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# NFPA 130 Standard for Fixed Guideway Transit Systems 1995 Edition

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An International Standards-Making Organization

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### Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.



### Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accept any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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**NFPA 130**

**Standard for**

# Fixed Guideway Transit Systems

**1995 Edition**

This edition of NFPA 130, *Standard for Fixed Guideway Transit Systems*, was prepared by the Technical Committee on Fixed Guideway Transit Systems and acted on by the National Fire Protection Association, Inc., at its Annual Meeting held May 22-25, 1995, in Denver, CO. It was issued by the Standards Council on July 21, 1995, with an effective date of August 11, 1995, and supersedes all previous editions.

This edition of NFPA 130 was approved as an American National Standard on August 11, 1995.

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.

## 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 the Association 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.

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*This list represents the membership at the time the Committee was balloted on the text of this edition. Since that time, changes in the membership may have occurred.*

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.

## Contents

# NFPA 130

## Standard for

# Fixed Guideway Transit Systems

## 1995 Edition

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

Information on referenced publications can be found in Chapter 8 and Appendix F.

## Chapter 1 General

### 1-1 Scope.

**1-1.1** This standard shall cover 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. This standard establishes minimum requirements for each of the identified subsystems.

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

(a) Conventional freight or passenger railroad systems including those that provide commuter services.

(b) Buses and trolley coaches.

(c) Any other system of transportation not included in the definition of fixed guideway transit system.

To the extent where a system, including those listed in 1-1.2(a) through (c), 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 a fixed guideway transit system 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 systems and to extensions of existing systems.

**1-4.2** That 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.

**Alternate Central Supervising Station.** 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.

**Approved.*** Acceptable to the "authority having jurisdiction."

**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.

**Authority.** The agency legally established and authorized to operate a fixed guideway transit system.

**Authority Having Jurisdiction.*** The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

**Automated Fixed Guideway Transit Systems.** A fixed guideway transit system that operates fully automated driverless vehicles along an exclusive right-of-way.

**Building.** Any structure or group of structures in which fixed guideway transit 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.

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

**Command Post.** The location during an emergency, selected by the person in command, for controlling and coordinating the emergency operation.

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

**Elevated Structure.** All structures not otherwise defined as surface or underground structures.

**Emergency Procedures Plan.** A plan developed by the authority with the cooperation of all participating agencies detailing specific actions required by all those who will respond during an emergency.

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

**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 the fire protection method(s) recommended that will provide a level of fire safety commensurate with this standard.

**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.

**Fixed Guideway Transit System (the 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.

**Fixed Guideway Transit Vehicle (the 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.

**Guideway.** That portion of the transit 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.

**Incidental Occupancies in Stations.** Refers to the use of the station by others who are neither transit system employees nor passengers.

**Labeled.** Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization 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.

**Listed.*** Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

**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 E136, *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.

**Nontransit Occupancy.** An occupancy not under the control of the system operating authority.

**Open Station.** 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.

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

**Person in Command.** A person designated by the authority or a responsible fire or police representative on the scene of an emergency fully responsible at the command post.

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

**Power Station.** An electric generating plant for supplying electrical energy to the system.

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

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

**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 replacement-in-kind).

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

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

**Surface Structure.** Any at-grade or unroofed structure other than an elevated or underground structure.

**System.** See definition of Fixed Guideway Transit System.

**Trainway.** That portion of the guideway in which the transit vehicles operate.

**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** This chapter shall apply to all 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 will be necessary beyond this standard.

**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 hr 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 hr from all other occupancies.*

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

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

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

**2-2.3.3** 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 1½ hr.

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

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

**2-2.3.5*** All station public areas shall have a fire separation of at least 3 hr 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** All openings from station public areas to all nontransit occupancies, i.e., private entrances, 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 detector, or, where a separate smoke barrier is provided, the operation may be by fusible links. *(See NFPA 80, Standard for Fire Doors and Fire Windows.)*

**2-2.4 Automatic Sprinkler System Requirements.** *(See 2-7.3.)*

**2-3 Ventilation.**

**2-3.1 General.** In enclosed stations, provisions shall be made for emergency ventilation for the protection of passengers and employees from fire or generation of smoke. *(See Appendix B.)*

**2-3.2 Design.** In enclosed stations, the design objectives of the emergency ventilation system shall be:

(a) To provide a stream of noncontaminated air to passengers in a path of egress away from a train fire;

(b) To produce airflow rates to prevent backlayering of smoke in a path of egress away from a train fire; and

(c) To limit the air temperature in a path of egress away from a train fire to 140°F (60°C) or less.

**2-3.3** The design heat release rate produced by a train fire shall be used to design the emergency ventilation system.

**2-3.4 Emergency Ventilation Fans.** *(See B-2.4.)*

**2-3.4.1** Ventilation fans used for emergency service, their motors, and all related components exposed to the ventilation airflow shall be designed to operate in an ambient atmosphere of 482°F (250°C) for a period of at least 1 hr.

**2-3.4.2** Local fan motor starters and related operating control devices shall be located away from the direct air stream of the fans to the greatest extent practical.

**2-3.4.3** Fans required for emergency operation shall be capable of satisfying emergency air velocity criteria in either supply or exhaust modes.

**2-3.4.4** Discharge/outlet openings for emergency fans shall be positioned a sufficient distance from supply air intake openings to prevent recirculation. If this is not possible due to area constraints, then intake openings shall be protected by other approved means or devices to prevent smoke from reentering the system.

**2-3.4.5** Operation and fail-safe verification of proper operation of emergency fans shall be effected from a central supervising station with indication provided for all modes of operation for each fan, as well as from a local control isolated as in 2-3.4.2.

**2-3.4.6** Thermal overload protective devices shall not be located on motor controls of fans used for emergency ventilation.

**2-3.4.7** Local controls shall permit overriding remote central supervising control. Local control shall be capable of operating the fans in all modes in the event the remote controls become inoperable.

**2-3.5 Ancillary Spaces.** Storage battery or similar ancillary rooms in which hydrogen gas or other hazardous gases could be released, and mechanical ventilation is required, shall be ventilated in accordance with NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*.

**2-4 Wiring Requirements.** *(See B-2.5.)*

**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 2-4.1.1 through 2-4.1.8.

**2-4.1.1** 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 hr and shall not support combustion under the same temperature condition. Other materials when encased in concrete shall be acceptable.

**2-4.1.2** 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*.

**2-4.1.3** 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).

**2-4.1.4** Wire and cable constructions intended for use in operating vital train signal circuits and power circuits to emergency fans, lights, etc., shall pass the flame propagating criteria of the IEEE Standard 383, *Standard for Type Tests of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations*. NEC-type listed cables suitable for use in plenums shall be permitted to be used in train signal circuits.

**2-4.1.5** 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 shall not be installed exposed or surface-mounted in air plenums that might carry air at the elevated temperatures accompanying fire-emergency conditions.

**2-4.1.6** Overcurrent elements (1) that are designed to protect conductors serving emergency equipment motors (fans, dampers, pumps, etc.), emergency lighting, and communications equipment, and (2) that are located in spaces other than the main electrical distribution system equipment rooms shall not depend on thermal properties for operation.

**2-4.1.7** The power supply for fans essential for emergency ventilation service shall consist of two separate electrical feeders. Each feeder shall originate from a different source (substation) and shall be separated physically to the extent possible.

**2-4.1.8** Conductors for emergency fans, emergency lighting, communications, etc., 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.

**2-5 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.

**2-5.2 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.

**2-5.2.2** Special consideration shall be given to station servicing areas where events occur that establish occupant loads not included in normal passenger loads. These include such areas as civic centers, sports complexes, and convention centers. Consideration of control of access to platform 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.

**2-5.3 Number and Capacity of Exits.**

**2-5.3.1** Exit capacities shall be calculated on the basis of 22-in. (558.8-mm) wide exit lanes. Width shall be measured in the clear at the narrowest point except that individual handrails shall be permitted to project $3\frac{1}{2}$ in. (88.9 mm) into the required width. Fractional lanes shall not be counted in measuring exit capacities except that 12 in. (304.8 mm) added to one or more lanes shall be counted as one-half a lane.

**2-5.3.2** There shall be sufficient exit lanes to evacuate the station occupant load as defined in 2-5.2 from the station platforms in 4 min 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 above evacuation time shall be permitted based on an engineering analysis by evaluating material heat release rates, station geometrics, and emergency ventilation systems.*

**2-5.3.3** The station also shall be designed to permit evacuation from the most remote point on the platform to a point of safety in 6 min or less.

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

**2-5.3.3.1** In at-grade or elevated structures so designed that 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.

**2-5.3.4** The capacity in persons per minute (ppm), passenger travel speeds in feet per minute (fpm), and requirements for exit lanes shall be as follows:

**2-5.3.4.1 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 number of exit lanes 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.

Per Exit Lane

Capacity — 50 ppm

Travel Speed — 200 fpm (61 m/m).

**2-5.3.4.2* 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 of two-lane capacity provided they are of standard 48 in. (1.22 m) width, of 1½-lane capacity provided they are of standard 32 in. (813 mm) width, and of 1-lane capacity if less than 32 in. (813 mm) width. 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.

Per Exit Lane "Up" Direction

Capacity — 35 ppm

Travel Speed — 50 fpm[1] (15.24 m/m).[1]

Per Exit Lane "Down" Direction

Capacity — 40 ppm

Travel Speed — 60 fpm[1] (18.3 m/m).

[1]Indicates vertical component of travel speed.

**2-5.3.4.3 Doors and Gates.** Exit doors and gates shall be a minimum of 36 in. (914.4 mm) in width.

Per Exit Lane

Capacity — 50 ppm.

