

NFPA 130

Fixed Guideway Transit Systems

1986



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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.

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NFPA 130

Standard for

Fixed Guideway Transit Systems

1986 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 Fall Meeting held November 18-20, 1985 in Baltimore, Maryland. It was issued by the Standards Council on December 10, 1985, with an effective date of December 30, 1985, and supersedes all previous editions.

The 1986 edition of this standard has been approved by the American National Standards Institute.

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 upon 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, *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 incorporates 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.

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

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NFPA 130**Standard for****Fixed Guideway Transit Systems****1986 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 E.

Chapter 1 General**1-1 Scope.**

1-1.1 This standard covers fire protection requirements for underground, surface, and elevated fixed guideway transit systems including trainways, vehicles, transit stations, 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 does not cover requirements for the following:

- (a) Conventional freight or passenger railroad systems including those which provide commuter services.
- (b) Buses and trolley coaches.
- (c) Any other system of transportation not included in the definition of fixed guideway transit system.
- (d) Automated Guideway Transit (A.G.T.). AGT is a class of transportation system in which unmanned vehicles are operated on fixed guideways along an exclusive right-of-way.

1-1.2.1 To the extent where a system, including those listed in 1-1.2(a) through (d), introduces hazards of a similar nature to those addressed herein, this standard may 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 which will provide a reasonable degree of safety from fire and its related hazards.

1-3 Characteristics of Firesafety. Firesafety on a fixed guideway transit system is achieved through a composite

of facility design, operating equipment, hardware, procedures and software subsystems which are integrated to provide requirements for the protection of life and property from the effects of fire. The level of firesafety 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 shall also 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 quickly be equipped, 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."

NOTE: 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 or 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 which is in a position to determine compliance with appropriate standards for the current production of listed items.

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.

NOTE: 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, 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 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."

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.

Engineering Analysis (Fire Hazard/Fire Risk Assessment). An analysis which evaluates all the various factors that affect the firesafety 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 firesafety 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 guidance methods involving positive mechanical contact with the fixed way, 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.

Person in Command. A designated person of the Authority or responsible fire or police representative on the scene of an emergency fully responsible at the Command Post.

Noncombustible. A material which, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors, when subjected to fire or heat. Materials reported as noncombustible, when tested in accordance with the *Standard Method of Test for Noncombustibility of Elementary Materials*, ASTM E136, shall be considered noncombustible materials.

Participating Agency. A public, quasi-public or private agency which has agreed to cooperate with and assist the Authority during an emergency.

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 and/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 so as 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.

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

System. See "Fixed Guideway Transit System."

Underground System. The system or that part of the system which is 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, 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 Material.

2-2.1 General.

2-2.1.1 Except as otherwise specified herein, all new rapid transit stations shall be not less than Type I or Type II or combinations of Types I and II approved noncombustible construction as defined in NFPA 220, *Standard on Types of Building Construction*.

2-2.1.1.1 During the course of construction or major modification of any structure, provisions of NFPA 241, *Standard for Safeguarding Building Construction and Demolition Operations*, shall apply.

2-2.2 Underground Stations. Building construction for underground (subway) stations shall not be less than Type I or Type II or combinations of Types I and II approved noncombustible construction as defined in NFPA 220. Type of construction shall be as determined by an engineering analysis of potential fire exposure hazards to the structure.

2-2.3 Aboveground Stations. Elevated and at-grade stations shall be designed to satisfy the following minimum fire and panic safety requirements:

2-2.3.1 Building construction for elevated stations shall be not less than Type I or Type II or combinations of Types I and II approved noncombustible construction as defined in NFPA 220 as determined by an engineering analysis of potential fire exposure hazards to the structure.

2-2.3.2 Stairs or escalators used regularly by passengers (which also may serve as emergency exit routes) need not be enclosed.

2-2.4 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 Fire Tests of Building Construction and Materials*.

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

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

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

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

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

2-2.4.1 Doors and other openings through the separations identified in 2-2.4, including Exceptions 2 through 5, shall be protected by fire door assemblies having a protection rating of 1½ hours.

Exception No. 1 identified in 2-2.4 shall be protected by fire door assemblies having a protection rating of three hours.

2-2.4.2 Agents' or information booths shall be constructed of approved noncombustible materials.

2-2.4.3 All station public areas shall have a fire separation of at least three hours from all nontransit occupancies. The fire separation for aboveground stations may be modified based upon an engineering analysis of potential fire exposure hazards.

2-2.4.4 All openings from station public areas to all nontransit occupancies, i.e., private entrances, shall be protected by fire protective assemblies of an approved type with an appropriate rating for the location in which installed. When 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 Windows*.)

2-2.4.5 Automatic Sprinkler System Requirements. (See 2-6.3.)

2-3 Ventilation.

2-3.1 General.

2-3.1.1 Provisions shall be made for emergency ventilation for the protection of passengers and employees from fire or generation of smoke. (See *Appendix B*.)

2-3.1.2 Air Quality Criteria. (See *Appendix B*.)

2-3.2 Emergency Air Temperature Criteria. (See B-2.2.) The ventilation systems shall be so designed that in an emergency situation the air temperature in exit pathways shall be controlled to a design goal of no more than 140°F (60°C). See design model in the *Subway Environmental Design Handbook*, Volume 1, 1975.

2-3.3 Emergency Air Velocity Criteria. (See B-2.3.) Emergency ventilation systems shall produce airflow rates so as to provide a stream of noncontaminated air to passengers in a path of egress.

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 300°F (148.8°C) for a period of at least one hour.

2-3.4.2 Local fan motor starters and related operating control devices shall be isolated from the ventilation airflow by a separation having a fire resistance rating of at least one hour.

