NFPA® 130

Standard for Fixed Guideway Transit and Passenger Rail Systems

2014 Edition

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An International Codes and Standards Organization

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NFPA® 130

Standard for

Fixed Guideway Transit and Passenger Rail Systems

2014 Edition

This edition of NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems,* was prepared by the Technical Committee on Fixed Guideway Transit and Passenger Rail Systems and acted on by NFPA at its June Association Technical Meeting held June 10–13, 2013, in Chicago, IL. It was issued by the Standards Council on August 1, 2013, with an effective date of August 21, 2013, and supersedes all previous editions.

This edition of NFPA 130 was approved as an American National Standard on August 21, 2013.

Origin and Development of NFPA 130

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

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

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

The scope of the 1988 edition was expanded to include automated guideway transit (AGT) systems. The sample calculations in Appendix C were revised, and Appendix D was completely revised.

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

Definitions for *enclosed station* and *open station* were added in the 1993 edition, along with minor changes to Chapters 2 and 3; the 1995 edition made minor changes to Chapters 1, 2, and 3.

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

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

The 2003 edition was reformatted in accordance with the 2003 *Manual of Style for NFPA Technical Committee Documents*. Beyond those editorial changes, there were technical revisions to the egress requirements and calculations for stations. The chapter on vehicles was extensively rewritten to include a performance-based design approach to vehicle design as well as changes to the traditional prescriptive-based requirements.

The 2007 edition included revisions affecting station egress calculations, the use of escalators in the means of egress, vehicle interior fire resistance, and power supply to tunnel ventilation systems. The chapter on vehicle maintenance facilities was removed because requirements for that occupancy are addressed in other codes; the performance-based vehicle design requirements were substantially revised to more accurately address the unique qualities of rail vehicles.

The 2010 edition of NFPA 130 included provisions that allowed elevators to be counted as contributing to the means of egress in stations. The 2010 edition also contained revisions relating to escalators, doors, gates, and turnstile-type fare equipment. The units in the standard were updated in accordance with the 2004 *Manual of Style for NFPA Technical Committee Documents*. Several fire scenarios were added to Annex A to provide guidance on the types of fires that can occur in vehicles, stations, and the operating environment as well.

The 2014 edition of NFPA 130 includes substantial re-organization of Chapters 5 and 6 for consistency and consolidation of wire and cable requirements into a new Chapter 12. Other changes include reconciliation of terminology related to enclosed trainways and engineering versus fire hazard analysis; revisions to interior finish requirements; revisions to requirements for prevention of flammable and combustible liquids intrusion in Chapters 5 and 6; and improvements to Annex C.

Technical Committee on Fixed Guideway Transit and Passenger Rail Systems

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Leong Kwok Weng, Land Transport Authority, Singapore, Singapore [U]
Stephen B. Wilchek, National Railroad Passenger Corporation (Amtrak), NY [U]
Joseph B. Zicherman, IFT/Fire Cause Analysis, CA [SE]

