) Fire and emergency incidents on adjoining properties

(i) Procedures typically implemented by responding jurisdictions for various types of emergencies as appropriate to site configuration

(j) Maps or plans of complex areas of the system at a minimum, such as underwater tubes, multilevel stations, adjacencies to places of large public assembly, or other unique areas

(k) Any other additional information or data that participating agencies determine to be necessary to provide effective response

7-5 Participating Agencies. Participating agencies that shall be summoned by operators of a fixed guideway transit or passenger rail system to cooperate and assist depending on the nature of an emergency include the following:

(1) Ambulance service
(2) Building department
(3) Fire department
(4) Medical service
(5) Police department
(6) Public works (i.e., bridges, streets, sewers)
(7) Sanitation department
(8) Utility companies (i.e., gas, electricity, telephone, steam)
(9) Water department (i.e., water supply)
(10) Local transportation companies
(11) Red Cross, Salvation Army, and similar agencies

The agencies and names might vary depending on the governmental structure and laws of the community.

7-6 Central Supervising Station (CSS).

7-6.1 The authority shall operate a CSS for the operation and supervision of the system.

7-6.2 The CSS shall be staffed by trained and qualified personnel and shall have the essential apparatus and equipment to communicate with, supervise, and coordinate all personnel and trains operating in the system.

7-6.3 The CSS shall provide the capability to communicate rapidly with participating agencies. Agencies such as fire, police, ambulance, and medical service shall have direct telephone lines or designated telephone numbers used for emergencies involving the system.

7-6.4 Equipment shall be available and used for recording radio and telephone communications during an emergency.

7-6.5 CSS personnel shall be thoroughly conversant with the emergency procedure plan and shall be trained to employ it effectively whenever required.

7-6.6 An alternate site(s) to function efficiently during an emergency in the event the CSS is out of service for any reason shall be selected and equipped or shall have equipment readily available.

7-6.7 The CSS shall be located in an area separated from other occupancies by 2-hour fire resistance construction. The area shall be used for the CSS and similar activities and shall not be jeopardized by adjoining or adjacent occupancies.

7-6.8* The CSS shall be protected by fire detection, protection, and extinguishing equipment so that there shall be early detection and extinguishment of any fire in the CSS.

7-7 Liaison.

7-7.1 An up-to-date listing of all liaison personnel from participating agencies shall be maintained by the authority and shall be part of the emergency procedure plan.

The listing shall include the full name, title, agency, business telephone number(s), and home telephone number of the liaison. An alternate liaison with the same information also shall be listed.

7-7.2 At least once every 3 months the list shall be reviewed and tested to determine the ability to contact the liaison without delay.

7-8 Command Post.

7-8.1 During an emergency on the system that requires invoking the emergency procedure plan, a command post shall be established by the incident commander for the supervision and coordination of all personnel, equipment, and resources at the scene of the emergency.

7-8.2 The emergency procedure plan shall clearly delineate the authority or participating agency that is in command and that is responsible for supervision, correction, or alleviation of the emergency.

7-8.3 The command post shall be located at a site that is convenient for responding personnel, easily identifiable, and suitable for supervising, coordinating, and communicating with participating agencies.

7-8.4 Participating agencies shall each assign a liaison to the command post.

7-8.5 The most effective use shall be made of radio, telephone, and messenger service to communicate with participating agencies operating at an emergency.

7-8.6 To identify the command post easily during day or night and under bad weather conditions, designated markers shall be employed. The emergency procedure plan shall prescribe the specific identification markers to be used for the command post and for personnel assigned thereto.

7-9 Auxiliary Command Post.

7-9.1 When an emergency operation requires an auxiliary command post because of the extent of the operation, the person in command shall establish an auxiliary command post(s) that will function as a subordinate control.

7-9.2 Any emergency response agency can establish an auxiliary command post to assist with the supervision and coordination of their personnel and equipment. This is in addition to providing a liaison at the command post.

7-10 Training, Exercises, Drills, and Critiques.

7-10.1 The authority and participating agency personnel shall be trained to function efficiently during an emergency. They shall be conversant with all aspects of the emergency procedure plan.

7-10.2 Exercises and drills shall be conducted at least twice per year to prepare the authority and participating agency personnel for emergencies. Critiques shall be held after the exercises, drills, and actual emergencies.

7-10.3 Drills shall be conducted at various locations on the system as well as at various times of the day so as to familiarize as many emergency response personnel as possible.

7-11 Records. Written records and telephone and radio recordings shall be kept at the CSS and written records shall be kept at the command post and auxiliary command post(s) during fire emergencies, exercises, and drills.

7-12 Removal and Restoring Traction Power.

7-12.1 During an emergency, the authority and participating agency personnel shall be supervised carefully so that only the minimum number of essential persons operate on the trainway.

7-12.2 The emergency procedure plan shall have a clearly defined procedure for removing and restoring traction power.

7-12.3 Prior to participating agency personnel operating on the trainway, the traction power shall be removed.

7-12.4 When traction power is removed by activation of an emergency traction power disconnect switch, the CSS shall be contacted by telephone or radio and given the full name, title, agency, and reason for removal of the traction power by the person responsible.

7-12.5 When shutdown of traction power is no longer required by a participating agency, control of such power shall be released to the authority.

Chapter 8 Communications

8-1 General. Comprehensive and dependable communications are essential for an effective and efficiently operated fixed guideway transit system during emergencies.

8-2 Central Supervising Station (CSS) and Command Post Relationship.

8-2.1 During normal operations, the CSS shall be the primary control for the system.

8-2.2 During emergency operations, the command post established at the scene of the emergency shall be responsible for controlling, supervising, and coordinating personnel and equipment working to correct or alleviate the emergency. The command post and CSS shall cooperate and coordinate to have an efficient operation. The CSS shall be responsible for operation of the system except for the immediate emergency area.

8-3 Radio Communication.

8-3.1 A fixed guideway transit or passenger rail system shall have at least one radio network that is capable of two-way communication with personnel on trains, motor vehicles, and all locations of the system.

8-3.2 Wherever necessary for dependable and reliable communications, a separate radio network capable of two-way radio communication for fire department personnel to the fire department communication center shall be provided.

8-3.3 A radio network shall comprise base transmitters and receivers, antennas, mobile transmitters and receivers, portable transmitters and receivers, and ancillary equipment.

8-4 Telephone.

8-4.1 The system shall have a telephone network of fixed telephone lines and handsets capable of communication with all stations, structures, offices, power stations and substations, control towers, ancillary rooms and spaces, and locations along the trainway.

8-4.2 The location and spacing of telephones along the trainway shall be determined by the authority having jurisdiction. Telephones along the trainway shall have distinctive signs and/or lights for identification. *(See 3-1.5.)*

8-5 Portable Telephones and Lines. For emergency operations where the trainway is a considerable distance from the street level, or unusual terrain features are present, or normal radio or telephone communication is inadequate or not functioning satisfactorily, portable telephones shall be employed. The authority shall provide portable telephones and arrange for their expeditious dispatch to an emergency scene when required.

8-6 Messenger Service. During emergency operations, messenger service shall be utilized to improve, replace, or augment overtaxed or inadequate communication facilities when such service is required.

8-7 Public Address (PA) System.

8-7.1 All stations, as determined by the authority having jurisdiction, shall have a PA system for communicating with passengers and employees. *(For communication requirements for vehicles, see 5-6.2.)*

8-7.2 The CSS shall have the capability of using the PA system to make announcements throughout stations.