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 air from fans designed to exhaust smoke shall be directed to the outside atmosphere, discharging in a manner so as not to create a hazard.

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.

2-3.5.1 Storage battery or similar ancillary rooms in which hydrogen gas or other hazardous gases may be released, and mechanical ventilation is required, shall be ventilated in accordance with NFPA 91, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*. Rooms containing such occupancies shall not be located beneath any means of egress.

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 following requirements:

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 one hour, and shall not support combustion under the same temperature condition. Other materials when encased in concrete are acceptable.

2-4.1.2 All conductors shall be insulated. Ground wires may be bare. All thicknesses of insulation and all thicknesses of jackets shall conform to NFPA 70.

2-4.1.3 All insulations shall conform to Article 310 of NFPA 70 and be moisture and heat resistant types carrying temperature ratings corresponding to the conditions of application and in no case lower than 90°C (194°F).

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.

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 may be embedded in concrete or run in concrete electrical duct banks but shall not be installed exposed or surface-mounted in air plenums which may carry air at the elevated temperatures accompanying fire-emergency conditions.

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

2-5.1.1 To provide minimum criteria for design of egress facilities, a station shall comply with the provisions of NFPA 101®, *Life Safety Code*®, Chapters 5 and 8, "Places of Assembly," 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 fifteen-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 would include such areas as civic centers, sports complexes and convention centers. Consideration of control of access to platform may 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 may project 3½ in. (88.9 mm) into 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 2-5.2.1 from the station platforms in four minutes or less. The maximum travel distance to an exit from any point on the platform shall not exceed 300 ft (91.4 m).

2-5.3.3 The station shall also be designed to permit evacuation from the most remote point on the platform to a point of safety in six minutes or less. A point of safety shall be defined as an enclosed fire exit that exits to a public way or safe location outside the structure, an at-grade point beyond any enclosing structure, or other area that affords adequate protection for passengers.

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 may 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 one-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* (15.24 m/m)

Per Exit Lane "down" direction

Capacity — 40 ppm

Travel Speed — 60 fpm* (18.3 m/m)

2-5.3.4.3 Doors and Gates. Exit doors and gates shall be a minimum of 3 ft 0 in. (914.4 mm) 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. 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 Appendix 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 may be left in operating mode. Escalators running reverse to exiting shall be capable of being stopped remotely, manually or automatically. (See Appendix 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 are also exposed to freezing temperatures, the landing and floor plates and steps shall be heated to keep those areas free of ice and snow.

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

2-5.6 Emergency Lighting.

2-5.6.1 Stations shall be provided with a system of

*Indicates vertical component of travel speed.

emergency lighting in accordance with NFPA 101, *Life Safety Code*, except as otherwise noted herein.

2-5.6.2 Emergency lighting systems shall be installed and maintained in accordance with NFPA 70, *National Electrical Code*.

2-5.6.3 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.

2-5.6.4 Emergency lighting for stairs and escalators shall be designed to emphasize illumination on the top and bottom steps or landings. All escalators steps' newell and comb lighting shall be on emergency power circuits.

2-6 Fire Protection.

2-6.1 Protective Signaling Systems.

2-6.1.1 Stations equipped with fire alarm devices shall be protected by a proprietary system as defined in NFPA 72D, *Standard for Proprietary Signaling Systems*.

2-6.1.2* 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.

2-6.1.3 All fire alarm, smoke detection, valve switches, and water flow indicator signals when activated shall be simultaneous with the local station and to the central supervising station.

2-6.1.4* Separate zones shall be established on local station annunciator panels to monitor water flow on sprinkler systems and supervise main control valves.

2-6.1.5 Automatic fire detection shall be provided by installation of combination fixed temperature and rate of rise sensors, or listed smoke detectors in all ancillary spaces except where protected with automatic sprinklers.

2-6.2 Emergency Communication.

2-6.2.1 A public address (PA) system and emergency voice alarm reporting devices (such as emergency telephone) conforming to NFPA 72A, *Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm and Supervisory Service*, or local (interior) fire alarm pull boxes shall be required in transit stations.

2-6.2.2 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.

2-6.2.3 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 plainly indicated by appropriate signs.

2-6.3 Automatic Sprinkler Systems.

2-6.3.1 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.

2-6.3.2 Installation of sprinkler systems shall comply with NFPA 13, *Standard for Installation of Sprinkler Systems*, or applicable local codes as called for.

2-6.3.3 A sprinkler system waterflow alarm and supervisory signal service shall be installed.

2-6.3.4 Other approved fire suppression systems may be substituted for automatic sprinkler systems in the areas listed in 2-6.3.1 with the approval of the authority having jurisdiction.

2-6.4 Standpipe and Hose Systems.

2-6.4.1 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 to be determined by the authority having jurisdiction. (See A-2-6.4.3.)

2-6.4.2 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.

2-6.4.3* 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 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.

2-6.4.4 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 of water through any fire department connection will furnish water throughout the entire system.

2-6.5 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. In all cases, however, before evacuation is started, it shall be confirmed that traction power circuits have been de-energized.

3-2 Underground (Subways).

3-2.1 Construction Materials.

3-2.1.1 When 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 as determined by an engineering analysis of potential fire exposure hazards to the structure.

3-2.1.2 When 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 may 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.

3-2.1.4 Underwater Tubes.

(a) Shall be not less than Type II (000) approved noncombustible construction as defined in NFPA 220 as applicable.

(b) Ancillary areas within tubes shall be separated from trackway areas by minimum three-hour fire-resistive construction.

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 may be used.