Alternates

Shane D. Allen, Los Angeles City Fire Department, CA [E]
(Alt. to M. J. Thomas)
Jarrod Alston, Arup, MA [SE]
(Alt. to J. R. Quiter)
Jason D. Averill, National Institute of Standards & Technology, MD [RT]
(Alt. to R. D. Peacock)
John Bumanis, Parsons Transportation Group, DC [SE]
(Alt. to S. A. Gilardi, Jr.)
Michel Champagne, Societe De Transport De Montreal (STM), Canada [U]
(Alt. to L. Martineau)
Ervin Cui, Aon Fire Protection Engineering Corporation, IL [I]
(Alt. to J. F. Devlin)
Gary L. English, Seattle Fire Department, WA [E]
(Alt. to J. Nelsen)
Katherine Fagerlund, Sereca Fire Consulting Ltd., Canada [SE]
(Alt. to H. A. Locke)
Robert W. Falvey, Lea & Elliott, Inc., FL [SE]
(Alt. to D. M. Casselman)
Michael J. Ferreira, Hughes Associates, Inc., MD [SE]
(Alt. to S. P. Hunt)
Paul Fok, Land Transport Authority, Singapore, Singapore [U]
(Alt. to L. K. Weng)
Martha K. Gulick, Port Authority of New York & New Jersey, NJ [U]
(Alt. to H. L. Levitt)
Ritch D. Hollingsworth, LTK Engineering Services, PA [SE]
(Alt. to S. W. Roman)
Donald Iannuzzi, New York City Transit Authority, NY [U]
(Alt. to R. Montfort)
Vincent Kwong, Bay Area Rapid Transit District (BART), CA [U]
(Alt. to M. Chan)
Pierre Laurin, Toronto Transit Commission, Canada [U]
(Alt. to S. R. Tanaka)
Neil E. Nott, Washington Metropolitan Area Transit Authority, VA [U]
(Alt. to J. F. Krempasky)
Thomas P. O'Dwyer, Parsons Brinckerhoff, Inc., NY [SE]
(Alt. to S. K. Li)
William R. Segar, Bombardier Transportation, PA [M]
(Alt. to K. M. Lewis)
Dilip S. Shah, AECOM Technical Services, Inc., CA [SE]
(Alt. to D. M. McKinney)
Joseph P. Streany, Metro North Railroad, NY [E]
(Alt. to L. M. Sorensen)
Don Tangarone, National Railroad Passenger Corporation (Amtrak), PA [U]
(Alt. to S. B. Wilchek)
Anthony Tedesco, Fire Department City of New York, NY [E]
(Alt. to K. P. Harrison)
John Powell White, IFT/Fire Cause Analysis, CA [SE]
(Alt. to J. B. Zicherman)

Nonvoting

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(Member Emeritus)
Arnold Dix, School Medicine, UWS, Australia [SE]
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Committee Scope: This Committee shall have primary responsibility for documents pertaining to fire safety requirements for underground, surface, and elevated fixed guideway transit and passenger rail systems including stations, trainways, emergency ventilation systems, vehicles, emergency procedures, communications and control systems and for life safety from fire and fire protection in stations, trainways, and vehicles. Stations shall pertain to stations accommodating occupants of the fixed guideway transit and passenger rail systems and incidental occupancies in the stations.

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Changes other than editorial are indicated by a vertical rule beside the paragraph, table, or figure in which the change occurred. These rules are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet (•) between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex H. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex H.

Chapter 1 Administration

1.1 Scope.

1.1.1* This standard shall cover life safety from fire and fire protection requirements for fixed guideway transit and passenger rail systems, including, but not limited to, stations, trainways, emergency ventilation systems, vehicles, emergency procedures, communications, and control systems.

1.1.2 Fixed guideway transit and passenger rail stations shall pertain to stations accommodating only passengers and employees of the fixed guideway transit and passenger rail systems and incidental occupancies in the stations. This standard establishes minimum requirements for each of the identified subsystems.

1.1.3 This standard shall not cover requirements for the following:

(1) Conventional freight systems
(2) Buses and trolley coaches
(3) Circus trains
(4) Tourist, scenic, historic, or excursion operations
(5) Any other system of transportation not included in the definition of *fixed guideway transit system (see 3.3.52.1)* or *passenger rail system (see 3.3.52.2)*
(6)*Shelter stops

1.1.4 To the extent that a system, including those listed in 1.1.3(1) through 1.1.3(6), introduces hazards of a nature similar to those addressed herein, this standard shall be permitted to be used as a guide.

1.2 Purpose. The purpose of this standard shall be to establish minimum requirements that will provide a reasonable degree of safety from fire and its related hazards in fixed guideway transit and passenger rail system environments.

1.3 Application.

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

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

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

1.3.4 This standard shall also apply as a basis for fixed guideway transit and passenger rail systems where nonelectric and combination electric-other (such as diesel) vehicles are used. Where such vehicles are not passenger-carrying vehicles or are buses or trolley coaches, the standard shall not apply to those vehicles but shall apply to the fixed guideway transit and passenger rail systems in which such vehicles are used.