8-7.3 Authority supervisory employees at stations shall have the capability of making announcements throughout their stations on the PA system.

8-7.4 During interruptions of train service or delays for any reason associated with an emergency, fire, or smoke, the passengers and employees shall be kept informed by means of the PA system.

8-7.5 At times of emergency, the PA system shall be used effectively to communicate to passengers, employees, and participating agency personnel.

8-8 Portable Powered Speakers (Audiohailers). During emergency operations, portable powered speakers shall be made available by the authority where other forms of communication are not available.

Chapter 9 Referenced Publications

9-1 The following documents or portions thereof are referenced within this standard as mandatory requirements and shall be considered part of the requirements of this standard. The edition indicated for each referenced mandatory document is the current edition as of the date of the NFPA issuance of this standard. Some of these mandatory documents might also be referenced in this standard for specific informational purposes and, therefore, are also listed in Appendix F.

9-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers,* 1998 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 1999 edition.

NFPA 14, *Standard for the Installation of Standpipe, Private Hydrant, and Hose Systems,* 2000 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances,* 1995 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 1996 edition.

NFPA 33, *Standard for Spray Application Using Flammable or Combustible Materials,* 1995 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 1999 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 1998 edition.

NFPA 70, *National Electrical Code®,* 1999 edition.

NFPA 72, *National Fire Alarm Code®,* 1999 edition.

NFPA 80, *Standard for Fire Doors and Fire Windows,* 1999 edition.

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems,* 1999 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 1999 edition.

NFPA *101®, Life Safety Code®,* 2000 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 1999 edition.

NFPA 220, *Standard on Types of Building Construction,* 1999 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations,* 1996 edition.

NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials,* 1999 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials,* 2000 edition.

NFPA 256, *Standard Methods of Fire Tests of Roof Coverings,* 1998 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Conversions, Maintenance, and Operation,* 1999 edition.

NFPA 1963, *Standard for Fire Hose Connections,* 1998 edition.

9-1.2 Other Publications.

9-1.2.1 AMCA Publications. Air Movement and Control Association, Inc., 30 West University Drive, Arlington Heights, IL, 60004-1893.

AMCA 300-96, *Reverberant Room Method for Sound Testing of Fans.*

ANSI/AMCA 210-85, *Laboratory Methods of Testing Fans for Rating.*

9-1.2.2 ANSI Publications. American National Standards Institute, Inc., 11 West 42nd Street, 13th Floor, New York, NY 10036.

ANSI B56.1, *Safety Standard for Low Lift and High Lift Trucks,* 1993.

ANSI C2, *National Electrical Safety Code,* 1993.

9-1.2.3 ASHRAE Publication. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle N.E., Atlanta, GA 30329-2305.

ASHRAE, *Handbook Fundamentals,* 1993, Additions and Corrections — 1996.

9-1.2.4 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM C 1166, *Standard Test Method for Flame Propagation of Dense and Cellular Elastometric Gaskets and Accessories,* 1991.

ASTM D 2724, *Standard Test Method for Bonded, Fused, and Laminated Apparel Fabrics,* 1987.

ASTM D 3675, *Standard Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source,* 1994.

ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials,* 1994.

ASTM E 119, Rev. B-92, *Standard Test Method for Fire Tests of Building Construction and Materials,* 1988.

ASTM E 136, Rev. A-92, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C,* 1994.

ASTM E 162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source,* 1994.

ASTM E 648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source,* 1994.

ASTM E 662, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials,* 1994.

9-1.2.5 FAR Publication. U.S. Federal Aviation Regulations, U.S. Government Printing Office, Washington, DC 20402.

FAR 25.853a.

9-1.2.6 ICEA Publication. Insulated Cable Engineers Association, P.O. Box 440, South Yarmouth, MA 02664.

ICEA S-19-1981/NEMA WC3, *Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.*

9-1.2.7 IEEE Publications. Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331.

IEEE Standard 11, *Standard for Rotating Electric Machinery for Rail and Road Vehicles,* 1980.

IEEE Standard 16, *American Standard for Electric Control Apparatus for Land Transportation Vehicles.*

IEEE Standard 383, *Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations,* 1974.

9-1.2.8 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

UL 44, *Standard for Safety Rubber-Insulated Wires and Cables,* 1991.

UL 83, *Standard for Safety Thermoplastic-Insulated Wires and Cables,* 1991.

9-1.2.9 U.S. Government Publication. U.S. Government Printing Office, Washington, DC 20402.

Federal Test Method Standard 191A, *Textile Test Method 5830,* July 1978.

Appendix A Explanatory Material

Appendix A is not a part of the requirements of this NFPA document but is included for informational purposes only. This appendix contains explanatory material, numbered to correspond with the applicable text paragraphs.

A-1-5.2 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A-1-5.4 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A-1-5.12 Critical Radiant Flux. Examples of acceptable test methods for determining critical radiant flux are NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source* and ASTM E 648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source.* See Table 5-2.4.

A-1-5.27 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A-2-1.1 This chapter is written for fixed guideway transit stations, but can be useful for passenger rail stations.

A-2-2.3.5 Because of the difference in the potential level of hazard between various stations (i.e., open stations as compared to enclosed stations), alternative methods to fire separation could be considered.

A-2-5.1.1 At multilevel stations, it can be reasonable to consider only entraining (or entraining plus detraining) loads for nonincident levels for determining required egress capacity at points where egress routes converge. Nonincident platform loads that do not adversely impact the egress route need not be considered.

A-2-5.2.5.2(1) The surge factor of 1.3 is typical based on surveys of transit system patronage data obtained from four transit systems from 1972 through 1981. Additional surge factors from 1.15 through 2.75 have been reported.

A-2-5.2.5.3(1) The surge factor of 1.3 is typical based on surveys of transit system patronage data obtained from four transit systems from 1972 through 1981. Additional surge factors from 1.15 through 2.75 have been reported.

A-2-5.2.5.4 The maximum for a calculated train load should be the most passengers capable of occupying the largest train.

A-2-5.3.3.2 Stairs should be positioned in close proximity to, but not necessarily adjacent to, escalators to allow emergency exiting no matter in which direction the escalator(s) is operating.

A-2-5.4.4 It is intended that escalators be as noncombustible as possible, realizing that certain components such as rollers or headrails might not currently be available in noncombustible materials. The authority having jurisdiction should review each installation proposal for compliance to the greatest extent possible.

A-2-7.1.2 Discrete zone indications are desirable for unmanned stations.

A-2-7.1.4 Separate zones on the annunciator panel to monitor main control valves on standpipe systems should be established.

A-2-7.4.3 It is desirable to locate fire department connections near one or more station access points.

A-3-1.1 This chapter is written for fixed guideway transit trainways, but can be useful for passenger rail stations.

A-3-1.5.3 The placement of blue light stations at the ends of station platforms should be governed on actual need. For instance, an at-grade system that has stations in dedicated streets and overhead power supply would not need blue light stations at ends of platforms.

A-3-2.3.6 The trainway, although used for ventilation, should not be considered as an air plenum for purposes of mounting electrical appurtenances.

A-3-2.5.1 The primary hazards presented by the electrified third rail in the trainway are electrical shock to employees and other personnel in the trainway and the heat and smoke generated by the cable or third rail due to combustion resulting from grounding or arcing.

A-3-3.3 See A-3-2.5.1.

A-3-4.3 See A-3-2.5.1.

A-4-7.7 The trainway, although used for ventilation, shall not be considered as an air plenum for purposes of mounting electrical appurtenances.