3-2.1.6 Ancillary 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.

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

3-2.2.1 Fans shall be single- or multi-speed, may be reversible and shall be locally controlled 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.

3-2.4 Emergency Exit Details.

3-2.4.1 Emergency exits shall be provided from tunnels to a point of safety. In a tunnel, a point of safety shall be defined as any one of the following:

- (a) An enclosed fire exit that exits to a public way or safe location outside the tunnel structure,
- (b) An at-grade point beyond any enclosing structure, or
- (c) Other passage that affords adequate protection for the passenger.

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 1,250 ft (381 m) unless otherwise approved by the authority having jurisdiction. The stairway shall be designed in accordance with NFPA 101, 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 two-hour rated firewalls, or trainways are in twin bores, such an arrangement shall be deemed to afford adequate protection for the passenger via crosspassageways between the trainways and may, therefore, 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) Crosspassageways 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 system of mechanical ventilation shall be maintained in the uncontaminated trainway.

(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 crosspassageway closures, and shall be equipped with hardware in accordance with NFPA 101. The force required to open the doors fully shall be as low as possible, but shall not exceed 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 which 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 which shall automatically latch the door in the open position so as 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 A blue light or other distinctive colored light station shall be provided adjacent to each exit stairway from tunnels or other designated points of safety. Each station shall contain:

(a) A blue light connected to emergency power for identification of its function.

(b) Information provided at the blue light station which clearly identifies the route and location of the exit.

(c) A traction power emergency disconnect device at the option of the authority.

3-2.4.8 Lighting. (See 2-5.6.)

3-2.4.8.1 Emergency tunnel lighting illumination levels shall not be less than 0.25 footcandles (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 devices¹, 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 following practices shall be implemented:

3-2.5.1.1 Coverboard Protection. A protective coverboard shall be provided on all sections of the power rail and be configured to prevent inadvertent contact with the power rail by people and/or material. The coverboard shall be constructed of electrical insulating material and be securely anchored. Adequate allowance must be made for transit vehicle pick-up shoe dynamics, manual disconnecting of the pick-up shoe, and for wearing of the power rail surface. The coverboard shall be capable of withstanding a load of 250 lb (113.4 kg) when applied at any point with no permanent visible deflection.

¹The 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.

Coverboard material shall have a flame spread rating of not more than 25 when tested in accordance with NFPA 255 (ASTM E 84), *Standard Method of Test of Surface Burning Characteristics of Building Materials*. Insulating material for cable connecting power to the rail shall meet the requirements of IEEE Standard 383, Section 2.5.

3-2.5.1.2 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 and OSHA requirements.

3-2.5.1.3 Wayside Emergency Power Disconnect Devices. Traction power sections disconnect devices shall be located along the trainway for emergency purposes. As these devices may be relatively inconspicuous this location shall be distinguished by a blue light station. See 3-2.4.7 for blue light station equipment.

Power rail disconnect devices shall be located along the trainway to allow the quick removal of power from rail sections. Power rail disconnect devices shall be located along the trainway at a minimum at ends of stations, at special trackwork, and at tunnel portals. Emergency shutoff of traction power shall be achieved by actuation of remote manual control devices which in turn cause the operation of substation circuit breakers and associated trackway disconnect devices.

3-2.6 Protection.

3-2.6.1 A telephone connected to a central supervising station shall be located within each tunnel at each point where the blue light or emergency power disconnect switches are located. These telephones shall be available for fire or other emergency calls. See Chapter 7.

3-2.6.2 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.

3-2.6.3 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 may be of the dry type.

3-2.6.3.1 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.

3-2.6.3.2 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 stand-

pipe 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.

3-2.6.4 Standpipe Installations in Tunnels under Construction.

3-2.6.4.1 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.

3-2.6.4.2 Permanent standpipes shall conform to NFPA 14 as outlined in 3-2.6.3 of this standard.

3-2.6.4.3 Temporary standpipes, which may be used by contractors to furnish water for construction purposes, shall be equipped with hose outlets and valves with 2½ in. (63.5 mm) hose thread conforming to NFPA 1963, *Standard for Screw Threads and Gaskets for Fire Hose Connections*, and may 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.

3-2.6.4.4 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 3-2.6.3.2 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 riser near connection to standpipe.

3-2.6.4.5 Both permanent or temporary standpipes installed during construction phase shall be securely and adequately supported, and shall be of sufficient strength to withstand the pressure and thrust forces to which they may be subjected.

3-2.6.4.6 Temporary standpipes shall remain in service until the permanent standpipe installation is complete.

3-2.6.5 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.

3-2.7 Flammable and Combustible Liquids Intrusion. This section deals with the prevention of accidental intrusion of flammable and combustible liquids due to spills.

3-2.7.1 Wherever possible vent or fan shafts utilized for ventilation of subway tunnels shall not terminate at grade on any vehicle roadway.

3-2.7.2 Vent and fans shafts may 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.

3-2.7.3 Underground Storage Tanks. Underground storage tanks for Class I flammable and Class II and 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 3-2.7.6 for tanks in or under existing buildings*).

3-2.7.4 Underground storage tanks and related piping for Class I flammable liquids and Class II and 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 where the tops of such tanks and piping are above a line 2 ft (610 mm) below the lowest point of excavation, shall be installed as follows:

3-2.7.4.1 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 observation of, or testing for, product and enclosure leakage shall be incorporated into the enclosure design.

3-2.7.4.2 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 and shall be provided with explosion and pressure relief devices conforming to local codes.

3-2.7.4.3 Vault, tank, and piping shall be protected from corrosion and have approved cathodic protection.