**2-5.3.4.4 Fare Collection Gates.** Fare collection gates, when deactivated, shall provide a minimum 20 in. (508 mm) clear unobstructed aisle. Console shall not exceed 40 in. (1016 mm) in height.

Per Gate

Capacity — 50 ppm.

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

Per Gate

Capacity — 25 ppm.

**2-5.3.5** 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.

**2-5.3.6** A second means of egress at least two lanes 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.

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

**2-5.4.1.1** 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 that 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 systems shall be installed and maintained in accordance with NFPA 70, *National Electrical Code*.

**2-6.3** 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 separately wired from emergency distribution panels.

**2-6.4** Emergency lighting for stairs and escalators shall be designed to emphasize illumination on the top and bottom steps or 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 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 simultaneously transmitted 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 telephone) 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 so that appropriate announcements can be made over the PA system 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 located at 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: The above 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 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 connection 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 Scope.** This chapter considers all 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 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, 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** 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:

(a) Ends of station platforms.
(b) Cross passages *(see 3-2.4.3)*.
(c) Emergency access points.
(d) 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 methods, 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. Walking 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 minimum 3-hr fire-resistive construction. Ancillary areas shall be separated from trackway areas within underground line sections by minimum 2-hr fire-resistive construction.

**3-2.2 Ventilation.** *(See Section 2-3 and Appendix B.)*

**3-2.2.1** Provisions shall be made for emergency ventilation for the protection of passengers, employees, and emergency personnel from fire and generation of smoke.

**3-2.2.2** In underground and underwater line sections, the design objectives of the emergency ventilation system shall be:

(a) To provide a stream of noncontaminated air to passengers in a path of egress away from a train fire;

(b) To produce airflow rates to prevent backlayering of smoke in a path of egress away from a train fire; and

(c) To limit the air temperature in a path of egress away from a train fire to 140°F (60°C) or less.

**3-2.2.3** The design heat release rate produced by a train fire shall be used to design the emergency ventilation system.

**3-2.2.4** Fans shall be single- or multi-speed, shall be permitted to be reversible, and shall be both locally and remotely controlled. They shall be connected to two power feeders from separate sources. Power feeders from a utility furnishing power for fans shall be isolated from each other and shall originate from separate and distinct utility sources to the extent possible. Fans shall otherwise be as described in 2-3.4 and shall be wired as per 2-4.1.7 and 2-4.1.8.

**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 following requirements:

**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 hr 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 fans, lights, etc., shall pass the flame propagating criteria of the 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. (NOTE: The trainway, although used for ventilation, shall not be considered as an air plenum for purposes of mounting electrical appurtenances.)

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

**3-2.3.8** The power supply for fans essential for emergency ventilation service shall consist of two electrical feeders. Each feeder shall originate from a different source (substation) and shall be separated physically to the extent possible.

**3-2.3.9** Conductors for emergency fans, emergency lighting, communications, etc., 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.

**3-2.4 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, 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 minimum 2-hr-rated fire walls or 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 shall be permitted, therefore, 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:

(a) Cross passageways shall not be farther than 800 ft (244 m) apart.

(b) Openings in open passageways shall be protected with fire door assemblies having a fire protection rating of 1½ hours with a self-closing fire door.

(c) A noncontaminated environment shall be provided in that portion of the trainway not involved in an emergency and that is being used for evacuation.

(d) A ventilation system for the contaminated tunnel shall be designed to control smoke in the vicinity of the passengers.

(e) 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 shall be as low as possible, not exceeding 50 lb (222 N), applied to the latch side. 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 or close the hatch shall not exceed 30 lb (133 N) applied at the latch side. 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.** *(See Section 2-6.)*

**3-2.4.7.1** Emergency tunnel lighting illumination levels shall not be less than 0.25 foot-candles (2.69 lx).

**3-2.5* Traction Power.** 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 section includes the wayside pothead, cable between pothead and contact (third) rail or overhead wire, contact rail supports, and special warning and identification devices, as well as electrical appurtenances associated with overhead trolley systems.

**3-2.5.1 Traction Power Contact Rail.** To provide safety isolation from the contact rail, the practices of 3-2.5.1.1 shall be implemented.

**3-2.5.1.1 Traction Power Conductor Rail Protection.** 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. Coverboards, where used, shall be capable of visible deflection.

Coverboard or protective material shall have a flame spread rating of not more than 25 when tested in accordance with NFPA 255 (ASTM E84), *Standard Method of Test of Surface Burning Characteristics of Building Materials*. Insulating material for 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.

**3-2.6 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.

**3-2.7 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 and Hose Systems*, shall be installed in all subway tunnels. Due to the nature and length of subway tunnels, standpipe shall be permitted to be of the dry type.

**3-2.7.2.1** Tunnel standpipe lines shall be of a minimum size of 4 in. (101.6 mm) diameter or sized by hydraulic calculations, and shall be increased in diameter as length of pipe increases in order to deliver the rate of water flow at proper pressure, as specified by the authority having jurisdiction.

**3-2.7.2.2** Identification numbers and letters conforming to the sectional identification numbers and letters of the subway track system shall be provided at each surface fire department connection and at each hose valve on 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 tunnels, the identifying signs shall be affixed to tunnel walls at each hose outlet valve, or painted directly on 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 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 $2\frac{1}{2}$ 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 contractor's hose. Such reducers or adapters shall be readily removable by use of fire fighter's hose spanner wrenches.

**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 3-2.7.2.2 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 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** Vent or fan shafts utilized for ventilation of subway tunnels shall not terminate at grade on any vehicle roadway.

**3-2.8.2** 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 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 over or within 25 ft (7.6 m) of a subsurface structure measured horizontally from the outside wall of such subsurface structure unless provided with an approved leak detection monitoring 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 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 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 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 grating or entrance or exit from a subway.

**3-2.8.6 Existing Storage Tanks in or under Buildings.** 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.

**3-2.8.6.1** 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 provisions of Appendix C of NFPA 30, *Flammable and Combustible Liquids Code*.

**3-2.8.7** 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 provisions of Appendix C of NFPA 30, *Flammable and Combustible Liquids Code*.

**3-2.8.7.1** 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 section 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.

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

**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 shall be provided on the gates or adjacent thereto that clearly identifies the route and location of each gate.

**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.**

**3-4.2.1** 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 section 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.

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

**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 maximum 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 Vehicles

**4-1 Applicability.**

**4-1.1 New Vehicles.** All new passenger-carrying fixed guideway transit vehicles shall be, as a minimum, designed and constructed to conform with the requirements set forth in this chapter.

**4-1.2 Retrofit.** Where existing fixed guideway transit vehicles are to be retrofitted, the appropriate sections of the standard shall apply only to the extent of such retrofit.

**4-2 Construction.**

**4-2.1** This standard is prepared with the intent to provide minimum requirements for those instances where noncombustible materials (as defined in Section 1-5) are not used due to other considerations in the design and construction of the vehicle. *(See B-2.4.3.)*

**4-2.2 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.

**4-2.3 Structural Fire Resistivity.** Portions of the vehicle body separating major ignition, energy, or fuel-loading sources from the passenger compartment 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.

**4-2.3.1 Component Test Criteria.**

**4-2.3.1.1** 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 E119), *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*, meet the following criteria:

(a) Resist temperature rise of 250°F (139°C) average and 325°F (181°C) single point temperature rise on the unexposed surface of the specimen.

(b) Resist flaming ignition of cotton waste on the unexposed surface of the specimen.

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

(d) As 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.).

**4-2.3.1.2** 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.

**4-2.3.2** Where vehicles are powered by overhead supply (trolley wire, catenary, etc.), roof design consideration shall be given to prevention of arc penetration and susceptibility of ignition in materials in the roof assembly.

**4-2.3.3** All floor, wall, and roof openings and penetrations shall be adequately sealed/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.

**4-2.4 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 risk assessment for transit 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 risk for materials and finishes used in a vehicle interior are to do a hazard load analysis (Appendix D) or use appropriate material properties (Table 4-2.4). The aforementioned materials and finishes shall include interior walls, floor coverings, ceiling, seats, glazing, transparencies, partitions, elastomer, and nonelectrical insulation.

Table 4-2.4 contains test procedures and minimum performance requirements for interior materials.

**4-2.5 Electrical Insulation.** Control wire and power cable shall be capable of passing the following tests:

(a) Wires for control and other low voltage (less than 100V ac and 150V 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 Underwriters Laboratories Standard 44, *Rubber-Insulated Wires and Cables*, for thermosetting insulation and Underwriters Laboratories Standard 83, *Thermoplastic-Insulated Wires*, 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 min after the start of the test.

**4-2.6 Equipment Arrangement.** Vehicle design shall arrange equipment apparatus external to the passenger compartment, where practical, to isolate potential ignition sources from combustible material and to control fire and smoke propagation. Where it is necessary to install equipment in passenger cars, suitable shields or enclosures shall be provided to isolate the equipment from the passenger compartment.

**4-2.6.1** Materials used for underfloor ducting and plenums serving the car interior shall be noncombustible.

**4-3 Electrical Fire Safety Requirements.**

**4-3.1 General Construction.** All motors, motor control, current collectors, and auxiliaries shall be of a type and construction suitable for use on fixed guideway transit vehicles.