A-6-3.9 See NFPA 204, *Guide for Smoke and Heat Venting.*

A-7-6.8 Fan units serving train control and communications rooms should be protected by fire detection, protection, and extinguishing equipment so that there will be early detection and extinguishment of any fire involving these units.

Appendix B Ventilation

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

B-1 General. The purpose of this appendix is to provide guidelines for the potential compatibility of the emergency ventilation system with the system employed with normal ventilation of trainways and stations. This appendix does not present all factors to be considered in the normal ventilation criteria. For normal ventilation, refer to the *Subway Environmental Design Handbook* (SEDH) and the ASHRAE *Handbook Series* (Fundamentals, Applications, Systems and Equipment). Current technology is capable of analyzing and evaluating all unique conditions of each property to provide proper ventilation for normal operating conditions and for pre-identified emergency conditions. The same ventilating devices might or might not serve both normal operating conditions and pre-identified emergency requirements. The goals of the subway ventilation system, in addition to addressing fire and smoke emergencies, are to assist in the containment and purging of hazardous gases and aerosols such as those that could result from a chemical/biological release.

B-1.1 Tenable Environments. Some factors that should be considered in maintaining a tenable environment for periods of short duration can be defined as follows.

(a) Air temperatures as follows: maximum of 140°F (60°C) for a few seconds, averaging 120°F (49°C) or less for the first 6 minutes of the exposure and decreasing thereafter.

(b) Air carbon monoxide (CO) content as follows: maximum of 2000 ppm for a few seconds, averaging 1500 ppm or less for the first 6 minutes of the exposure, averaging 800 ppm or less for the first 15 minutes of the exposure, averaging 50 ppm or less for the remainder of the exposure. These values should be adjusted for altitudes above 3000 ft (984 m).

(c) CO generated during smoke conditions that does not exceed 800 ppm based on a 30-minute evacuation period. CO concentrations should decrease as the evacuation period increases.

(d) Smoke obscuration levels that are continuously maintained below the point at which a sign illuminated at 7.5 ft-candles (80 lx) is discernible at 100 ft (30 m) Doors and walls that are discernible at 33 ft (10 m).

(e) Radiation heat flux as follows: maximum of 2000 Btu/ft^2/hr (6305 W/m^2) for a few seconds, averaging 500 Btu/ft^2/hr (1576 W/m^2)or less for the first 6 minutes of the exposure, averaging 300 Btu/ft^2/hr (946 W/m^2) for the remainder of the exposure.

(f) Air velocities in the enclosed trainway should be greater than or equal to 150 fpm (0.82 m/s) and less than or equal to 2200 fpm (12 m/s).

(g) Noise levels as follows: maximum of 115 dBa for a few seconds, maximum of 92 dBa for the remainder of the exposure.

B-2 Configurations. Configurations can vary among properties, but engineering principles remain constant, and the application of those principles should reflect the unique geometries and characteristics of each property.

Enclosed stations and trainways might be configured with the following:

(1) High or low ceilings
(2) Open or doored entrances
(3) Open or screened platform edges
(4) End-of-station or midtunnel fan shafts
(5) End-of-station or midtunnel vent shafts
(6) Single, double, or varying combinations of tracks in tunnels
(7) Intersecting tunnels
(8) Multilevel stations
(9) Multilevel tunnels
(10) Varying depths below the surface
(11) Varying grades and curvatures of tracks and tunnels
(12) Varying blockage ratios of vehicles to tunnel cross section
(13) Varying surface ambient conditions
(14) Varying exit points to surface or points of safety

B-3 Draft Control.

B-3.1 For patron comfort in stations, the air velocities induced by train motion should be evaluated carefully by designers. Infrequent exposure to higher velocities can be tolerated briefly but are to be avoided wherever possible. *[Refer to the Subway Environmental Design Handbook (SEDH); the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Handbook Fundamentals; and the Beaufort Scale.]*

B-3.2 Draft control can be achieved by the placement of shafts along the tunnel length between stations. Shafts can be arranged with the fan shafts at the ends of stations with vent shafts midtunnel if required or with vent shafts at the ends of stations and fan shafts midtunnel. End-of-station shaft configurations should be related to the station geometries when considering patron comfort in the station relative to train piston draft effects.

B-4 Temperature Control.

B-4.1 Temperature control for patron comfort in the station can be achieved by circulating ambient air in moderate climates or by providing heating and/or cooling in more extreme regions. Preferred temperature goals should be defined in the criteria developed for the design of an individual property relative to the local climate and the length of station occupancy, such as train headways specific to the property during which the patron would be exposed to the station temperatures.

B-4.2 Temperature control and ventilation for ancillary areas housing special equipment should reflect the optimum operating conditions for the specific equipment to ensure the availability of critical equipment and should also give consideration for intermittent occupancy by maintenance personnel. These systems should be separate from the emergency ventilation system for stations and tunnels and should be considered when designing the emergency ventilation system.

B-5 Under-Platform Ventilation System.

B-5.1 An under-platform ventilation system should be considered for the extraction of heat from traction and braking devices. Intakes should be provided below the platform level and should be situated relative to the heat-producing devices on a train berthed in a station.

B-5.2 Ceiling ventilation, by powered or gravity design, to aid in the removal of smoke and/or heat should be considered.

B-6 Platform Edge Screens.

B-6.1 The inclusion of platform edge screens is a design option that is effective for comfort control in stations as well as for smoke control in tunnels. When used, the screens should meet both fire resistivity and structural strengths relative to the train and ventilation system drafts and the operational efficiency requirements.

B-6.2 In a tunnel-to-station evacuation scenario, access to the platform level from the track level should be considered.

B-7 Nonfire Tunnel Ventilation. Where trains might be stopped or delayed in a tunnel for a period of time, the vehicle ventilation system should be capable of maintaining an acceptable level of patron comfort. If not operating in a fire emergency scenario, the tunnel ventilation fans can be used to augment the vehicle system capability. Velocities should consider the comfort levels of employees required to be in the tunnels.

Appendix C Emergency Egress

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

C-1 Transit Station Occupant Load. Transit station dimensions are determined as a function of the length of trains employed in a transit system. Thus the areas of station platforms in light density outlying stations will be equal to those of heavy density downtown central business district transit stations. Consequently, occupancy loads in rapid transit stations, based on the emergency condition requiring evacuation of that station to a point of safety, are a function of the train-carrying capacities rather than platform areas categorized as a "place of assembly." The tunnel can be considered as an auxiliary exit from the station under certain fire scenarios.

C-1.1 Calculating Occupant Load Exit Capacity. The occupant load, as used in this section, is the basis on which most new or expanding transit systems are designed. The methodology for determining passenger use of transit systems varies considerably between specific systems, but a study usually will permit a determination of "peak hour loads." Most systems also will determine "peak hour reversal" from morning to afternoon to reflect commuter loads.

The basis on which the occupant load data is determined should be considered carefully in establishing the need for emergency egress. In new transit systems a survey of actual usage should be made within 2 years of completion of the project to verify design predictions. In operating systems, predicted passenger loads should be established to determine the need for expansion of the system or significant operating changes. Verification by survey should be made following any extension or significant operating change or at a maximum of 5-year intervals.

The basis for calculating occupant loads should be the peak hour patronage figures as commonly projected for design of new transit systems or as established by survey for operating systems.

For new transit systems, the projected peak hour passenger figures can be converted to the peak 15-minute loads by dividing by four and multiplying by the system surge factor. The system surge factor is a distribution curve correction and can be varied for a particular system if sufficient data is available for verification. Both link loads (i.e., number of passengers traveling between two stations over a given period) and entraining loads (i.e., number of passengers entering a station to board trains during a given period) are converted in this manner.