3-2.7.4.4 All related piping of Class I flammable liquids and Class II and III combustible liquids shall conform to provisions of NFPA 30, Chapter 3, "Piping, Valves and Fittings."

3-2.7.5 Service Stations. Service stations dispensing Class I flammable liquids and Class II and 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 the following:

3-2.7.5.1 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.

3-2.7.5.2 Appropriate continuous drains across driveways, ramps, and/or curbs of at least 6 in. (152.4 mm) in height shall separate service station properties from adjacent subway property.

3-2.7.5.3 No connection (such as venting or drainage) of any storage tanks and related piping of Class I flam-

mable liquids and Class II and III combustible liquids to a subsurface fixed guideway transit structure shall be permitted.

3-2.7.5.4 Dispensing pumps for Class I flammable liquids and Class II and 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.

3-2.7.6 Existing Storage Tanks in or under Buildings. Existing storage tanks for Class I flammable liquids and Class II and 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.

3-2.7.6.1 Where it is not possible to relocate tanks for Class I flammable liquids due to limited space, such underground tanks shall be abandoned in accordance with provisions of Appendix C of NFPA 30.

3-2.7.6.2 Existing storage tanks for Class III combustible liquids located in or under buildings, and which cannot be relocated, shall be placed within a masonry or welded steel, oil-tight vault, of adequate capacity to contain the contents of the tank. Masonry vaults shall be at least 6 in. (152.4 mm) thick and steel vaults shall be made of not less than 18-gage metal.

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 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 includes the wayside pothead, cable between pothead and contact (third) rail or overhead wire, contact rail supports, and special warning and identification devices.¹

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

¹The 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.

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 A blue light station shall be located inside the fence and adjacent to each access gate as deemed by the Authority. Each station shall contain:

(a) A blue light connected to emergency power for identification of its function.

(b) A telephone dedicated to the central supervising station.

(c) A traction power emergency disconnect device.

3-3.5.4 Information shall be provided on the gates or adjacent thereto which clearly identify 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 safe area. System egress points shall be illuminated.

3-3.6.1 Blue Light Station. See 3-3.5.3.

3-3.6.2 Information shall be provided adjacent to each blue light station which identifies the route and location and the distance to the next station in each direction as deemed necessary by the authority having jurisdiction.

3-3.7 Communication.

3-3.7.1 Emergency Voice Communication. A telephone connected to a central supervising station shall be located along surface trainways at each point where blue light or emergency power disconnect switches are located. This telephone shall be available for fire or other emergency calls.

3-4 Elevated.

3-4.1 General. All structures not previously herein otherwise defined 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 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 includes the wayside pothead, cable between pothead and

contact (third) rail or overhead wire, contact rail supports walkways, and special warning and identification devices.¹

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.

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 A blue light station shall be provided at each gate and/or every 800 ft (244 m). See 3-3.5.3. A dedicated radio communication system is acceptable as a means of communication.

3-4.5.3 Information shall be provided adjacent to each blue light station which 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 either proceed to the nearest station or wait for an evacuation train to arrive.

3-4.7 Communications.

3-4.7.1 Emergency Voice Communication. A telephone connected to a central supervising station shall be located along surface trainways at each point where blue light or emergency power or disconnect switches are located. This telephone shall be available for fire or other emergency calls.

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 as set forth in this chapter.

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

¹The 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.

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 may not accurately predict the behavior of materials under hostile fire conditions. Therefore, the use of tests which evaluate materials in subassemblies and full-scale configurations is 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. The floor construction of the vehicle 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 The portion of the floor assembly exposed shall be no less than 12 ft (3.6 m) in length. The exposed width shall be the full car width reduced no more than 1 ft (0.3 m) to permit support. As a minimum, floor assemblies shall meet the requirements of NFPA 251 (ASTM E-119) when tested for 15 minutes.

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. Appropriate tests may be selected from Appendix D. The aforementioned materials and finishes include (a) interior walls, (b) floor coverings, (c) ceiling, (d) seats, (e) glazing, (f) transparencies, (g) partitions, (h) elastomer, and (i) non-electrical insulation.

4-2.4.1 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-19-81/NEMA WC 3 (with Amendment FR-1) paragraph 6.19.6, or of Underwriters Laboratories Standard 44 for thermosetting insulation and

Underwriters Laboratories Standard 83 for thermoplastic insulation.

(b) Power cable shall meet the requirements of IEEE Standard 383, Section 2.5, with the additional requirement that circuit integrity continue for 5 minutes after the start of the test.

4-2.5 Equipment Arrangement. Vehicle design shall arrange equipment apparatus external to the passenger compartment, where practical, so as 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.

4-2.5.1 Materials used for underfloor ducting and plenums, serving the car interior, shall be noncombustible.

4-3 Electrical Firesafety Requirements.

4-3.1 General Construction. All motors, motor control, current collectors and auxiliaries shall be 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.

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:

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

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

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:

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

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

4-3.3 Propulsion Motors. Motors shall be rated and tested per *American Standard for Rotating Electric Machinery Forming a Part of the Power Equipment on Electrically-propelled Railway Cars, Railway Locomotives and Coaches (Trolley and Prime Mover)*, IEEE No. 11.

Motor leads shall have an insulation suitable for the operating environment and shall be so supported and protected as to offer the least possible chance of mechanical damage. Motor leads where entering the

frame shall be securely clamped and shall fit snugly so as to prevent moisture from entering the motor case. Drip loops shall be formed in motor leads so as 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.

4-3.4 Motor Control. Motor control shall be rated and tested per *American Standard for Electric Control Apparatus for Land Transportation Vehicles*, IEEE No. 16.