**4-3.2 Gap and Creepage.**

**4-3.2.1 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.

**Table 4-2.4 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 |
|---|---|---|---|
| Seating | Cushion[1,2,5,9] | ASTM D3675 | $I_s \leq 25$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| | Frame[1,5,8] | ASTM E162 | $I_s \leq 35$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| | Shroud[1,5] | ASTM E162 | $I_s \leq 35$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| | Upholstery[1,2,3,5] | FAR 25.853 (Vertical) | Flame time ≤ 10 sec; burn length ≤ 6 inch |
| | | ASTM E662 | $D_s(4.0) \leq 250$ coated<br>$D_s(4.0) \leq 100$ uncoated |
| Panels | Wall[1,5] | ASTM E162 | $I_s \leq 35$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| | Ceiling[1,5] | ASTM E162 | $I_s \leq 35$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| | Partition[1,5] | ASTM E162 | $I_s \leq 35$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| | Windscreen[1,5] | ASTM E162 | $I_s \leq 35$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| | HVAC ducting[1,5] | ASTM E162 | $I_s \leq 35$ |
| | | ASTM E662 | $D_s(4.0) \leq 100$ |
| | Window[4,5] | ASTM E162 | $I_s \leq 100$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| | Light diffuser[5] | ASTM E162 | $I_s \leq 100$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| Flooring | Structural[6] | ASTM E119 | Pass |
| | Covering[7] | ASTM E648 | C.R.F. $\geq 0.5 w/cm^2$ |
| Insulation | Thermal[1,2,5] | ASTM E162 | $I_s \leq 25$ |
| | | ASTM E662 | $D_s(4.0) \leq 100$ |
| | Acoustic[1,2,5] | ASTM E162 | $I_s \leq 25$ |
| | | ASTM E662 | $D_s(4.0) \leq 100$ |
| Miscellaneous | Elastomers[1] | ASTM C542 | Pass |
| | Exterior shell[1,5] | ASTM E162 | $I_s \leq 35$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |
| | Component box covers[1,5] | ASTM E162 | $I_s \leq 35$ |
| | | ASTM E662 | $D_s(1.5) \leq 100$; $D_s(4.0) \leq 200$ |

Notes

1. Materials tested for surface flammability should not exhibit any flaming running, or flaming dripping.
2. The surface flammability and smoke emission characteristics of a material should be demonstrated to be permanent by washing, if appropriate, according to FEDSTD-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 D2724. Materials that cannot be washed or dry-cleaned should be so labeled and should meet the applicable performance criteria after being cleaned as recommended by the manufacturer.
4. For double window glazing, only the interior glazing should meet the material requirements specified herein; the exterior need not meet those requirements.
5. ASTM E662 maximum test limits for smoke emission (specific optical density) should be measured in either the flaming or nonflaming mode, depending on which mode generates the most smoke.
6. Structural flooring assemblies should meet the performance criteria during a nominal test period determined by the transit agency. The nominal test period should not be less than 15 minutes. Only one specimen needs to be tested. A proportional reduction may 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 (ducts, etc.) should be designed against acting as conduits for fire and smoke.
7. Carpeting should be tested in accordance with ASTM E-648 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.

**4-3.2.2 Air Gap.** The air gap distances between voltage potentials (up to 2,000 volts) and ground shall comply with the following formula:

Gap (inches) = 0.125 + (0.0005 × nominal voltage).

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

**4-3.2.3 Creepage Distance.** Creepage distance for voltage potentials (up to 2,000 volts) to ground in ordinary enclosed environments shall comply with the following formula:

Creepage (inches) = 0.125 + (0.001875 × 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.

**4-3.3 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.

**4-3.4 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.*

**4-3.5 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 beyond resistor supports, horizontally, 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:

(a) Ventilation airflow, if appropriate.

(b) Temperature controls, if appropriate.

(c) 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.

**4-3.6** 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.

**4-3.7 Wiring.**

**4-3.7.1** In no case shall wire smaller than the sizes listed below be used:

(a) No. 14 AWG: for wire that is pulled through conduits or wireways or installed exposed between enclosures,

(b) No. 22 AWG: for wire used on electronic units, cards, and card racks,

(c) No. 18 AWG: for all other wire including wire laid in (rather than pulled through) wireways.

**4-3.7.2 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 4-3.7.1.

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

**4-3.7.3 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 or combination of the following ways:

(a) In raceways: metallic and nonmetallic, rigid or flexible.

(b) In enclosures boxes, cabinets for apparatus housing.

(c) Exposed: cleated, tied, or secured by other means.

Firestops shall be provided in raceways to control 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 same. 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.

**4-3.8 Overload Protection.**

**4-3.8.1 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.

**4-3.8.2 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.

**4-3.8.3 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.

**4-3.9 Battery Installation.** The design of battery installation and circuitry shall include the following:

(a) Minimal use of organic material, particularly those having hygroscopic properties.

(b) Fire retardant treatment for necessary organic materials used.

(c) Battery chargers designed for protection against overcharging.

(d) Use of smoke and heat detectors, if appropriate.

(e) Use of an emergency battery cut-off switch, if appropriate.

(f) Isolation of battery compartment from car interior using noncombustible materials as defined in Section 1-5, if appropriate.

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

**4-5 Emergency Egress Facilities.**

**4-5.1** Each vehicle shall be provided with emergency exit facilities on the sides or in the end(s). Alternate emergency exit facilities, as necessary for the type of vehicle, shall be approved by the authority having jurisdiction.

**4-5.2** 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.

**4-5.3 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 hr.*

**4-6 Protection.**

**4-6.1 General.** During normal vehicle operation, protective devices shall not introduce new hazards.

**4-6.2 Communications.**

**4-6.2.1** Each manually operated vehicle shall be equipped with a communication system consisting of the following:

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

(b) A radio system whereby the train operator can communicate with the central supervising station, and

(c) 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.

**4-6.2.2** Each AGT system vehicle shall be equipped with a communication system consisting of the following:

(a) A public address (PA) system whereby the central supervising station can make announcements to the passengers, and

(b) A system whereby the passengers can communicate with the central supervising station.

**4-6.2.3** Unauthorized opening of doors or emergency exit facilities on vehicles shall be communicated to the central supervising station or train operator.

**4-6.3 Portable Fire Extinguishers.** Each vehicle or operator's cab shall be equipped with an approved portable fire extinguisher (*see NFPA 10, Standard for Portable Fire Extinguishers*) except where sufficient wayside extinguishers, standpipe systems, or other fire fighting equipment are available.

**4-6.4 Lightning Protection.**

**4-6.4.1** 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.

**4-6.4.2** 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.

**4-6.5 Heater Protection.** All heater elements shall incorporate protective devices for the following failures:

(a) Ventilation airflow, if appropriate.
(b) Temperature controls, if appropriate.
(c) 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.

**4-6.6 Testing and Maintenance.**

**4-6.6.1 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*, and IEEE Standard 11, *Standard for Rotating Electric Machinery for Rail and Road Vehicles*, and any additional tests specified by the authority having jurisdiction.

**4-6.6.2 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.

**4-7 Vehicle Support and Guidance System.** The vehicle support and guidance system (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 5 Vehicle Storage and Maintenance Areas

**5-1 General.** The following requirements are directed toward maintaining adequate fire protection in all transit vehicle storage and maintenance areas. Implementation of these requirements shall be according to the authority having jurisdiction and applicable local codes.

**5-2 Open Areas.**

**5-2.1 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*.

**5-2.2 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 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.

**5-2.3 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.

**5-2.4 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*.

**5-3 Structures.**

**5-3.1 Structural Requirements.** Structures shall be of noncombustible construction in accordance with NFPA 220, *Standard on Types of Building Construction*.

**5-3.2 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.

**5-3.2.1** Oil separators, grease, 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.

**5-3.2.2** 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 perform their designed function. Any flammable liquids and greases shall be removed to an area approved for disposal.

**5-3.3 Floors.** The surface of the grade floor of storage or maintenance areas shall be of noncombustible material.

**5-3.4 Roofs.** Roof deck coverings shall be tested in accordance with NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*, Class A or Class B, and shall be listed.

**5-3.5 Electrical Requirements.**

**5-3.5.1** 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 C-2, *National Electrical Safety Code*; and applicable local codes as called for by the authority having jurisdiction.

**5-3.5.2 Traction Power.**

**5-3.5.2.1 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 C-2, *National Electrical Safety Code*.

**5-3.5.2.2 Power Rail Conductors.** Power rails (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 C-2, *National Electrical Safety Code*.

**5-3.5.2.3 Emergency Power Shutoff.** All traction power conductors shall have emergency power shutoff devices or means in accessible locations.

**5-3.6 Maintenance Pit Areas.**

**5-3.6.1** 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 and equipment shall be of noncombustible construction. *(See also 5-3.8.1.)*

**5-3.6.2** Walls, floors, and piers shall be of masonry or concrete.

**5-3.6.3** Pits shall have at least two exits. Steps shall be noncombustible and constructed with no free space underneath.

**5-3.6.4** Pits and subfloor work areas shall be kept clean. Smoking shall be prohibited in pits and subfloor maintenance areas.

**5-3.7 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*.

**5-3.8 Ventilation.**

**5-3.8.1 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.

**5-3.8.2 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 Materials*.

**5-3.9 Draft Stops.** Permanent draft stops in sprinklered buildings shall be installed in structures having a height of over 25 ft (7.6 m) to top of roof trusses. Draft stops shall be constructed of rigidly supported noncombustible material. The authority having jurisdiction shall be consulted with regard to the exact location of these draft stops. *(See NFPA 204M, Guide for Smoke and Heat Venting.)*

**5-4 Fire Protection Suppression Systems.**

**5-4.1 Automatic Suppression Systems.** An approved automatic sprinkler system shall be installed in all areas of enclosed structures used for storage and maintenance of transit 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 in accordance with NFPA 72, *National Fire Alarm Code*.

**5-4.2 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*.

**5-4.3 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 and Hose Systems*.

**5-4.4 Portable Fire Extinguishers.**

**5-4.4.1 General.** Fire extinguishing equipment and devices shall be provided in accordance with NFPA 10, *Standard for Portable Fire Extinguishers,* subject to the provisions of 5-4.4.2 through 5-4.4.4.

**5-4.4.2 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.

**5-4.4.3 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-B-C fires. The number and capacity of such units shall be determined by the authority having jurisdiction.