For existing transit systems, where actual patronage data are available, statistical methods can be used to calculate occupant load data. The use of statistical methods for calculation of "calculated train loads" and "calculated entraining loads" will provide a more accurate indication of exiting needs.

The station occupant load is composed of two parts: the entraining load and the calculated train load. The entraining load as used for exit calculations is calculated from peak 15-minute entraining loads by dividing by 15 minutes and multiplying by 12 minutes or two times the headway, whichever is greater.

Where trains arrive at a platform from only one direction, the calculated train load as used for exit calculations is calculated from the peak 15-minute link load by dividing the number of trains arriving at the station during 15 minutes based on headways and multiplying by two to allow for one missed headway. The maximum for the calculated train load should be the most passengers capable of occupying a train.

Where trains arrive at a platform from more than one direction, the entraining load and calculated train load for the peak direction are computed as described above. In the off-peak direction, the entraining load and calculated train load are computed from the peak 15-minute entraining load and the peak 15-minute link load, respectively, by dividing by the number of trains arriving at the station during 15 minutes based on headway.

The total exit time is the sum of the walking travel time for the longest exit route plus the waiting times at the various circulation elements.

The walking travel time is calculated using station geometry data and the travel speeds indicated in 2-5.3.3. The exit route is broken down into sequential horizontal and vertical segments and then tabulated. The travel distance for each segment is then divided by the appropriate travel speed to determine the time needed to traverse each segment. The walking travel time is the sum of the times for each segment.

The flow time (i.e., the time for the last person to pass through the particular element) for each of the various circulation elements (e.g., platform exits, fare barriers, concourse exits) is calculated using the capacities and conditions specified in 2-5.3, 2-5.4, and 2-5.5 along with the occupant load calculated as described above. Care should be taken to ensure that the most restrictive elements are included in the calculations.

For instance, a nominal 3-ft (1-m) wide door provides access to a 44-in. (1.22-m) wide stair, and the clear width of the door opening, with the door in the fully open position, is usually about 32 in. (0.91 m). Using the capacities specified in 2-5.3.3, the door has a capacity of 2.27 pim. The stair has a capacity of 1.59 pim (i.e., unit) in the up direction or 1.82 pim (i.e., unit) in the down direction. So the capacity of this stair is either 70 ppm or 80 ppm, depending on direction of travel. In this case the door is more restrictive than the up stair condition, meaning that the door should be used in the capacity calculations. If the door were wider (36 in.) the capacity of the door would be 82 ppm. The stair capacity would then be more restrictive in either case, meaning that the stair capacity should be used.

Where exit paths divide (i.e., where a choice of exit paths is presented), it is presumed (as it is in the model codes) that the passengers will divide into groups roughly in proportion to the exit capacity provided by the various paths at the decision point. It also is presumed that passengers, once having selected an exit path, will stay on that path until another decision point is reached or egress is achieved.

The waiting time at each of the various circulation elements is calculated as follows:

(1) For the platform exits, by subtracting the walking travel time on the platform from the platform exits flow time
(2) For each of the remaining circulation elements, by subtracting the maximum of all previous element flow times

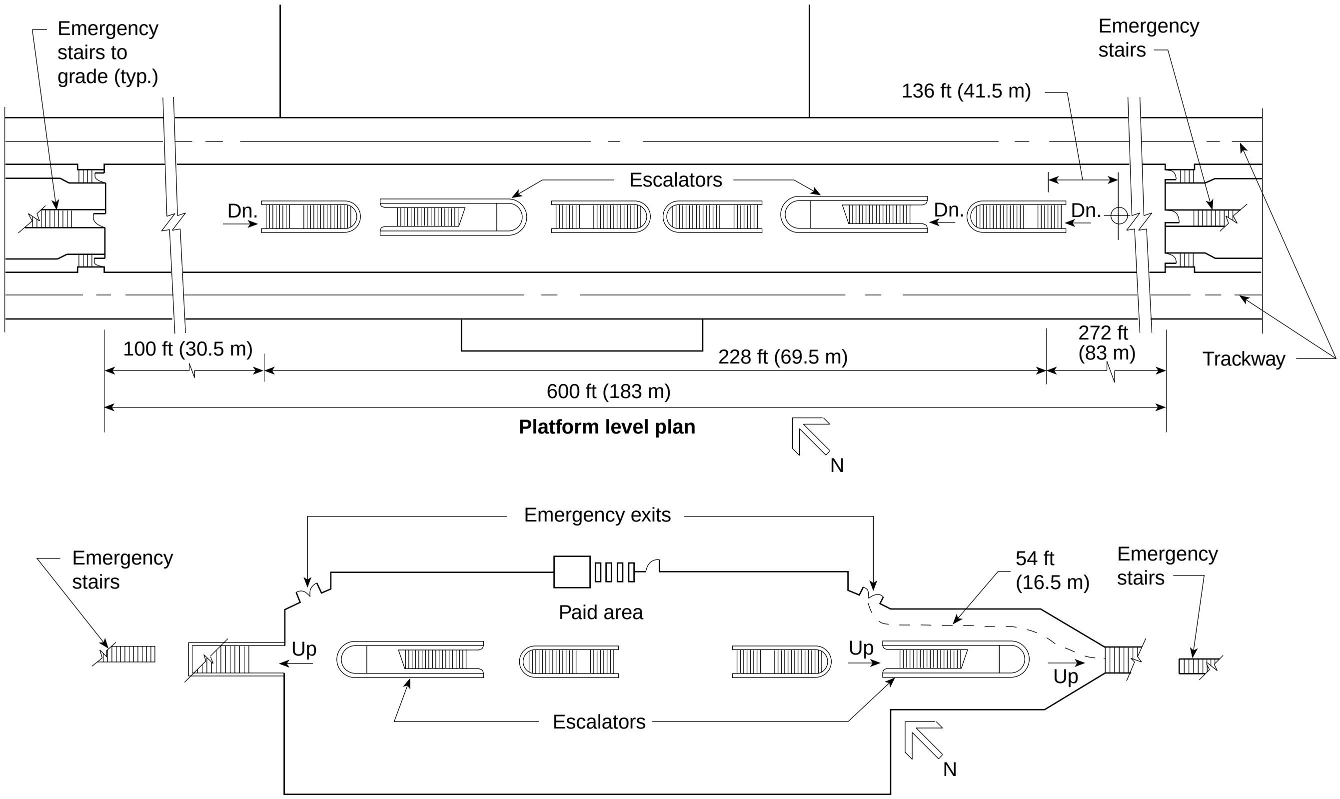
The symbols used in the sample calculations represent the walking times, flow times, and waiting times as follows:

T = total walking travel time for the longest exit route
T_1 = walking travel time on the platform
T_X = walking travel time for the Xth segment of the exit route
W_1 = platform exits flow time
W_2 = fare barrier flow time
W_3 = concourse exits flow time
WN = flow time for any additional circulation element
$Wp = W_1 - T_1$ = waiting time at platform exits
$Wf = W_2 - W_1$ = waiting time at fare barriers
$Wc = W_3 - \max(W_1 \text{ or } W_2)$ = waiting time at concourse exits
$Wn = WN - \max(W_3, W_2, \text{ or } W_1)$ = waiting time at any additional circulation element

NOTE: The waiting time at any circulation element cannot be less than zero.