Control equipment enclosures shall be so arranged and installed as 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, with the exception that lining will not be required when the arc chutes extend through the enclosure and vent the arc to the outside air. Adequate shields or separations shall be provided to prevent arcing to adjacent equipment and wiring.

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 ¼ 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 should incorporate protective devices for the following failures:

- (a) Ventilation air flow 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. When 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 must 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 which 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 assure 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 especially for this purpose and shall be equipped with arc blow-out aids. Third rail shoe fuses mounted on the shoe beams shall be mounted so 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 may 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 provision for operation of all ventilation equipment throughout the train from the controlling cab.

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) as determined by the authority having jurisdiction.

4-5.2 A means of exit from car to track level to allow passengers to evacuate the vehicle safely 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.

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 one (1) hour.

4-6 Protection.

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

4-6.2 Communications. Each vehicle shall be equipped with a communication system consisting of the following:

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

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

(3) An intercommunication system whereby the train crew can communicate with one another.

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

4-6.3 Portable Fire Extinguishers. Each vehicle or operator's cab shall be equipped with an approved portable fire extinguisher (*see NFPA 10*) 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 air flow if appropriate.
- (b) Temperature controls if appropriate.
- (c) Short circuits and overloads in supply wiring.

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

4-6.6 Testing and Maintenance.

4-6.6.1 Testing. Qualification testing shall be performed by the equipment manufacturer in accordance with IEEE No. 16 and IEEE No. 11 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 upon operating experience as determined by the Authority.

Chapter 5 Vehicle Storage and Maintenance Areas

5-1 General.

5-1.1 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 Accessibility. 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 72A, 72B or 72C.

5-3 Structures.

5-3.1 Structural Requirements. Structures shall be of noncombustible construction, in accordance with NFPA 220, *Standard 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 which 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 assure 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, *Fire Tests of Roof Coverings*, Class A or 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*; the *National Electric Safety Code*, ANSI C2; and applicable local codes as called for by the authority having jurisdiction.

5-3.5.2 Traction Power.

(a) **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 and ANSI C2.

(b) **Third Rail Conductors.** Third rails shall be secured to suitable insulating supports, properly bonded at joints, and properly guarded to prevent contact with personnel. Electrical supply for other than traction power details shall be in accordance with NFPA 70 and ANSI C2.

(c) All traction power conductors shall have emergency power shut-off 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 may 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 ten per hour or 1 cfm/ft² (1 m³/m²·h) of pit floor area, whichever is greater, during normal operation and designed to discharge to the outside atmosphere.

5-3.8.2 Abovefloor Ventilation. When 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*. When blower and exhaust systems are installed for vapor removal, the systems shall be installed in accordance with NFPA 91, *Standard for the Installation of Blower and Exhaust Systems*.

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 waterflow alarm and supervisory signal service shall be in accordance with NFPA 72C.

5-4.2 Protective Signaling Systems. Nonsprinklered, covered vehicle storage areas shall be equipped with an automatic smoke or heat detection and signaling system installed in accordance with NFPA 72E. A signal of a fire shall be relayed to the supervising station, or directly to the fire department in accordance with the appropriate NFPA signaling standard.

5-4.3 Standpipe and Hose Systems. When standpipes and connections are required, the complete installation including water supply shall comply with NFPA 14, *Standard for 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 below.

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 or 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 3 ft 0 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 de-energized except in those cases where 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 which require the de-energizing of all electrical circuits.

Exception: Batteries need not be disconnected or removed when the vehicle is equipped with a battery cutout switch which 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 which may 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 may 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 the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*. 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.

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 which 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 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 When 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 Protection in Use of Cutting and Welding Processes*.

5-5.5.2 Welding shall not be done in an area which 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 and Areas of Use*; American National Standard Safety Code for Powered Industrial Trucks, ANSI B56.1; 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, *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 may involve the system. Participating agencies shall be invited and should 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 and/or a smoke condition on a train (passenger or work) or any other part of the system.
- (b) Fire and/or a smoke condition adjoining or adjacent to the system that threatens the system or disrupts service.
- (c) Collision and/or derailment involving one or more cars.
- (d) Loss of electric power resulting in a stalled train(s) and/or loss of illumination.
- (e) Evacuation of passengers from a train under adverse conditions where they require assistance.
- (f) Panic of passengers.
- (g) Disabled and/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, 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 upon 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 upon 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 have the essential apparatus and equipment to communicate with, supervise, and coordinate all personnel and trains operating in the system.

6-5.3 It 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 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 in a fire-resistive structure used solely for the CSS and not jeopardized by adjoining or adjacent structures.

6-5.8* The CSS shall be protected by fire detection, protection, and extinguishing equipment so that there will 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 shall also 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 person without delay.

6-7 Command Post.

6-7.1 During an emergency on the system requiring the invoking of 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 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 person 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 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 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 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 and/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.²

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, it may be necessary to employ portable telephones. 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).

7-8.1 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 current as of the date of the NFPA issuance of this document. These references are listed separately to facilitate updating to the latest edition by the user.

8-1.1 NFPA Publications. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269.