**5-4.4.4** 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.

**5-5 Operations and Maintenance.**

**5-5.1 Vehicle Placement.** Transit vehicles shall be so placed and tracks shall be arranged to allow a minimum clearance of 36 in. (914 mm) between the sides of adjacent transit 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*.

**5-5.2 Vehicle Maintenance.**

**5-5.2.1 Vehicle Electrical Systems.** Vehicle electrical systems, including battery circuits, shall be deenergized except in those cases in which an energized circuit is necessary to accomplish the required maintenance.

**5-5.2.2 Batteries.** Transit 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.

**5-5.2.2.1** 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 Materials*. 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*.

**5-5.2.2.2** Batteries shall be charged at a rate (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 prominently displayed.

(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.

**5-5.3 Painting/Cleaning/Paint Removal.**

**5-5.3.1** 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*.

**5-5.3.2** 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.

**5-5.3.3** 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.

**5-5.3.4** 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 and Combustible Materials*.

**5-5.3.5** 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 automatically close.

**5-5.4 Storage of Painting/Cleaning Liquids.** Storage of painting/cleaning liquids shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.

**5-5.5 Welding.**

**5-5.5.1** All welding operations performed on component transit vehicle parts on the transit vehicle shall be in accordance with NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*.

**5-5.5.2** 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.

**5-5.5.3** Welding equipment shall have no electrical components other than flexible lead cables within 18 in. (457 mm) of the floor.

**5-5.5.4** Only qualified welders, trained in the techniques and familiar with the hazards involved, shall be permitted to do this work.

**5-5.6 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, Maintenance, and Operation*; ANSI B56.1, *Safety Standard for Low Lift and High Lift Trucks*; and as determined by the authority having jurisdiction.

**5-5.6.1 Fuel Handling.** The storage and handling of liquefied petroleum gas (LP-Gas) shall be in accordance with NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*.

**5-5.6.2** The storage and handling of liquid fuels (gasoline and diesel) shall be in accordance with NFPA 30, *Flammable and Combustible Liquids Code*, and local codes.

## Chapter 6 Emergency Procedures

**6-1 General.** The authority, which is responsible for the safe and efficient operation of a fixed guideway transit system, shall anticipate and plan for emergencies that could involve the system. Participating agencies shall be invited to assist with the preparation of the emergency procedure plan.

**6-2 Emergencies.**

**6-2.1** The following types of emergencies shall be considered as requiring the invoking of the emergency procedure plan:

(a) Fire or a smoke condition on a train (passenger or work) or any other part of the system.

(b) Fire or a smoke condition adjoining or adjacent to the system that threatens the system or disrupts service.

(c) Collision or derailment involving one or more cars.

(d) Loss of electric power resulting in a stalled train(s) and loss of illumination.

(e) Evacuation of passengers from a train under adverse conditions where they require assistance.

(f) Panic of passengers.

(g) Disabled or stalled trains under adverse conditions.

(h) Serious flooding condition due to water main break, heavy rain, poor drainage, loss of electric power, or failure of pumping equipment.

(i) Structural collapse or imminent collapse that threatens system.

(j) Seepage of petroleum products or flammable, toxic, or irritating vapors into system.

(k) Serious vandalism or other criminal acts, such as a bomb threat.

(l) First aid or medical attention required by passengers.

(m) Extreme weather conditions, such as heavy snow, rain, high winds, high heat, low temperatures, or sleet and ice conditions, causing disruption of service.

(n) Earthquake.

**6-3 Emergency Procedure Plan.**

**6-3.1** The emergency procedure plan shall include, but not be limited to, the following:

(a) Name of plan; name of authority; and date adopted, reviewed, and revised.

(b) Policy, purpose, scope, and definitions.

(c) Participating agencies, top officials, and signatures of executives signing for each agency.

(d) Safety during emergency operations.

(e) Purpose and operation of central supervising station and alternate central supervising station.

(f) Command post and auxiliary command post, and their purpose and operation.

(g) Communications. Radio, telephone, and messenger service available at central supervising station and command post. Also, efficient operation of those facilities.

(h) Fire detection, fire protection, fire extinguishing equipment, and exit and fan facilities available in system. Details of the type, amount, location, and method of utilization.

(i) Procedures for fire emergencies. Various types of fire emergencies, agency in command, and procedures to follow.

(j) Maps and plans of complex areas of the system, such as underwater tubes and multilevel stations.

(k) Any additional information and data that the participating agencies desire to have in the plan.

**6-4 Participating Agencies.**

**6-4.1** Participating agencies that shall be summoned by operators of a fixed guideway transit system to cooperate and assist depending on the nature of an emergency include:

(a) Ambulance service.

(b) Building department.

(c) Fire department.

(d) Medical service.

(e) Police department.

(f) Public works, bridges, streets, sewers.

(g) Sanitation department.

(h) Utility companies, gas, electricity, telephone, steam.

(i) Water supply.

(j) Local transportation companies.

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

**6-5 Central Supervising Station (CSS).**

**6-5.1** The authority shall operate a CSS for the operation and supervision of the system.

**6-5.2** The CSS shall be manned 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.

**6-5.3** 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.

**6-5.4** Equipment shall be available and used for recording radio and telephone communications during an emergency.

**6-5.5** CSS personnel shall be thoroughly conversant with the emergency procedure plan and trained to employ it effectively whenever required.

**6-5.6** 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 have equipment readily available.

**6-5.7** The CSS shall be located in an area separated from other occupancies by a 2-hr fire resistance construction. The area shall be used for the CSS and similar activities and shall not be jeopardized by adjoining or adjacent occupancies.

**6-5.8*** 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.

**6-6 Liaison.**

**6-6.1** 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 person. An alternate person with the same information also shall be listed.

**6-6.2** At least once every three months the list shall be reviewed and tested to determine the ability to contact the liaison without delay.

**6-7 Command Post.**

**6-7.1** During an emergency on the system that requires invoking the emergency procedure plan, a command post shall be established by the person in command for the supervision and coordination of all personnel, equipment, and resources at the scene of the emergency.

**6-7.2** The emergency procedure plan shall clearly delineate the authority or participating agency that is in command and responsible for supervision, correction, or alleviation of the emergency.

**6-7.3** 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.

**6-7.4** Participating agencies shall each assign a liaison to the command post.

**6-7.5** The most effective use shall be made of radio, telephone, and messenger service to communicate with participating agencies operating at an emergency.

**6-7.6** 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.

**6-8 Auxiliary Command Post.**

**6-8.1** 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.

**6-8.2** A participating agency, when not in command, shall, when authorized, establish an auxiliary command post to assist with the supervision and coordination of their personnel and equipment.

**6-9 Training, Exercises, Drills, and Critiques.**

**6-9.1** 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.

**6-9.2** 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.

**6-10 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.

**6-11 Removal and Restoring Traction Power.**

**6-11.1** During an emergency, the authority and participating agency personnel shall be carefully supervised so that only the minimum number of essential persons operate on the trainway.

**6-11.2** The emergency procedure plan shall have a clearly defined procedure for removing and restoring traction power.

**6-11.3** Prior to participating agency personnel operating on the trainway, the traction power shall be removed.

**6-11.4** 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.

**6-11.5** When shutdown of traction power is no longer required by a participating agency, control of such power shall be released to the authority.

## Chapter 7 Communications

**7-1 General.** Comprehensive and dependable communications are essential for a serviceable and efficiently operated fixed guideway transit system during emergencies.

**7-2 Central Supervising Station (CSS)/Command Post Relationship.**

**7-2.1** During normal operations, the CSS shall be the primary control for the system.

**7-2.2** 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.

**7-3 Radio Communication.**

**7-3.1** A fixed guideway transit 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.

**7-3.2** 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.

**7-3.3** A radio network shall comprise base transmitters and receivers, antennas, mobile transmitters and receivers, portable transmitters and receivers, and ancillary equipment.

**7-4 Telephone.**

**7-4.1** The system shall have a telephone network of fixed telephone lines and hand sets capable of communication with all stations, structures, offices, power stations and substations, control towers, ancillary rooms and spaces, and locations along the trainway.

**7-4.2** 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.

**7-5 Portable Telephone 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.

**7-6 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.

**7-7 Public Address System.**

**7-7.1** All stations, as determined by the authority having jurisdiction, shall have a public address system for communicating with passengers and employees. *(For communication requirements for vehicles, see 4-6.2.)*

**7-7.2** The CSS shall have the capability of using the public address system to make announcements throughout stations.

**7-7.3** Authority supervisory employees at stations shall have the capability of making announcements throughout their stations on the public address system.

**7-7.4** 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 public address system.

**7-7.5** At times of emergency, the public address system shall be used effectively to communicate to passengers, employees, and participating agency personnel.

**7-8 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 8 Referenced Publications

**8-1** The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

**8-1.1 NFPA Publications.** National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 10, *Standard for Portable Fire Extinguishers*, 1994 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 1994 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*, 1993 edition.

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

NFPA 30, *Flammable and Combustible Liquids Code*, 1993 edition.

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

NFPA 51B, *Standard for Fire Prevention in Use of Cutting and Welding Processes*, 1994 edition.

NFPA 58, *Standard for the Storage and Handling of Liquefied Petroleum Gases*, 1995 edition.

NFPA 70, *National Electrical Code*, 1996 edition.

NFPA 72, *National Fire Alarm Code*, 1993 edition.

NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilating Systems*, 1993 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Materials*, 1995 edition.

NFPA *101*, *Life Safety Code*, 1994 edition.

NFPA 220, *Standard on Types of Building Construction*, 1995 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations*, 1993 edition.

NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*, 1995 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials*, 1990 edition.