C-1.2 Center Platform Station Sample Calculation. The sample center platform station is an elevated station with the platform above the concourse, which is at grade *(see Figure C-1.2)*. The platform is 600 ft (183 m) long to accommodate the train length. The vertical distance from the platform to the concourse is 30 ft (9 m).

FIGURE C-1.2 Center platform station.



The station has one paid area separated from the outside by a fare array containing four electronic fare gates and one 48-in. (1.22-m) handicapped/service gate. In addition, two 72-in. (1.83-m) wide emergency exits are provided. Six open wells communicate between the platform and the concourse. Each well contains one stair or one escalator. Station ancillary spaces are located at the concourse level.

Elevators (although not shown on Figure C-1.2) are provided for use by the handicapped or service personnel. Open emergency stairs are provided at each end of the platform. They discharge directly to grade through grill doors with panic hardware.

Escalators are nominal 48 in. (1.22 m) wide. Stairs regularly used by patrons are 72 in. (1.83 m) wide; emergency stairs are 48 in. (1.22 m) wide. Gates to emergency stairs are 48 in. (1.22 m) wide.

The station occupant load is 2498 persons.

In Test No. 1 following Table C-1.2, the time to clear the platform is found to be 3.178 minutes. This meets the requirement of 2-5.3.1.

In Test No. 2 following Table C-1.2, the time to reach a point outside any enclosing structure is found to be 3.352 minutes. This meets the requirement of 2-5.3.2.

Table C-1.2 NFPA 130 Exiting Analysis Station: Sample Center Platform Date: Apr 1, 87 By: DRF Exit Lanes and Capacity Provided

Element	Direction	No. Units	in.	p/m	= ppm
Platform to concourse					
Stairs	Up	0	0	1.59	0
	Down	4	72	1.82	524
Escalators	Up	0	48	1.59	0
	Down*	1	48	1.82	87
Emergency stairs	Up	0	72	1.595	0
	Down	2	48	1.82	175
Escalator test: 8.67% (Not > 50%) per 2-5.3.3.2				Total	786
Through fare barriers					
Turnstiles		0	1	25	0
Fare gates		4	1	50	200
Service gates		1	48	2.27	109
Emergency gates		2	72	2.27	327
				Total	636
Fare barriers to safe area (fare barriers discharge to outside)					
Stairs	Up	0	3	1.59	0
	Down	0	0	1.82	0
Escalators	Up	0	2	1.59	0
	Down	0	0	1.82	0
Emergency stairs	Up	0	0	1.59	0
	Down	0	0	1.82	0
Escalator test: 0.00% (Not > 50%) per 2-5.3.3.2				Total	0

Walking Time for Longest Exit Route		Ft	fpm	Minutes
Platform to safe area				
On platform	T_1	136	200	0.680
Platform to concourse	T_2	30	60	0.500
On concourse	T_3	54	200	0.270
Concourse to grade	T_4	0	50	0.000
On grade to safe area	T_5	10	200	0.500
T (total walking time) = $T_1 + T_2 + T_3 + T_4 + T_5$ =				1.500

*One escalator discounted per 2-5.4.1.1.

Test No. 1: Evacuate platform occupant load(s) from platform(s) in 4 minutes or less.

$$W_1 \text{ (time to clear platform)} = \frac{\text{Platform occupant load}}{\text{Platform exit capacity}}$$

$$W_1 = \frac{2498}{786} = 3.178 \text{ minutes}$$

Test No. 2: Evacuate platform occupant load from most remote point on platform to a point of safety in 6 minutes or less.

Wp (waiting time at platform exits) = $W_1 - T_1$

$Wp = 3.178 - 0.680 = 2.498$ minutes

Concourse occupant load =

Platform occupant load − (W_1 × emergency stair capacity)

Concourse occupant load = 2498 − 556

Concourse occupant load = 1942 persons

Wf (waiting time at fare barriers) = $W_2 - W_1$

$$W_2 \text{ (fare barrier flow time)} = \frac{\text{Concourse occupant load}}{\text{Fare barrier exit capacity}}$$

$$W_2 = \frac{1942}{636} = 3.053 \text{ minutes}$$

$Wf = W_2 - W_1$
$Wf = 3.053 - 3.178 = 0.000$ minutes
Wc (waiting time at concourse exits)
= [W_3 − max (W_2 or W_1)]

$$W_3 \text{ (concourse exit flow time)} = \frac{\text{Concourse occupant load}}{\text{Concourse exit capacity}}$$

$$W_3 = \frac{1942}{0} = 0.000 \text{ minutes}$$

$Wc = W_3$ − max (W_2 or W_1)
$Wc = 0.000 - 3.178 = 0.000$ minutes
Total exit time = $T + Wp + Wf + Wc$
Total = 1.500 + 2.498 + 0.000 + 0.000
Total = 3.998 minutes

Were the concourse of this station considered to meet the point of safety definition by the authority having jurisdiction, the calculation for Test No. 2 would be modified. The time to reach a point of safety would include the walking travel time from the remote point on the platform to the concourse only, plus the waiting time at the platform exits. The area of the concourse would have to be large enough to accommodate the concourse occupant load calculated in Test No. 2.

C-1.3 Side Platform Station Sample Calculation. The sample side platform station is a subway station with a concourse above the platform level but below grade. *(See Figure C-1.3.)* The platform is 600 ft (183 m) long to accommodate the train length. The vertical distance from grade to concourse is 26 ft (8 m). The concourse is 18 ft (5.5 m) above the platform.

The station has two entrances normally used by patrons, each containing one escalator and one stair. The entrances are covered at grade level to a point 10 ft (3 m) beyond the top of the stairs.

The concourse is divided into two free areas and one paid area separated by fare arrays. Each fare array contains 12 fare gates of the turnstile type and one swinging service gate, 48 in. (1.22 m) wide, equipped with panic hardware for use by the handicapped and service personnel. Three open wells, containing two stairs and one escalator, communicate between each platform and the concourse.

Elevators are provided from grade level to concourse and from the concourse to each platform for use by the handicapped and service personnel. Station ancillary spaces are located at concourse level.

Enclosed emergency stairs, discharging directly to grade, are provided at both ends of each platform. Escalators are nominal 48 in. (1.22 m) wide. Stairs regularly used by patrons are 72 in. (1.83 m) wide. Emergency stairs are 48 in. (1.22 m) wide. Doors to emergency stairs are 48 in. (1.22 m) wide.

The station occupant load is 1600 persons, 228 on the outbound platform and 1372 on the inbound platform.

The sample calculation shown is one of several that needs to be done to properly analyze this type of station. The sample calculation shows the effect of discounting one of the escalators from concourse to grade. The exit capacity from platform to concourse meets the criteria of 2-5.3.1 in Test No. 1 following Table C-1.3, where the time to clear the platform is found to be 2.897 minutes for the inbound platform and 0.498 minutes for the outbound platform.

However, in Test No. 2 following Table C-1.3, the total exit time (i.e., the maximum for the two paths examined) is found to be 6.459 minutes. This does not meet the criteria of 2-5.3.2; therefore, additional exit capacity is needed from concourse to grade.

Additional calculations should also be made to examine the results of discounting an escalator between platform and concourse (rather than an escalator between concourse and grade) to verify that the inbound platform can still be cleared in 4 minutes or less under this condition.

FIGURE C-1.3 Side platform station.