NFPA 10-1984, *Standard for Portable Fire Extinguishers*

NFPA 13-1985, *Standard for Installation of Sprinkler Systems*

NFPA 14-1986, *Standard for the Installation of Stand-pipe and Hose Systems*

NFPA 24-1984, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*

NFPA 30-1984, *Flammable and Combustible Liquids Code*

NFPA 33-1985, *Standard for Spray Application Using Flammable and Combustible Materials*

NFPA 51B-1984, *Standard for Fire Prevention in Use of Cutting and Welding Processes*

NFPA 58-1986, *Standard for the Storage and Handling of Liquefied Petroleum Gases*

NFPA 70-1984, *National Electrical Code*

NFPA 72A-1985, *Standard for the Installation, Maintenance and Use of Local Protective Signaling Systems for Guard's Tour, Fire Alarm and Supervisory Service*

NFPA 72B-1986, *Standard for the Installation, Maintenance and Use of Auxiliary Protective Signaling Systems for Fire Alarm Service*

NFPA 72C-1986, *Standard for the Installation, Maintenance and Use of Remote Station Protective Signaling Systems*

NFPA 72D-1986, *Standard for the Installation, Maintenance and Use of Proprietary Protective Signaling Systems*

NFPA 72E-1984, *Standard on Automatic Fire Detectors*

NFPA 80-1983, *Standard for Fire Doors and Windows*

NFPA 90A-1985, *Standard for the Installation of Air Conditioning and Ventilating Systems*

NFPA 91-1983, *Standard for the Installation of Blower and Exhaust Systems for Dust, Stock and Vapor Removal or Conveying*

NFPA 101-1985, *Life Safety Code*

NFPA 220-1979, *Standard on Types of Building Construction*

NFPA 241-1980, *Standard for Safeguarding Building Construction and Demolition Operations*

NFPA 251-1985, *Standard Methods of Fire Tests of Building Construction and Materials*

NFPA 255-1984, *Standard Method of Test of Surface Burning Characteristics of Building Materials*

NFPA 256-1982, *Standard Methods of Fire Tests of Roof Coverings*

NFPA 505-1982, *Fire Safety Standard for Powered Industrial Trucks Including Type Designations and Areas of Use, Maintenance and Operation*

NFPA 1963-1985, *Standard for Screw Threads and Gaskets for Fire Hose Connections*

8-1.2 Other Publications.

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

ANSI C-2-81, *National Electrical Safety Code*

ANSI B56.1-75, *American National Standard Safety Code for Powered Industrial Trucks*

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

ASTM E 84-1981a, *Surface Burning Characteristics of Building Materials*

ASTM E 119-1982, *Fire Tests of Building Construction*

ASTM E 136-1981, *Standard Method of Test for Non-combustibility of Elementary Materials*

8-1.2.3 IEEE Publications. Institute of Electrical and Electronic Engineers, Inc., 345 East 47th Street, New York, NY 10017.

IEEE No. 11, *American Standard for Rotating Electric Machinery Forming a Part of the Power Equipment on Electrically-propelled Railway Cars, Railway Locomotives and Coaches (Trolley and Prime Mover)*

IEEE No. 16, *American Standard for Electric Control Apparatus for Land Transportation Vehicles*

IEEE No. 383, *Standard for Type Tests of Class 1E Electric Cables, Field Splices and Connections for Nuclear 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 44-1983, *Rubber-Insulated Wires and Cables*

UL 83-1983, *Thermoplastic-Insulated Wires*

8-1.2.6 Subway Environmental Design Handbook, Volume 1, *Principles and Applications*, Second Edition, 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.

Appendix A Fire Protection

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

A-2-6.1.2 Discrete zone indications are desirable for unmanned stations.

A-2-6.1.4 Separate zones on the annunciator panel to monitor main control valves on standpipe systems should be established.

A-2-6.4.3 It is desirable to locate fire department connections near one or more station access points.

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 information 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 may 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-2.1.2 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_r .

B-2.1.3 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 know the exposure time of passengers in the smoke. These quantities are dependent 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_r , for different airflow rates (see *Subway Environmental Design Handbook*, Vol. 1, *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 is also 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 immediate activation of emergency ventilation equipment.

B-2.3.1 When emergency ventilation air is needed in evacuation routes, it may 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 2,200 fpm (11.2 m/s).

B-2.3.2 In some instances, it may be desirable for fresh air to be felt by the passengers to give them a sense of direction enabling them to walk away from the emergency condition. If this air motion is to serve as an indicator for passengers, it must be at least 500 fpm (2.5 m/s).

B-2.4 Emergency Ventilation Fans. In some instances, it may 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 may 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 upon how each operating transit agency responds to all elements involved in combatting an emergency. Each subway system must integrate all the elements which 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 may arise where 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/sq ft (0.511×10^9 J/m²) of gross floor area. The figure of 45,000 Btu/sq ft (0.511×10^9 J/m²) has been derived as one which is readily obtainable based upon a comparison of

available data for seven different makes, sizes, and types of rapid-transit vehicles. Values of 30,000 Btu/sq ft (0.341×10^9 J/m²) can be achieved if deemed desirable. Values as high as 135,000 Btu/sq ft (1.53×10^9 J/m²) 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:

(1) The amount of smoke generated is reduced. This may be accomplished by design and/or maintenance to minimize the quantity of material which may 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 may be isolated (for example, by enclosing wiring in conduit). The smoke produced by short circuits may be reduced by de-energizing the circuit. All aspects of subway design, including maintenance procedures, should incorporate the philosophy of reducing sources of smoke.

(2) 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 will enable the passenger 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 which 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 90°C (194°F) 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 for rubber insulated wire and cable and to ICEA S-66-524/NEMA WC7 for crosslinked polyethylene wire and cable or ICEA S-68-516/NEMA WC8 for ethylene-propylene-rubber-insulated wire and cable.

B-2.5.4 Insulation and jacketing materials yielding lowest amounts of toxic and/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 document, but is included for information 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 may be considered as an auxiliary exit from the station under certain fire scenarios.

C-1.2 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 will also determine "peak hour" reversal from morning to afternoon to reflect commuter loads.