NFPA 256, *Standard Methods of Fire Tests of Roof Coverings*, 1993 edition.

NFPA 505, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Maintenance, and Operation*, 1992 edition.

NFPA 1963, *Standard for Fire Hose Connections*, 1993 edition.

**8-1.2 Other Publications.**

**8-1.2.1 ANSI Publications.** American National Standards Institute, 1430 Broadway, New York, NY 10018.

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

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

**8-1.2.2 ASTM Publications.** American Society of Testing Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM C542, *Standard Specification for Lock-Strip Gaskets*, 1994.

ASTM D2724, *Standard Test Method for Bonded, Fused, and Laminated Apparel Fabrics*, 1987.

ASTM D3675, *Standard Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source*, 1994.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 1994.

ASTM E119, Rev. B-92, *Standard Test Method for Fire Tests of Building Construction and Materials*, 1988.

ASTM E136, Rev. A-92, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 1994.

ASTM E162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*, 1994.

ASTM E648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source*, 1994.

ASTM E662-94 *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*, 1994.

**8-1.2.3 IEEE Publications.** Institute of Electrical and Electronic Engineers, Inc., 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.

**8-1.2.4 ICEA Publication.** Insulated Cable Engineers Association, P.O. Box P, South Yarmouth, MA 02664.

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

**8-1.2.5 Underwriters Laboratories Inc.** Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

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

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

**8-1.2.6 U.S. Government Publication.** U.S. Government Printing Office, Washington, DC 20402.

Federal Test Method Standard No. 191A - 1978, *Textile Test Method 5830*, July 1978.

## Appendix A Explanatory Material

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

**A-1-5 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 concerned with product evaluations that is in a position to determine compliance with appropriate standards for the current production of listed items.

**A-1-5 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 Listed.** The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which 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-2-2.3.5** 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 might be considered.

**A-2-5.3.4.2** 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-3-1.5.3** 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 BLS at ends of platforms.

**A-3-2.5** 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** 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-3-4.3** 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-6-5.8** 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 Air Quality Criteria in Emergencies

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

**B-1 General.** In this appendix, criteria for protection of passengers and employees during emergency situations are presented for air quality, temperatures, and velocities.

**B-1.1** To a large extent, the quantitative aspects of the criteria for emergency situations will be arbitrary because there are no universally accepted tolerance limits pertaining to air quality, temperatures, and velocities. In fact, the tolerance limits vary with age, health, weight, sex, and acclimatization. Most of the studies on human tolerance to adverse situations have dealt with exposure tests on healthy acclimated adults. These individuals can survive in environments potentially harmful to the less physically fit. It must be assumed, however, that under emergency conditions in subways some of the passengers might be infants, aged, or suffering from respiratory or cardiac ailments. The tolerances of these passengers will form the basis upon which criteria must be established. Little information is available on the physiological tolerance limits of people with health impediments, especially for short but intense exposures.

**B-2 Air Quality Criteria in Emergencies.** During subway emergencies involving fire or generation of smoke, the products of combustion or electrical arcing will produce gases and aerosols, some of which are potentially toxic or incapacitating. All the aerosols in smoke also tend to limit visibility. The intended effects of all emergency ventilation

equipment, therefore, are to provide, in the event of fire, control of smoke migration and an effective means to purge smoke and supply fresh air to passengers and fire department personnel during evacuation and early fire-fighting operations.

**B-2.1** Since some emergency situations could conceivably occur where all the passengers cannot be provided with fresh air for the entire length of an evacuation route, criteria are required to maintain air quality for those passengers. Such a situation would occur, for example, when there is a fire in the middle of a train. Because fresh air might come from only one direction, passengers in one-half of the train could be exposed to air containing some combustion products while passengers in the other half could receive fresh air. Sufficient fresh air, however, must be supplied to passengers downwind of a fire to dilute adequately any harmful combustion product.

**B-2.1.1** The usual way in which potentially harmful gases or aerosols enter a human body is through the respiratory tract. The physiological reactions of the person depend on the contaminant, its concentration, and exposure time, and will be different for different persons. A person's reaction to potentially harmful combustion products is proportional to a characteristic of the environment that is quantified by the concentration-time product, $C_T$.

**B-2.1.2** The environmental air control engineer, however, will not know during design how much of the smoke and combustion products will be made airborne, nor will he/she know the exposure time of passengers in the smoke. These quantities depend on the nature of the emergency, the construction materials, and the subway's overall emergency policies. Nevertheless, emergency fans must be sized, and some guidance is provided by approximating the concentration-time product, $C_T$, for different airflow rates. *(See Subway Environmental Design Handbook, Vol. I, Principles and Applications.)*

**B-2.2 Emergency Air Temperature Criteria.** It is anticipated that the 140°F (60°C) air temperature will place a physiological burden on a few of the passengers, but the exposure also is anticipated to be brief and to produce no lasting harmful effects. Passengers should not be exposed to maximum air temperatures exceeding 140°F (60°C) during emergencies. The heat released from a fire depends on the type and amount of material burning as well as the rate at which it burns. In a subway, materials capable of supporting combustion are plastics, oil, wood, paper, cardboard, and bituminous products.

**B-2.2.1** When the severity of subway fires is studied with respect to human environmental criteria, the air temperature in the absence of toxic smoke is found to be a limiting criterion for human survival.

**B-2.3 Emergency Air Velocity Criteria.** Ventilation equipment in a subway emergency must sweep out heated air, remove smoke of any fire, and remove fumes from any electric arcs. In essentially all emergency cases, protection of the passengers and employees is enhanced by the prompt activation of emergency ventilation procedures as planned in advance.

**B-2.3.1** When emergency ventilation air is needed in evacuation routes, it might be necessary to expose passengers to air velocities higher than those permitted by normal nuisance considerations. The only upper limit to the ventilation rate occurs when the air velocity becomes great enough to create a hazard to persons walking in that airstream. According to the descriptions of the effects of various air velocities given in the Beaufort scale, passengers under emergency conditions can tolerate as much as 2200 fpm (11.2 m/sec).

**B-2.3.2** The minimum air velocity within the tunnel section experiencing the fire emergency should be sufficient to mitigate back layering of the smoke, i.e., a flow of smoke in the upper cross section of the tunnel opposite in direction to the forced ventilation air.

**B-2.4 Emergency Ventilation Fans.** In some instances it might be desirable to locate remote control operation of the fans at a surface location accessible to authorized fire and emergency personnel.

**B-2.4.1** In response to an emergency situation resulting from fire or generation of smoke, the ventilation equipment can be used to:

(1) Move combustion and decomposition products and heat in a preferred direction;

(2) Lessen the airborne concentration of combustion and decomposition products; and

(3) Lessen the heat buildup and air temperatures in the subway. A consensus on definitive design guidelines for subway emergencies is unavailable because of the present level of the state of the art. Ventilation system uses in subway emergencies vary depending on how each operating transit agency responds to all elements involved in combating an emergency. Each subway system must integrate all the elements that respond to emergencies to form an overall policy. The qualitative relationships discussed herein will assist subway operators in taking preventive and corrective actions to guard against fires and other related emergencies.

**B-2.4.2** Increasing the airflow rate in the tunnel will decrease the airborne concentration of potentially harmful chemical compounds (referred to hereinafter by the general term "smoke"). The decrease in concentration will be beneficial to those exposed to the compounds. However, a situation can arise in which the smoke source is completely removed from the passengers, and actuating any fans would draw the smoke to the evacuation routes. Under these conditions the fans should not be activated until it is safe to do so. To make decisions under these circumstances requires a rapid and thorough communication system so that the responsible personnel can make judgments based on information available consistent with established emergency policies.

**B-2.4.3** The effectiveness of an emergency ventilation system in providing a sufficient quantity of noncontaminated air and in minimizing the hazard of smoke back layering in an evacuation pathway is a function of the fire load. The fire load in a trainway results from the burning rate of a train, which in turn is a function of the combustible load in Btu of the vehicle.

Combustible load of a vehicle is defined as the total amount of Btu emitted by its total combustion. The load for a vehicle is determined by multiplying the aggregate weight in pounds of similar materials by its heat content in Btu/lb and taking the sum of the loads of the different materials.

The heat content of the materials should be as determined in accordance with NFPA 259, *Standard Test Method for Potential Heat of Building Materials*.

Available test data on combustibility of material utilized in transit vehicles is either incomplete or not directly applicable to the situation of a train fire in an underground confined trainway. Once a fire has penetrated to the interior (passenger compartment) of a vehicle, its combustibility load becomes a significant factor in the rate of propagation of the fire to other vehicles of the train.

Practical design considerations of emergency ventilation systems, including constraints of limiting emergency air velocity criteria *(see B-2.3)*, are such that high vehicle combustible loads could negate the capability of the emergency ventilation system to achieve its desired objectives.

Consequently, the combustible load of a vehicle above the floor of the car (including floor covering and adhesion material) should not exceed 45,000 Btu/ft$^2$ (0.511 × 10$^9$ J/m$^2$) of gross floor area. The figure of 45,000 Btu/ft$^2$ (0.511 × 10$^9$ J/m$^2$) has been derived as one that is readily obtainable based on a comparison of available data for seven different makes, sizes, and types of rapid-transit vehicles. Values of 30,000 Btu/ft$^2$ (0.341 × 10$^9$ J/m$^2$) can be achieved if deemed desirable. Values as high as 135,000 Btu/ft$^2$ (1.533 × 10$^9$ J/m$^2$) exist.

**B-2.5 Smoke Generation and Wiring Insulation.**

**B-2.5.1** Electrical shorts have probably been the most common cause of smoke in subways. Electrical shorts can result in an application of intense heat to combustible or decomposable materials located adjacent to electrical conductors. Due to electrical short circuits smoke comes from the burning of insulation and oily substances accumulated in the insulation, or from the vaporizing or fuming from the conductor itself.