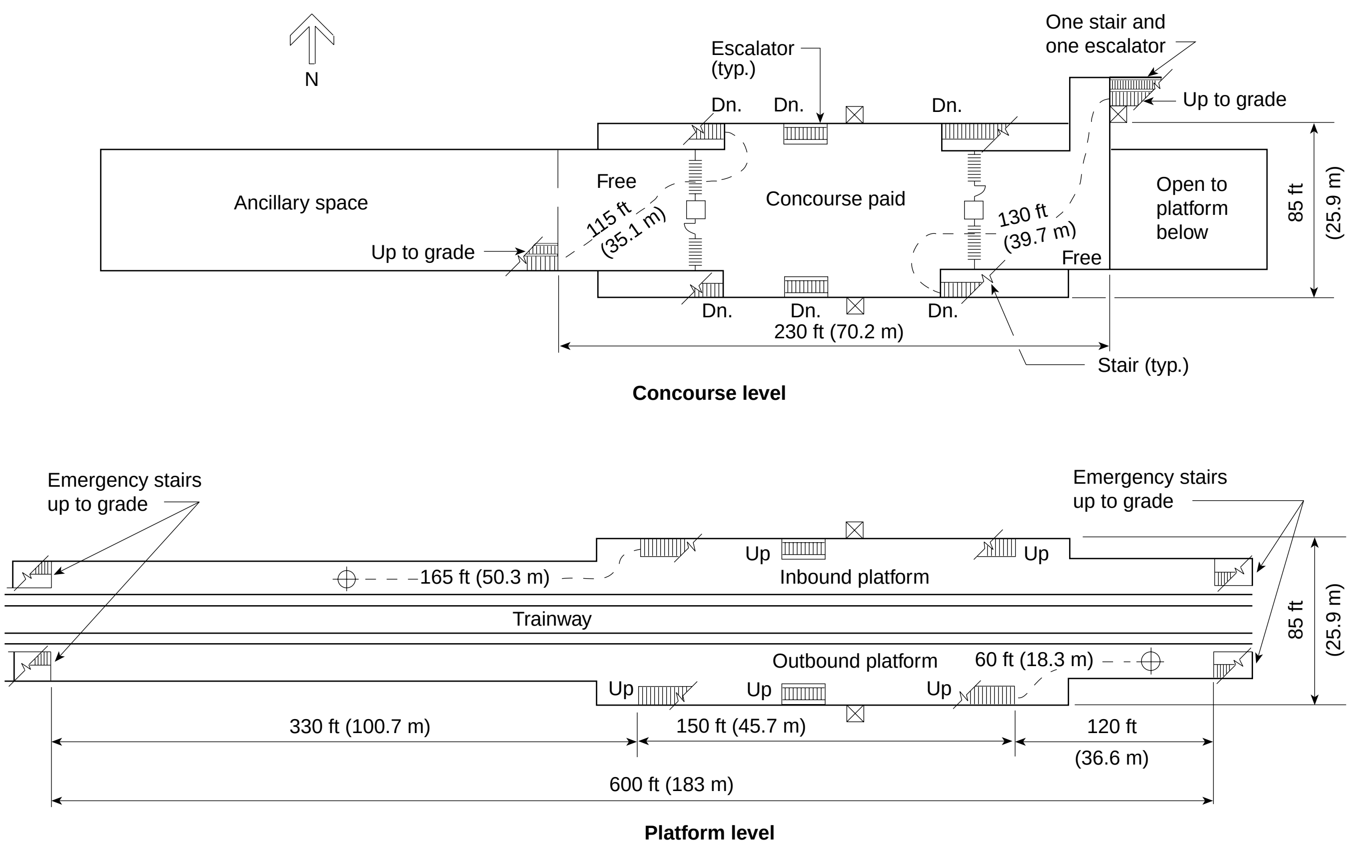


Table C-1.3 NFPA 130 Exiting Analysis Station: Sample Center Platform Date: Apr 1, 87 By: DRF
Exit Lanes and Capacity Provided

Element	Direction	No. Units	in.	p/m	= ppm
Inbound platform to concourse					
Stairs	Up	2	72	1.59	229
	Down	0	0	1.82	0
Escalators	Up	1	48	1.59	70
	Down*	0	0	1.82	0
Emergency stairs	Up	2	48	1.59	140
	Down	0	0	1.82	0
				Total	458
Through fare barriers					
Turnstiles		12	1	25	300
Fare gates		0	1	50	0
Service gates		0	0	2.27	0
Emergency gates		1	2	2.27	109
				Total	409
Fare barriers to safe area					
Stairs	Up	1	72	1.59	114
	Down	0	0	40	0
Escalator	Up*	0	48	1.59	0
	Down	0	0	40	0
Emergency stairs	Up	0	0	35	0
	Down	0	0	40	0
				Total	114

Walking Time for Longest Exit Route		ft	fpm	Minutes
Inbound platform				
On platform	T_1	165	200	0.825
Platform to concourse	T_2	18	50	0.360
On concourse	T_3	115	200	0.575
Concourse to grade	T_4	26	50	0.520
On grade to safe area	T_5	10	200	0.500
T (total walking time) = $T_1 + T_2 + T_3 + T_4 + T_5$				2.330

Element	Direction	No. Units	in.	p/m	= ppm
Outbound platform to concourse					
Stairs	Up	2	78	1.59	229
	Down	0	0	1.82	0
Escalator	Up	1	48	1.59	76
	Down	0	0	1.82	0
Emergency stairs	Up	2	48	1.59	153
	Down	0	0	1.82	0
					458
Through fare barriers					
Turnstiles		12	1	25	300
Fare gates		0	1	50	0
Service gates		0	0	2.27	0
Emergency gates		1	48	2.27	109
					409

(Sheet 1 of 2)

Table C-1.3 NFPA 130 Exiting Analysis Station: Sample Center Platform Date: Apr 1, 87 By: DRF Exit Lanes and Capacity Provided *(Continued)*

Element	Direction	No. Units	in.	p/m	= ppm
Fare barriers to safe area					
Stairs	Up	1	72	1.59	114
	Down	0	0	1.82	0
Escalator	Up	1	48	1.59	76
	Down	0	0	1.82	0
Emergency stairs	Up	0	0	1.59	0
	Down	0	0	1.82	0
					190
Walking Time for Longest Exit Route			**ft**	**fpm**	**Minutes**
Outbound platform					
On platform		T_1	60	200	0.300
Platform to concourse		T_2	18	50	0.360
On concourse		T_3	130	200	0.650
Concourse to grade		T_4	26	50	0.520
On grade to safe area		T_5	10	200	0.050
T (total walking time) = $T_1 + T_2 + T_3 + T_4 + T_5$					1.880

(Sheet 2 of 2)

*One escalator test per 2-5.4.1.1.

Test No. 1: Evacuate platform occupant load(s) from platform(s) in 4 minutes or less.

$$W_1(\text{time to clear platform}) = \frac{\text{Platform occupant load}}{\text{Platform exit capacity}}$$

Inbound platform

$$W_1 = \frac{1372}{458} = 2.897(3.267)\text{ minutes}$$

Outbound platform

$$W_1 = \frac{228}{458} = 0.498\text{ minutes}$$

Test No. 2: Evacuate platform occupant load from most remote point on platform to a point of safety in 6 minutes or less.