The basis on which the occupant load data is determined should be carefully considered 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 significant operating changes. Verification by survey should be made following any extension or significant operating change, or at a maximum of five-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.

The peak hour passenger figures can be converted to peak 15-minute loads by dividing by four and multiplying by one and one-half. The one and one-half is a distribution curve correction and may 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.

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.

When 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.

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

To calculate this evacuation time, the walking travel time should be tabulated using the longest exit route and travel speeds indicated in 2-5.3.4. To this time should be added the following factors:

(a) $W_1 - T$ — The waiting time at the vertical elements at platform level (as calculated in 2-5.3) minus the longest walking travel time at platform level.

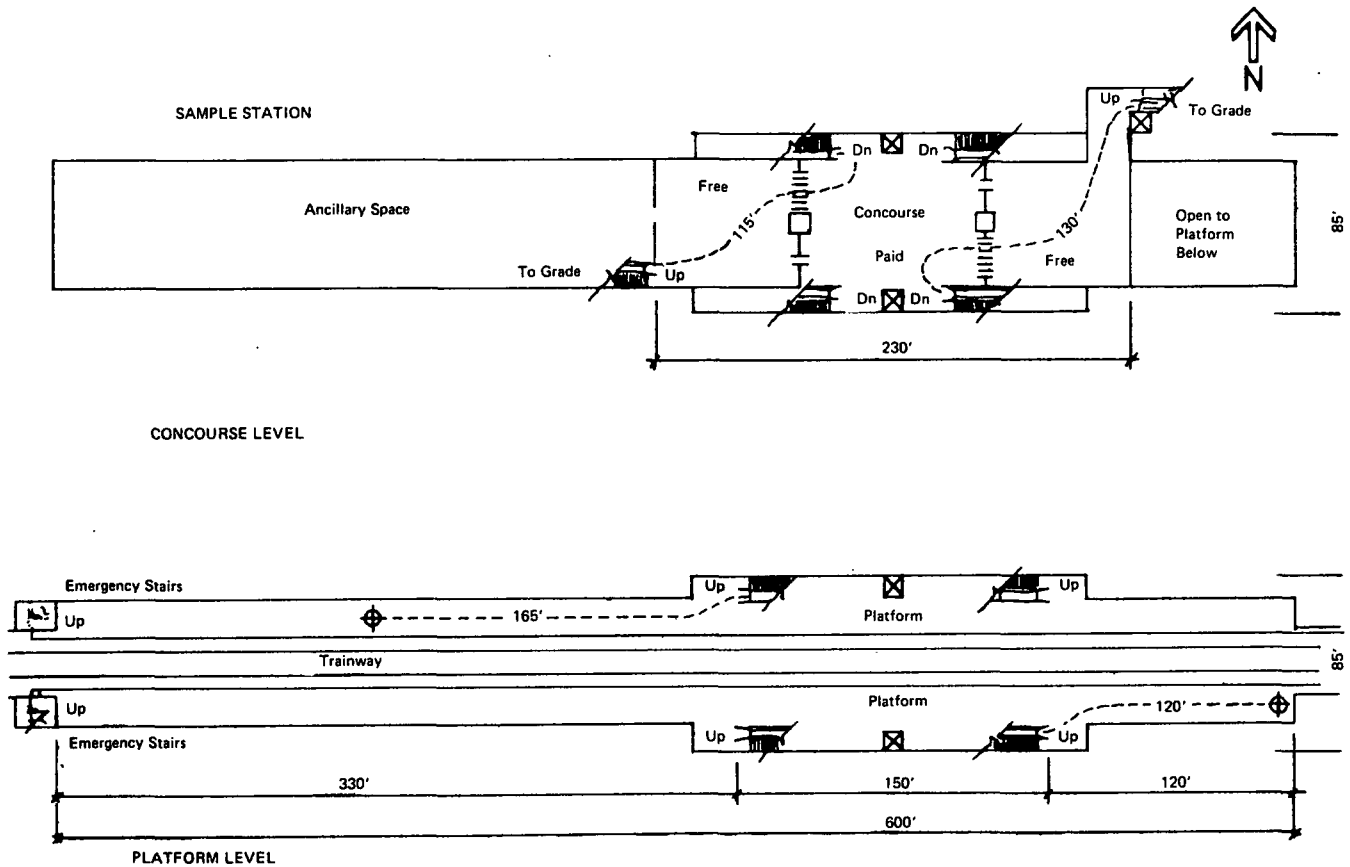
(b) $W_2 - W_1$ — The waiting time at the fare collection barrier minus the waiting time at the platform vertical circulation elements.

(c) $W_3 - W_1$ — The waiting time at the vertical circulation elements from concourse to grade minus the waiting time at the platform vertical circulation elements.

(d) $W_4 - W_1$ — The waiting time at any additional construction, if any, minus the waiting time at the platform vertical circulation elements. (Repeat for all additional constructions.)

NOTE: The total of any of the above factors cannot be less than zero.

A sample calculation procedure is as follows:



The sample station is a side platform 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 (8.0 m), and the concourse is 18 ft (5.5 m) above the platform. Based on normal patronage, the station has two entrances, each containing one escalator and one stair. The entrances are covered at grade level to a point 10 ft (3.0 m) beyond the top of the stairs. The concourse is divided into two free areas and one paid area separated by fare barriers, each containing six fare gates of the turnstile type and one 3 ft 6 in. (1.1 m) wide swinging service gate with panic hardware for the use of the handicapped and service personnel. Two open wells communicate between the concourse and each platform, each containing one stair and one escalator. Station auxiliary spaces are located at concourse level, and elevators are provided from grade level to concourse and from concourse to each platform for the use of the handicapped and service personnel.