**B-2.5.2** The effects of smoke are reduced if:

(a) *The amount of smoke generated is reduced.* This can be accomplished by design, maintenance, or both to minimize the quantity of material that might produce smoke. Maintenance should include clearing of combustible deposits of potential smoke sources from underneath the train. Materials used in a subway system should be selected for minimum smoke production. The smoke-producing material might be isolated (for example, by enclosing wiring in conduit). The smoke produced by short circuits might be reduced by de-energizing the circuit. All aspects of subway design, including maintenance procedures, should incorporate the philosophy of reducing sources of smoke.

(b) *The passengers' exposure time is reduced.* The passengers' exposure time can be reduced by limiting the length of time that the smoke is generated, or by evacuation procedures that enable the passengers to get away from the smoke quickly.

**B-2.5.3** The amount of material available for smoke generation and the evacuation procedures to be used involve consideration of numerous design features, while the amount of air flowing through the tunnels is directly related to the fan capacity installed.

**B-2.5.3.1** The decomposition rate of materials that cannot support combustion depends on the rate and quantity of heat externally applied to the materials and not on the airflow to the materials. Potential smoke evolution from these materials can be limited by material selection, control, and correction of electrical shorts, and by minimizing the accumulation of oily substances in the materials. Increased airflow is desirable to dilute whatever smoke is generated.

**B-2.5.3.2** All insulations should be resistant to moisture as demonstrated by an essentially flat response of a plot of power factor vs. time when tested by immersion of a No. 14 AWG wire with 47 mils of insulation in 194°F (90°C) continuously for six months while energized with 600 volts dc continuous with the power factor measured every month at 80 volts mil. Other physical and electrical properties of the insulations should conform to those given for the type of insulation in ICEA S-19-81/NEMA WC3, *Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy*, for rubber insulated wire and cable and to ICEA S-66-524/NEMA WC7, *Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy*, for crosslinked polyethylene wire and cable or ICEA S-68-516/NEMA WC8, *Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy*, for ethylene-propylene-rubber-insulated wire and cable.

**B-2.5.4** Insulation and jacketing materials yielding lowest amounts of toxic or corrosive products during combustion are preferred; however, the electrical integrity of the wire and cable systems and the nonfire propagating properties in a fire of the constructions of wire and cable systems should be given a high priority when selecting materials.

## 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 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 two 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 signifi-

cant 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 4 and multiplying by 1½. The 1½ is a distribution curve correction and can be varied for a particular system if sufficient data is available for verification. Both link loads (number of passengers traveling between two stations over a given period) and entraining loads (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-min entraining load and the peak 15-min link load, respectively, by dividing by the number of trains arriving at the station during 15 min 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 2-5.3.4. The exit route is broken down into sequential horizontal and vertical segments and 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 (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 must be taken to be sure that the most restrictive elements are included in the calculations.

For instance, if 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), this door would be considered to provide 1 unit of exit width. The stair, with code-complying handrails, would be considered to provide 2 units of exit width. Using the capacities specified in 2-5.3.4, the door has a capacity of 50 ppm per lane (unit) of exit width. The stair has a capacity of 35 ppm per lane (unit) in the up direction or 40 ppm per lane (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 either stair condition, meaning that the door should be used in the capacity calculations. If the door were wider, for example enough to provide 2 units of exit width, the capacity of the door would be 100 ppm. The stair capacity would then be more restrictive, 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 made a decision (selecting 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, for the platform exits, by subtracting the walking travel time on the platform from the platform exits flow time, and for each of the remaining circulation elements, by subtracting the maximum of all previous element flow times.

The symbols used in the sample calculations that follow represent the walking times, flow times, and waiting times where:

T = Total walking travel time for the longest exit route.
$T_1$ = Walking travel time on the platform.
TX = 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. 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).

The station has one paid area separated from the outside by a fare array containing 4 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

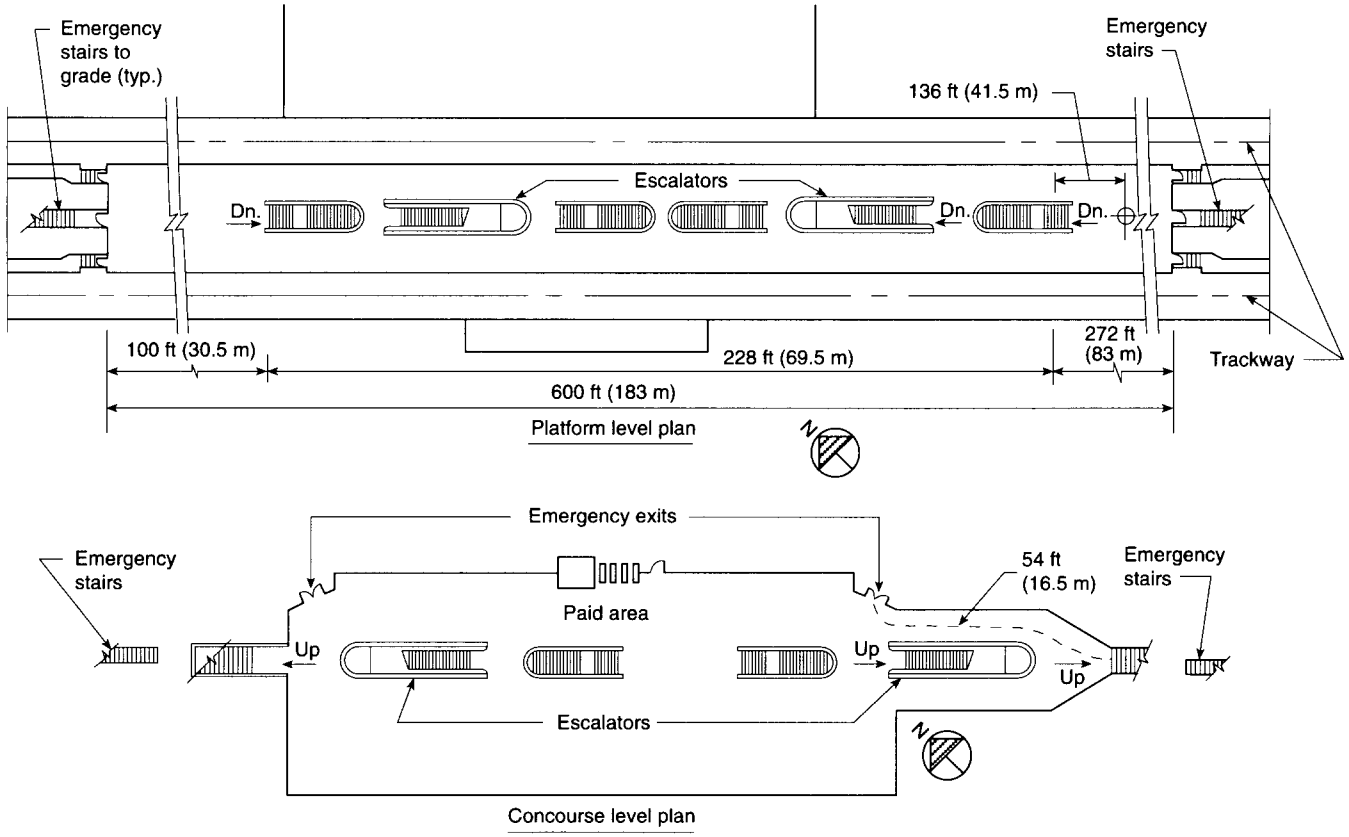


**Figure C-1.2 Center platform station.**

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 of Table C-1.2, the time to clear the platform is found to be 3.469 minutes. This meets the requirement of 2-5.3.2.

In Test No. 2 of Table C-1.2, the time to reach a point outside any enclosing structure is found to be 4.289 minutes. This meets the requirement of 2-5.3.3.

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. 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 turnstyle 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 need to be done to properly analyze this type of station. The sample calculation shows the effect of discounting one of

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

| Element | Direction | No. Units | No. Lanes | Capacity/ Lane | | = PPM |
|---|---|---|---|---|---|---|
| PLATFORM TO CONCOURSE | | | | | | |
| Stairs | —Up | 0 | 3 | 35 | = | 0 |
| | —Down | 4 | 3 | 40 | = | 480 |
| Escalator | —Up | 0 | 2 | 35 | = | 0 |
| | —Down* | 1 | 2 | 40 | = | 80 |
| Emer. Sta | —Up | 0 | 2 | 35 | = | 0 |
| | —Down | 2 | 2 | 40 | = | 160 |
| Escalator Test: 11.11% (Not >50%) | | | | Total | | 720 |
| *One escalator discounted per 2-5.4.1.1 | | | | | | |
| THROUGH FARE BARRIERS | | | | | | |
| Turnstiles | | 0 | 1 | 25 | = | 0 |
| Fare Gates | | 4 | 1 | 50 | = | 200 |
| Service Gates | | 1 | 2 | 50 | = | 100 |
| Emergency Gates | | 2 | 3 | 50 | = | 300 |
| | | | | Total | | 600 |
| FARE BARRIERS TO SAFE AREA **FARE BARRIERS DISCHARGE TO OUTSIDE** | | | | | | |
| Stairs | —Up | 0 | 3 | 35 | = | 0 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Escalator | —Up | 0 | 2 | 35 | = | 0 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Emer. Sta | —Up | 0 | 0 | 35 | = | 0 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Escalator Test: 0.00% (Not > 50%) | | | | Total | | 0 |

| WALKING TIME FOR LONGEST EXIT ROUTE PLATFORM TO SAFE AREA | | Feet | /FPM | Min. |
|---|---|---|---|---|
| On Platform | T1 | 136 | 200 | 0.680 |
| Platform to Concourse | T2 | 30 | 60 | 0.500 |
| On Concourse | T3 | 54 | 200 | 0.270 |
| Concourse to Grade | T4 | 0 | 50 | 0.000 |
| On Grade to Safe Area | T5 | 10 | 200 | 0.500 |
| Total walking time T = T1 + T2 + T3 + T4 + T5 = | | | | 1.500 |