Inbound platform:
Wp (waiting time at platform exits) = $W_1 - T_1$
$Wp = 2.897 - 0.825 = 2.072$ minutes
Concourse occupant load =
Platform occupant load − (W_1 × emergency stair capacity)
Concourse occupant load = 1372 − 443
Concourse occupant load = 929 persons
Total concourse occupant load =
Concourse load (inbound) + Concourse load (outbound)
Total concourse occupant load = 929 + 152 = 1081
Wf (waiting time at fare barriers) = $W_2 - W_1$

$$W_2 = \frac{\text{Concourse occupant load}}{\text{Fare barrier exit capacity}}$$

$$W_2 = \frac{540}{400} = 1.320\text{ minutes}$$

$Wf = W_2 - W_1$
$Wf = 1.320 - 2.897 = 0.000$ minutes
Wc (waiting time at concourse exits)
= [W_3 − max (W_2 or W_1)]

$$W_3 = \frac{540}{109} = 4.954\text{ minutes}$$

$Wc = W_3$ − max (W_2 or W_1)
$Wc = 4.954 - 2.897 = 2.057$ minutes

Outbound platform:
Wp (waiting time at platform exits) = $W_1 - T_1$
$Wp = 0.498 - 0.300 = 0.198$ minutes
Concourse occupant load =
Platform occupant load − (W_1 × emergency stair capacity)
Concourse occupant load = 228 − 76
Concourse occupant load = 152 persons
Wf (waiting time at fare barriers) = $W_2 - W_1$

$$W_2 = \frac{\text{Concourse occupant load}}{\text{Fare barrier exit capacity}}$$

$$W_2 = \frac{540}{409} = 1.320\text{ minutes}$$

$Wf = W_2 - W_1$
$Wf = 1.320 - 0.498 = 0.822$ minutes
Wc (waiting time at concourse exits) = W_3 − max (W_2 or W_1)

$$W_3 = \frac{\text{Concourse occupant load}}{\text{Concourse exit capacity}}$$

$$W_3 = \frac{540}{190} = 2.842\text{ minutes}$$

$Wc = W_3$ − max (W_2 or W_1)
$Wc = 2.842 - 1.320 = 2.522$ minutes
Total exit time = $T + Wp + Wf + Wc$
Total = 2.330 + 2.072 + 0.000 + 2.057
Total = 6.459 minutes

C-1.4 Multilevel Platform Stations. The procedures for calculating exiting times for multilevel platform stations is similar to the prior sample calculations *(see C-1.2 and C-1.3)*. The changes in the exiting calculations are primarily a function of the concurrent occupancy load determinations for the two platform levels.

The step-by-step procedure relating to the occupancy load calculations generally is recommended as follows:

(a) Calculate the occupancy load for each platform level as per the appropriate examples in C-1.2 and C-1.3 for the same assumed time(s) of day.

(b) If the fire is on the upper-level platform (for an underground station), an assumption can be made as to the percentage of occupants who might be expected to evacuate the lower level through the normal egress routes versus those who might be expected to exit via emergency stairs. These assumptions will be unique for each system as a function of various parameters, including physical configuration of stations, means of egress, and location of emergency exits; communications facilities to advise passengers, both verbal and signing; level of transit personnel working in stations; and transit personnel emergency procedure responsibilities established for the transit operating authority.

(c) The upper-level occupant load is increased by the people evacuating from the lower level through the normal egress routes per the above.

(d) For a fire on the lower level, appropriate assumptions relative to the distribution of the occupancy loads to the available means of egress are calculated in a fashion similar to the procedures described above.

The remainder of the exiting calculations essentially are unchanged from the other sample calculations in C-1.2 and C-1.3.

C-2 Escalators. ANSI/ASME A17.1, *Safety Code for Elevators and Escalators,* which governs the design of escalators, is generally recognized as one of the strictest consensus standards. However, considering the critical operational nature of the escalators in rapid-transit stations, specially designed units with additional safety features should be provided.

The number of flat steps at the upper landings should be increased in proportion to the vertical rise of the escalator. For a rise up to 20 ft (6.1 m), use the manufacturers' standard number of flat steps. From 20-ft (6.1-m) to 60-ft (18.3-m) rise, use three flat steps; and over 60-ft (18.3-m) rise, use four flat steps.

A remote monitoring panel should be provided in the station that displays the following for each escalator:

(1) Direction of travel

(2) Operating speed (if more than one)

(3) Out of service

(4) Flashing light that indicates the escalator stopped because of activation of a safety device

A remote stopping device should be provided only if the entire escalator is visible from the remote location or stop is delayed until it is preceded by an appropriate warning.

Appendix D Suggested Test Procedures for Fire Hazard Assessment

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

D-1 General. The two most important features in fire safety design of a fixed guideway transit or passenger rail vehicle are to provide sufficient time for evacuation in the event of a fire before the vehicle compartment becomes untenable and to prevent a self-propagating fire.

D-1.1 Modeling has the capability of providing an evaluation of a fire system. A model can predict what effect the use of various combinations of materials will have in preventing fully developed fires in a specific situation.

D-2 Hazard Load Calculations. Hazard load calculations *[see Table D-2(a)]* provide a way to examine the potential fire hazard of materials used in a transit vehicle interior. Using the example in Table D-2(b), the selection of the seating materials can seriously affect the "loading" in a vehicle. A self-propagating fire depends on the size of the initiating fire; therefore, the heat flux or exposing fire used to evaluate materials at their location in the fire system is important. Hazard load values are useful in determining if a self-propagating fire is possible. The hazard load analysis is a method for comparing release rate information used to determine the level of safety selected. The release rate information in Table D-2(b) is based on the 3-minute release determined at the exposure identified in Table D-2(b).

The data in Table D-2(b) is based on tests of materials conducted in accordance with ASTM E 906, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products.* Data of similar types can also be obtained based on results for testing of materials conducted in accordance with ASTM E 1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter.* Test results from ASTM E 1354 and from ASTM E 906, while usually showing similar trends, cannot be compared directly, as the exposure conditions (e.g., orientation, piloted ignition, radiant source) and measurement methods are different. In particular, thermoplastic materials (and others causing melting or dripping when exposed to a heat source) can be better evaluated using ASTM E 1354, as the standard exposure orientation is horizontal, while that in ASTM E 906 is vertical. The exposure heat flux in both ASTM E 906 and ASTM E 1354 test procedures can be varied by the location of the materials within the fire compartment. For example, materials at the ceiling will be exposed to a greater heat flux than materials located at the floor level. For a more complete explanation of the hazard load concept, information is available, for example, in a publication entitled, *Transit Vehicle Material Specification Using Release Rate Tests for Flammability and Smoke.*

To determine the hazard load in Tables D-2(c) and D-2(d), the following should be done:

(1) The 3-minute release rate value for each item in Table D-2(b) is multiplied by its exposed surface area.

(2) The Btu and smoke values for all items are totaled.

(3) The total value is divided by the volume of the vehicle to convert to Btu/ft^3.

Based on extremes of materials in Table D-2(b), examples of the hazard load calculations for the "best" and "worst" material combinations from available samples are shown in Tables D-2(c) and D-2(d), which illustrate the "heat" and "smoke" hazard load. Three-minute release rate values for materials to be used in transit vehicle interiors, where tested in accordance with NFPA 263, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products*, should be substituted for those shown in Table D-2(b) and the actual surface area of each material should also be used.