The station's occupant load is 1,600 persons. Escalators are nominal 48 in. (1.22 m) wide. Regular stairs are 72 in. (1.83 m) wide, and emergency stairs are 48 in. (1.22 m) wide. Doors to emergency stairs are 36 in. (0.91 m) wide.

In that the distance from the west end of the platform exceeds 200 ft (61 m) to the first stair or escalators, emergency stairs in enclosed stairwells exiting directly to grade are provided at the west end of each platform. In Test No. 1, the platform exiting time is found to be 3.81 minutes. Therefore, no additional emergency exits from platform are required.

In Test No. 2, two exit routes are tested. The route from the midpoint of the west end of the platform is found to be the longest, and its exiting time is 5.32 minutes. Therefore, neither additional emergency gates through the fare barrier nor emergency exits from concourse to grade are required.

EMERGENCY EXIT CAPACITY CALCULATION

STATION _____ Sample _____

OCCUPANCY LOAD 1600 PERSONS

EXIT LANES AND CAPACITY PROVIDED

PLATFORM TO CONCOURSE

STAIRS	<u>2</u>	<u>×</u>	<u>3</u>	LANES <u>×</u>	<u>35</u>	PPM =	<u>210</u>	PPM
ESCALATORS	<u>2</u>	<u>×</u>	<u>2</u>	LANES <u>×</u>	<u>35</u>	PPM =	<u>140</u>	PPM
EMG. STAIRS	<u>1</u>	<u>×</u>	<u>2</u>	LANES <u>×</u>	<u>35</u>	PPM =	<u>70</u>	PPM
TOTAL							<u>420</u>	PPM

THRU FARE BARRIER

FARE GATES	<u>12</u>	<u>×</u>	<u>1</u>	LANE <u>×</u>	<u>25</u>	PPM =	<u>300</u>	PPM
SERVICE GATES	<u>2</u>	<u>×</u>	<u>1.5</u>	LANES <u>×</u>	<u>50</u>	PPM =	<u>150</u>	PPM
EMG. GATES		<u>×</u>	<u>1.5</u>	LANES <u>×</u>		PPM =		PPM
TOTAL							<u>450</u>	PPM

CONCOURSE TO GRADE

STAIRS	<u>2</u>	<u>×</u>	<u>3</u>	LANES <u>×</u>	<u>35</u>	PPM =	<u>210</u>	PPM
ESCALATORS	<u>2</u>	<u>×</u>	<u>2</u>	LANES <u>×</u>	<u>35</u>	PPM =	<u>140</u>	PPM
EMG. STAIRS		<u>×</u>	<u>2</u>	LANES <u>×</u>		PPM =		PPM
TOTAL							<u>350</u>	PPM

TEST #1

EVACUATE STATION OCCUPANT LOAD FROM STATION PLATFORM(S)
IN FOUR MINUTES OR LESS.

WAITING TIME AT PLATFORM EXITS

$$W = \text{OCCUPANCY LOAD/EXIT CAPACITY}$$

$$= \frac{1600 \text{ PERSONS}}{420 \text{ PPM}} = 3.81 \text{ MINUTES}$$

TEST #2

EVACUATE STATION OCCUPANT LOAD FROM THE MOST
REMOTE POINT ON THE PLATFORM TO A POINT OF SAFETY
IN SIX MINUTES OR LESS.

WALKING TIME FOR LONGEST EXIT ROUTE

PLATFORM	= T_1 =	165 FEET 200 FPM = 0.83
PLAT. TO CONCOURSE	= T_2 =	18 FEET 50 FPM = 0.36
CONCOURSE	= T_3 =	115 FEET 200 FPM = 0.58
CONC. TO GRADE	= T_4 =	26 FEET 50 FPM = 0.52
GRADE	= T_5 =	10 FEET 200 FPM = 0.05
TOTAL	= T =	2.34 MIN.

ADDITIONAL WAITING TIME AT PLATFORM EXITS

$$W_1 = 3.81 \text{ MIN. } T_1 = 0.83 \text{ MIN.}$$

$$(W_1 - T_1) = 3.81 - 0.83 = 2.98 \text{ MIN.}$$

ADDITIONAL WAITING TIME AT FARE BARRIER

$$\text{OCCUPANT LOAD AT CONCOURSE}$$

$$= \text{OCCUPANT LOAD} - \text{EMERGENCY STAIR CAPACITY}$$

$$= 1600 - (70 \text{ PPM} \times 3.81) = 1334 \text{ Patrons}$$

W_2 = CONCOURSE OCCUPANT LOAD/GATE CAPACITY

$$= 1334 \text{ P/450 PPM} = 2.96 \text{ MIN.}$$

$$(W_2 - W_1) = 2.96 - 3.81 = 0 \text{ MIN.}$$

ADDITIONAL WAITING TIME AT CONCOURSE EXITS

W_3 = CONCOURSE OCCUPANT LOAD/EXIT CAPACITY

$$= 1334 \text{ P/350 PPM} = 3.81 \text{ MIN.}$$

$$(W_3 - W_1) = 3.81 - 3.81 = 0 \text{ MIN.}$$

TOTAL EXIT TIME

$$= T + (W_1 - T_1) + (W_2 - W_1) + (W_3 - W_1)$$

$$= 2.34 + 2.98 + 0 + 0 = 5.32 \text{ MINUTES}$$

C-2 Escalators.

The ANSI Code A17.1 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 which have 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 which displays the following for each escalator: direction of travel, operating speed (if more than one), out of service, and a flashing light which indicates the escalator stopped because of activation of a safety device.

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