**Table C-1.2 NFPA 130 Exiting Analysis**
**Station: Sample Center Date: Apr 1, 87 (continued)**

**Test #1**

Evacuate PLATFORM OCCUPANT LOAD(S) from Platform(s) in 4 minutes or less.
W1 (time to clear platform) = PLATFORM OCCUPANT LOAD/ PLATFORM EXIT CAPACITY
W1 = 2498/ 720 = 3.469 minutes

**Test #2**

Evacuate PLATFORM OCCUPANT LOAD from most remote point on platform to a point of safety in 6 minutes or less.
Waiting Time at Platform Exits, Wp [ = W1 − T1]
Wp = [W1 − T1]
Wp = 3.469 − 0.680 = 2.789 minutes
Concourse Occupant Load = Platform Occupant Load − (W1 × Emergency Stair Capacity)
Concourse Occupant Load = 2498 − 555
Concourse Occupant Load = 1943 Persons

Waiting Time at Fare Barriers, WF [ = W2 − W1]
W2 = Concourse Occupant Load / Fare Barrier Exit Capacity
W2 = 1943/ 600 = 3.238 minutes
Wf = W2 − W1
Wf = 3.238 3.469 = 0.000 minutes

Waiting Time at Concourse Exits, Wc [ = W3 − MAX (W2 or W1)]
W3 = Concourse Occupant Load / Concourse Exit Capacity
W3 = 1943/ 0 = 0.000 minutes
Wc = W3 − Max (W2 or W1)
Wc = 0.000 − 3.469 = 0.000 minutes

Total Exit Time [ = T + WP + Wf + Wc]
Total = 1.500+ 2.789+ 0.000+ 0.000
Total = 4.289 minutes

the escalators from concourse to grade. The exit capacity from platform to concourse meets the criteria of 2-5.3.2 in Test No. 1 of Table C-1.3, where the time to clear the platform is found to be 3.267 minutes for the inbound platform and 0.543 minutes for the outbound platform.

In Test No. 2 of Table C-1.3, however, the total exit time (the maximum for the two paths examined) is found to be 6.591 minutes. This does not meet the criteria of 2-5.3.3. Additional exit capacity is needed from concourse to grade.

Additional calculations must also be made to examinethe 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 min or less under this condition.

**C-1.4 Multilevel Platform Stations.** The procedures for calculating exiting times for such stations is similar to the prior sample calculations (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 manning 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.

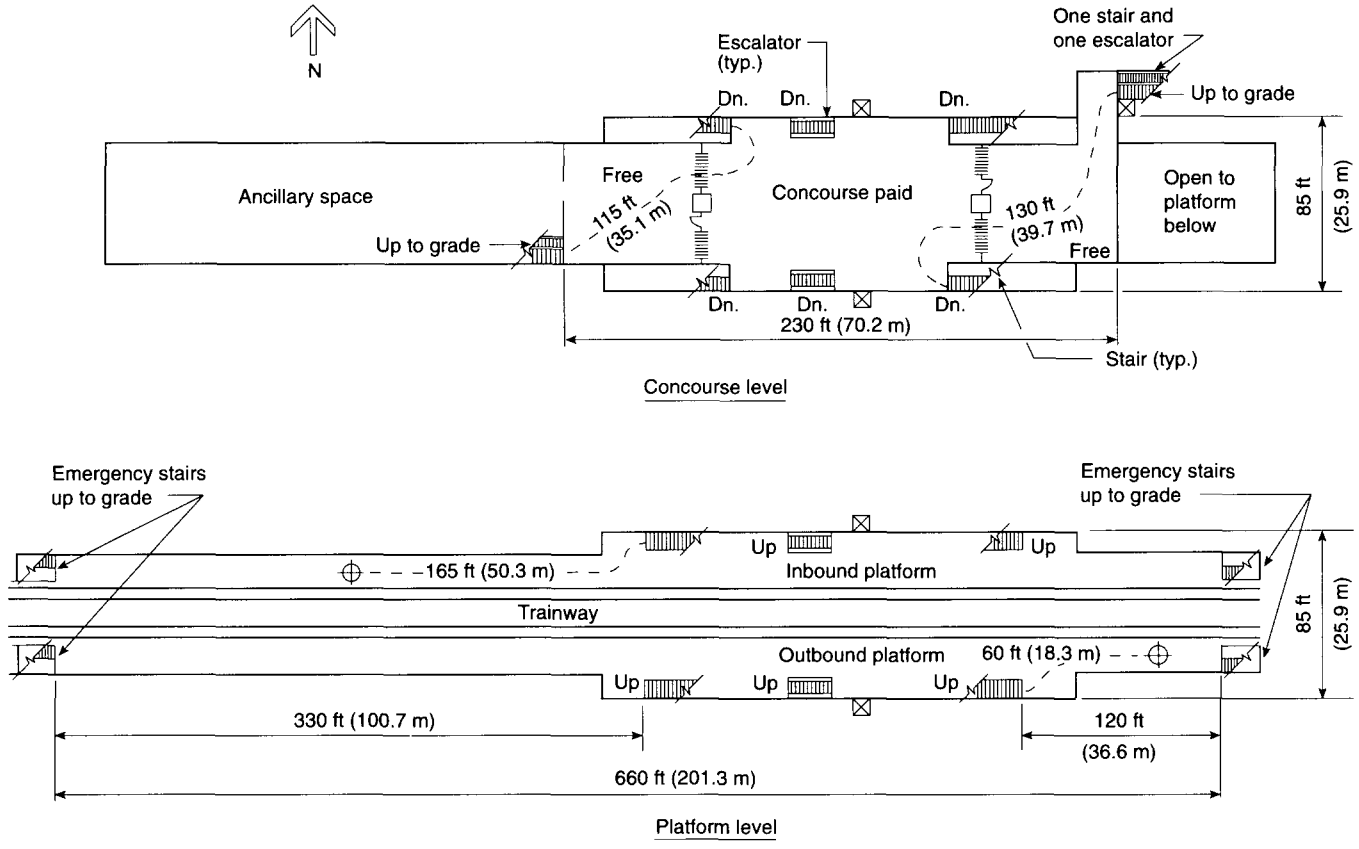


**Figure C-1.3 Side platform station.**

(d) For a fire on the lower level, appropriate assumptions relative to 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: direction of travel, operating speed (if more than one), out of service, and a flashing light that indicates the escalator stopped because of activation of a safety device.

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

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

| Element Direction | | No. Units | No. Lanes | Capacity/ Lane | | = PPM |
|---|---|---|---|---|---|---|
| INBOUND PLATFORM TO CONCOURSE | | | | | | |
| Stairs | —Up | 2 | 3 | 35 | = | 210 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Escalator | —Up | 1 | 2 | 35 | = | 70 |
| | —Down* | 0 | 0 | 40 | = | 0 |
| Emer. Sta | —Up | 2 | 2 | 35 | = | 140 |
| | —Down | 0 | 0 | 40 | = | 0 |
| | | | | Total | 420 | |
| THROUGH FARE BARRIERS | | | | | | |
| Turnstiles | | 12 | 1 | 25 | = | 300 |
| Fare Gates | | 0 | 1 | 50 | = | 0 |
| Service Gates | | 0 | 0 | 50 | = | 0 |
| Emergency Gates | | 1 | 2 | 50 | = | 100 |
| | | | | Total | 400 | |
| FARE BARRIERS TO SAFE AREA | | | | | | |
| Stairs | —Up | 1 | 3 | 35 | = | 105 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Escalator | —Up* | 0 | 2 | 35 | = | 0 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Emer. Sta | —Up | 0 | 0 | 35 | = | 0 |
| | —Down | 0 | 0 | 40 | = | 0 |
| *One escalator test: per 2-5.4.1.1 | | | | Total | 105 | |

WALKING TIME FOR LONGEST EXIT ROUTE

INBOUND PLATFORM

| | | Feet | /FPM | Min. |
|---|---|---|---|---|
| On Platform | T1 | 165 | 200 | 0.825 |
| Platform to Concourse | T2 | 18 | 50 | 0.360 |
| On Concourse | T3 | 115 | 200 | 0.575 |
| Concourse to Grade | T4 | 26 | 50 | 0.520 |
| On Grade to Safe Area | T5 | 10 | 200 | 0.500 |
| Total walking time T = T1 + T2 + T3 + T4 + T5 | | | | 2.330 |

| Element Direction | | No. Units | No. Lanes | Capacity/ Lane | | = PPM |
|---|---|---|---|---|---|---|
| OUTBOUND PLATFORM TO CONCOURSE | | | | | | |
| Stairs | —Up | 2 | 3 | 35 | = | 210 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Escalator | —Up | 1 | 2 | 35 | = | 70 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Emer. Sta | —Up | 2 | 2 | 35 | = | 140 |
| | —Down | 0 | 0 | 40 | = | 0 |
| | | | | | | 420 |
| THROUGH FARE BARRIERS | | | | | | |
| Turnstiles | | 12 | 1 | 25 | = | 300 |
| Fare Gates | | 0 | 1 | 50 | = | 0 |
| Service Gates | | 0 | 0 | 50 | = | 0 |
| Emergency Gates | | 1 | 2 | 50 | = | 100 |
| | | | | | | 400 |
| FARE BARRIERS TO SAFE AREA | | | | | | |
| Stairs | —Up | 1 | 3 | 35 | = | 105 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Escalator | —Up | 1 | 2 | 35 | = | 70 |
| | —Down | 0 | 0 | 40 | = | 0 |
| Emer. Sta | —Up | 0 | 0 | 35 | = | 0 |
| | —Down | 0 | 0 | 40 | = | 0 |
| | | | | | | 175 |

OUTBOUND PLATFORM

| | | Feet | /FPM | Mm. |
|---|---|---|---|---|
| On platform | T1 | 60 | 200 | 0.300 |
| Platform to concourse | T2 | 18 | 50 | 0.360 |
| On concourse | T3 | 130 | 200 | 0.650 |
| Concourse to grade | T4 | 26 | 50 | 0.520 |
| On grade to safe area | T5 | 10 | 200 | 0.050 |
| Total walking time T = T1 + T2 + T3 + T4 + T5 | | | | 1.880 |

**Table C-1.3 NFPA 130 Exiting Analysis**
**Station: Sample Center Date: Apr 1, 87 (continued)**

**Test #1**

Evacuate PLATFORM OCCUPANT LOAD(S) from Platform(s) in 4 minutes or less.