Table D-2(a) Hazard Load Calculations

Interior volume of a rail transit vehicle is 4095 ft^3 (115.9 m^3)		Hazard Load Calculations	
Exposed Surface Areas		**ft^2**	**m^2**
Seating			
Padded (bottom and back)		365	33.9
Hardback (seat backs)		133	12.4
Windows	(65 ft × 7 ft) × 40% × 2	= 365	33.9
Lower walls	(65 ft × 7 ft) × 60% × 2	= 546	50.7
Light fixture covers	(65 ft × 0.83 ft) × 2	= 108	10
Floor	(65 ft × 9 ft)	= 585	54.3
Ceiling	(65 ft × 9 ft)	= 585	54.3

Table D-2(b) Release Rate Data

		"Best" 3-Min Release		"Worst" 3-Min Release	
Transit Vehicle Interior Material	**Area (ft^2)**	**Heat (Btu/ft^2)**	**Smoke (part.*/ft^2)**	**Heat (Btu/ft^2)**	**Smoke (part.*/ft^2)**
Seating at 1.0 W/cm^2					
Padded	365	90	2,100	2,400	10,140
Hardback	133	150	330	300	2,500
Windows at 1.5 W/cm^2	365	60	165	1,500	600
Lower walls at 1.5 W/cm^2	546	150	330	300	2,500
Light fixture covers at 1.5 W/cm^2	108	85	275	860	200
Floor at 1.0 W/cm^2	585	0	0	75	90
Ceiling at 3.5 W/cm^2	585	0**	0**	1,150	30

*A "particle" of smoke is defined in terms of % transmission of the smoke one particle in 1 ft^3 of air will reduce % transmission by 10% when viewed through a light path of 1 ft.
**Assumed noncombustible aluminum panels.

Table D-2(c) Hazard Load Calculations "Best" Loading

Interior Material	Heat Hazard Load	Smoke Hazard Load
Seating		
Padded	365 ft^2 × 90 Btu/ft^2 = 32,850 Btu	365 ft^2 × 2,100 part./ft^2 = 766,500 part.
Hardback	133 ft^2 × 150 Btu/ft^2 = 19,950 Btu	133 ft^2 × 330 part./ft^2 = 43,890 part.
Windows	365 ft^2 × 60 Btu/ft^2 = 21,900 Btu	365 ft^2 × 165 part./ft^2 = 60,225 part.
Lower walls	546 ft^2 × 150 Btu/ft^2 = 81,900 Btu	546 ft^2 × 330 part./ft^2 = 180,180 part.
Light fixture covers	108 ft^2 × 85 Btu/ft^2 = 9,180 Btu	108 ft^2 × 275 part./ft^2 = 29,700 part.
Floor	585 ft^2 × 0 Btu/ft^2 = 0 Btu	585 ft^2 × 0 part./ft^2 = 0 part.
Ceiling	585 ft^2 × 0 Btu/ft^2 = 0 Btu	585 ft^2 × 0 part./ft^2 = 0 part.
Total	= 165,780 Btu	= 1,080,495 part.
Divided by car volume = 4,095 ft^3 (65 ft × 9 ft × 7 ft)	= 40 Btu/ft^3*	264 part./ft^3

*Based on the October, 1976, Phase I Report to the Transit Development Corporation referenced earlier, "Heat Hazard Load values of 80 Btu/ft^3 appear to be the maximum allowable loading to ensure that a self-propagating fire will not occur with an initiating fire consisting of the equivalent of 1 lb of newsprint or 8 oz. of lighter fluid."

Table D-2(d) Hazard Load Calculations "Worst" Loading

Interior Material	Heat Hazard Load		Smoke Hazard Load	
Seating				
Padded	365 ft^2 × 2,400 Btu/ft^2	= 876,000 Btu	365 ft^2 × 10,140 part./ft^2	= 3,701,100 part.
Hardback	133 ft^2 × 300 Btu/ft^2	= 39,900 Btu	133 ft^2 × 2,500 part./ft^2	= 322,500 part.
Windows	365 ft^2 × 1,500 Btu/ft^2	= 547,500 Btu	365 ft^2 × 600 part./ft^2	= 219,000 part.
Lower walls	546 ft^2 × 300 Btu/ft^2	= 163,800 Btu	546 ft^2 × 2,500 part./ft^2	= 1,365,000 part.
Light fixture covers	108 ft^2 × 860 Btu/ft^2	= 92,800 Btu	108 ft^2 × 220 part./ft^2	= 23,760 part.
Floor	585 ft^2 × 75 Btu/ft^2	= 43,875 Btu	585 ft^2 × 90 part./ft^2	= 52,650 part.
Ceiling	585 ft^2 × 1,150 Btu/ft^2	= 672,750 Btu	585 ft^2 × 30 part./ft^2	= 17,550 part.
Total		= 2,436,705 Btu		= 5,711,560 part.
Divided by car volume = 4,095 ft^3 = 595 Btu/ft^3				1,395 part./ft^3

Appendix E Creepage Distance

This appendix is not a part of the requirements of this NFPA document but is included for informational purposes only.

E-1 See Table E-1 for the minimum creepage distance for transit vehicles.

Table E-1 Minimum Creepage Distance for Transit Vehicles

	Class:	Low Energy	Ordinary (Enclosed Environment with Breathing)	Underfloor Exposed Environment	Highly Exposed (No External Protection)
	Application:	Electronic & Protected Electrical Devices ($^1/_2$ amp where max)	Control & Power Devices Mounted in Control Group Enclosures (Short Circuit Limits)	Power Resistors, Open Disconnect Devices Mounted Outside Protective Enclosures	Third Rail Shoe Beams and Current Collection Devices (Short Circuit Unlimited by Onboard Devices)
Nominal Voltage	**Surface**	**(in.)**	**(in.)**	**(in.)**	**(in.)**
38	Horizontal	$^1/_{16}$	$^1/_8$	$^3/_4$	N/A
	Vertical	$^1/_{16}$	$^1/_8$	$^1/_2$	N/A
230	Horizontal	$^3/_8$	$^5/_8$	3	4
	Vertical	$^3/_8$	$^5/_8$	2	$2^1/_4$
600	Horizontal	$^3/_4$	$1^1/_4$	7	10
	Vertical	$^3/_4$	$1^1/_4$	5	6

Appendix F Referenced Publications

F-1 The following documents or portions thereof are referenced within this standard for informational purposes only and are thus not considered part of the requirements of this standard unless also listed in Chapter 9. The edition indicated here for each reference is the current edition as of the date of the NFPA issuance of this standard.

F-1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 204, *Guide for Smoke and Heat Venting,* 1998 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source*, 2000 edition.

NFPA 263, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products,* 1994 edition.

F-1.2 Other Publications.

F-1.2.1 ANSI Publication. American National Standards Institute, Inc., 11 West 42nd Street, 13th Floor, New York, NY 10036.

ANSI/ASME A17.1, *Safety Code for Elevators and Escalators,* 1993.

F-1.2.2 ASHRAE Publications. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-2305.

ASHRAE *Handbook Series.*

ASHRAE *Handbook Fundamentals,* 1993, Additions and Corrections — 1996.

F-1.2.3 ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshocken, PA 19428-2959.

ASTM E 648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source*, 1994.

ASTM E 906, *Standard Test Method of Heat and Visible Smoke Release Rates for Material and Products*, 1999.

ASTM E 1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 1999.

F-1.2.4 TDC Publications. Transit Development Corporation, Inc., 1201 New York Avenue, NW, Washington, DC 20005.

Smith, Edwin E., *Transit Vehicle Material Specification Using Release Rate Tests for Flammability and Smoke,* Oct. 1976.

Subway Environmental Design Handbook, Vol. 1, Principles and Applications, 2nd ed., 1976, Associated Engineers, A joint venture: Parsons Brinckerhoff Quade & Douglas, Inc.; Deleuw, Cather and Company; Kaiser Engineers under the direction of Transit Development Corporation, Inc.

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