W1 (time to clear platform) = PLATFORM OCCUPANT LOAD/ PLATFORM EXIT CAPACITY

Inbound Platform
W1 = 1372/ 420 = 3.267 minutes

Outbound Platform
W1 = 228/ 420 = 0.543 minutes

**Test #2**

Evacuate PLATFORM OCCUPANT LOAD from most remote point on platform to a point of safety in 6 minutes or less.

INBOUND PLATFORM

Waiting Time at Platform Exits, Wp [= W1 − T1]
Wp = [W1 − T1]
Wp = 3.267 − 0.825 = 2.442 minutes

Concourse Occupant Load = Platform Occupant Load − (W1 × Emergency Stair Capacity)
Concourse Occupant Load = 1372 − 457
Concourse Occupant Load = 915 Persons

Total Concourse Occupant Load = Concourse Load (inbound) + Concourse Load (Outbound) = 915 + 152 = 1067

Waiting Time at Fare Barriers, Wf [= W2 − W1]
W2 = Concourse Occupant Load / Fare Barrier Exit Capacity
W2 = 534/ 400 = 1.335 minutes
Wf = W2 − W1
Wf = 1.335 − 3.267 = 0.000 minutes

Waiting Time at Concourse Exits, Wc [= W3 − MAX (W2 or W1)]
W3 = 534/ 105 = 5.086 minutes
Wc = W3 − Max (W2 or W1)
Wc = 5.086 − 3.267 = 1.819 minutes

OUTBOUND PLATFORM

Waiting Time at Platform Exits, Wp [= W1 − T1]
Wp = [W1 − T1]
Wp = 0.543 − 0.300 = 0.243 minutes

Concourse Occupant Load = Platform Occupant Load − (W1 × Emergency Stair Capacity)
Concourse Occupant Load = 228 − 76
Concourse Occupant Load = 152 Persons

Waiting Time at Fare Barriers, Wf [= W2 − W1]
W2 = Concourse Occupant Load / Fare Barrier Exit Capacity
W2 = 534/ 400 = 1.335 minutes
Wf = W2 − W1
Wf = 1.335 − 0.543 = 0.792 minutes

Waiting Time at Concourse Exits, Wc [= W3 − MAX (W2 or W1)]
W3 = Concourse Occupant Load / Concourse Exit Capacity
W3 = 534/ 175 = 3.051 minutes
Wc = W3 − Max (W2 or W1)
Wc = 3.051 − 1.335 = 1.716 minutes
Total Exit Time [= T + Wp + Wf + Wc]
Total = 2.330 + 2.442 + 0.000 + 1.819
Total = 6.591 minutes

## Appendix D Suggested Test Procedures for Fire Risk Assessment

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

The two most important features in fire safety design of a transit 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.

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.

Hazard load calculations provide a way to examine the potential fire hazard of materials used in a transit vehicle interior. Using the example in Table D-1, 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-1 is based on the 3-min release determined at the exposure identified in Table D-1.

The data in Table D-1 is based on tests of materials conducted in accordance with NFPA 263, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products*. The exposure in the NFPA 263 test procedure can be varied depending on 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 in a publication entitled, *Transit Vehicle Material Specification Using Release Rate Tests for Flammability and Smoke*, October 1976, Edwin E. Smith, prepared for the Transit Development Corporation, Washington, DC.

To determine the hazard load in Tables D-2 and D-3:

(1) The 3-min release rate value for each item in Table D-1 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 per $ft^3$.

HAZARD LOAD CALCULATIONS

Interior Volume of a Rail Transit Vehicle Is 4095 $ft^3$ (115.9 $m^3$)

Exposed Surface Areas:

Seating:

Padded (bottom and back) = 365 $ft^2$ (33.9 $m^2$)

Hard back (seat backs) = 133 $ft^2$ (12.4 $m^2$)

Windows:

(65 ft × 7 ft) × 40% × 2 = 365 $ft^2$ (33.9 $m^2$)

Lower walls:

(65 ft × 7 ft) × 60% × 2 = 546 $ft^2$ (50.7 $m^2$)

Light fixture covers:

(65 ft × 0.83 ft) × 2 = 108 $ft^2$ (10 $m^2$)

Floor:

(65 ft × 9 ft) = 585 $ft^2$ (54.3 $m^2$)

Ceiling:

(65 ft × 9 ft) = 585 $ft^2$ (54.3 $m^2$)

Based on extremes of materials in Table D-1, examples of the hazard load calculations for the "best" and "worst" material combinations from available samples are shown in Tables D-2 and D-3, which illustrate the "heat" and "smoke" hazard load. Three-minute release rate values for materials to be used in transit vehicle interiors, when 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-1 and the actual surface area of each material also used.

**Table D-1 Release Rate Data**

| | | "Best" 3-minute Release | | "Worst" 3-minute Release | |
|---|---|---|---|---|---|
| | 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 one cubic foot of air will reduce % transmission by 10% when viewed through a light path of 1 foot.

**Assumed noncombustible aluminum panels.

**Table D-2 Hazard Load Calculations "Best" Loading**

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

*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-propogating 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-3 Hazard Load Calculations "Worst" Loading**

| | Heat Hazard Load | | Smoke Hazard Load | |
|---|---|---|---|---|
| Seating | | | | |
| Padded | 365 sq ft x 2,400 Btu/sq ft = | 876,000 Btu | 365 sq ft x 10,140 "Part."/sq ft = | 3,701,100 "Part." |
| Hardback | 133 sq ft x 300 Btu/sq ft = | 39,900 Btu | 133 sq ft x 2,500 "Part."/sq ft = | 322,500 "Part." |
| Windows | 365 sq ft x 1,500 Btu/sq ft = | 547,500 Btu | 365 sq ft x 600 "Part."/sq ft = | 219,000 "Part." |
| Lower walls | 546 sq ft x 300 Btu/sq ft = | 163,800 Btu | 546 sq ft x 2,500 "Part."/sq ft = | 1,365,000 "Part." |
| Light fixture covers | 108 sq ft x 860 Btu/sq ft = | 92,800 Btu | 108 sq ft x 220 "Part."/sq ft = | 23,760 "Part." |
| Floor | 585 sq ft x 75 Btu/sq ft = | 43,875 Btu | 585 sq ft x 90 "Part."/sq ft = | 52,650 "Part." |
| Ceiling | 585 sq ft x 1,150 Btu/sq ft = | 672,750 Btu | 585 sq ft x 30 "Part."/sq ft = | 17,550 "Part." |
| Total | | = 2,436,705 Btu | Total | = 5,711,560 "Part." |
| Divided by Car Volume = 4,095 $ft^3$ = 595 $Btu/ft^3$ | | | | 1395 "Particles"/$ft^3$ |

## Appendix E Creepage Distance

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

**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 Max) | Control & Power Devices Mounted in Control Group Enclosures (Short Circuit Limits) | Power Resistors, Open Disconnect Devices Mounted Outside Protective Enclosures | Three Rail Shoe Beams and Current Collection Devices (Short Circuit Unlimited by Onboard Devices) |
| Nominal Voltage | Surface | | | | |
| 38 | Horizontal | 1/16 in. | 1/8 in. | 3/4 in. | N/A |
| | Vertical | 1/16 in. | 1/8 in. | 1/2 in. | N/A |
| 230 | Horizontal | 3/8 in. | 5/8 in. | 3 in. | 4 in. |
| | Vertical | 3/8 in. | 5/8 in. | 2 in. | 2 1/4 in. |
| 600 | Horizontal | 3/4 in. | 1 1/4 in. | 7 in. | 10 in. |
| | Vertical | 3/4 in. | 1 1/4 in. | 5 in. | 6 in. |

## Appendix F Referenced Publications

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

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

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1995 edition.

NFPA 204M, *Guide for Smoke and Heat Venting*, 1991 edition.

NFPA 259, *Standard Test Method for Potential Heat of Building Materials*, 1993 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, 1430 Broadway, New York, NY 10018.

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

**F-1.2.2 ASTM Publications.** American Society of Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

ASTM D2724, *Standard Test Methods for Bonded, Fused, and Laminated Apparel Fabrics*, 1987.

ASTM E622, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*, 1994.

ASTM E648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source*, 1994.

**F-1.2.3 ICEA Publications.** Insulated Cable Engineers Association, P.O. Box P, South Yarmouth, MA 02664.

ICEA S-19-81/NEMA WC3, *Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.*

ICEA S-66-524/NEMA WC7, *Cross-Linked-Thermosetting-Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.*

ICEA S-68-516/NEMA WC8, *Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.*

**F-1.2.4 Other Publications.**

Smith, Edwin E., *Transit Vehicle Material Specification Using Release Rate Tests for Flammability and Smoke*, Transit Development Corporation, Washington, DC, 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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