1.4* Equivalency. 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 performance and life safety.

1.4.1 Technical Documentation. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.4.2 Approval. The new methods, materials, or devices shall be approved for the intended purpose.

1.4.3* Equivalent Compliance. Alternative systems, methods, materials, or devices approved as equivalent shall be recognized as being in compliance with this standard.

1.5 Units and Formulas.

1.5.1 SI Units. The metric units of measurement in this standard are in accordance with the International System of Units (SI).

1.5.2 Primary and Equivalent Values. If a value for a measurement as given in this standard is followed by an equivalent value in other units, the first stated value shall be regarded as the requirement. A given equivalent value might be approximated.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2013 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2013 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2013 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2013 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2014 edition.

NFPA 70®, National Electrical Code®, 2014 edition.

NFPA 72®, National Fire Alarm and Signaling Code, 2013 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 2010 edition.

NFPA *101®, Life Safety Code®,* 2012 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 2013 edition.

NFPA 220, *Standard on Types of Building Construction,* 2012 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations,* 2013 edition.

• NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source,* 2011 edition.

NFPA 262, *Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces,* 2011 edition.

• NFPA 286, *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth,* 2011 edition.

NFPA 703, *Standard for Fire Retardant–Treated Wood and Fire-Retardant Coatings for Building Materials,* 2012 edition.

2.3 Other Publications.

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

ANSI/AMCA 210, *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating*, 2007.

AMCA 250, *Laboratory Methods of Testing Jet Tunnel Fans for Performance*, 2005.

AMCA 300, *Reverberant Room Method for Sound Testing of Fans*, 2008.

2.3.2 APTA Publications. American Public Transportation Association, 1666 K Street NW, Washington, DC 20006.

APTA SS-PS-002, Rev 3, *Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment*, 1998, revised 2007.

2.3.3 ASHRAE Publications. ASHRAE, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.

ASHRAE *Handbook — Fundamentals*, 2009.

ASHRAE 149, *Standard of Laboratory Methods of Testing Fans Used to Exhaust Smoke in Smoke Management Systems*, 2009.

2.3.4 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM C 1166, *Standard Test Method for Flame Propagation of Dense and Cellular Elastometric Gaskets and Accessories,* 2006 (2011).

ASTM D 2724, *Standard Test Methods for Bonded, Fused, and Laminated Apparel Fabrics*, 2006 (2011)e1.

ASTM D 3574, *Standard Test Methods for Flexible Cellular Materials — Slab, Bonded, and Molded Urethane Foams*, 2011.

ASTM D 3675, *Standard Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source*, 2011.

ASTM E 84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2012b.

ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 2012a.

ASTM E 136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2012.

ASTM E 162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*, 2012a.

ASTM E 648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source*, 2010e1.

ASTM E 662, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*, 2012.

ASTM E 814, *Standard Test Method for Fire Tests of Through-Penetration Fire Stops*, 2011a.

ASTM E 1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 2011b.

ASTM E 1537, *Standard Test Method for Fire Testing of Upholstered Furniture*, 2012.

ASTM E 1590, *Standard Test Method for Fire Testing of Mattresses*, 2012.

ASTM E 2061, *Standard Guide for Fire Hazard Assessment of Rail Transportation Vehicles*, 2012.

ASTM E 2652, *Standard Test Method for Behavior of Materials in a Tube Furnace with a Cone-Shaped Airflow Stabilizer, at 750°C*, 2012.

2.3.5 California Technical Bulletins. State of California, Department of Consumer Affairs, Bureau of Home Furnishings and Thermal Insulation, 3485 Orange Grove Avenue, North Highlands, CA 95660-5595.

Technical Bulletin 129, *Flammability Test Procedure for Mattresses for Use in Public Buildings*, October 1992.

Technical Bulletin 133, *Flammability Test Procedure for Seating Furniture for Use in Public Occupancies*, January 1991.

2.3.6 ICEA Publications. Insulated Cable Engineers Association, P.O. Box 1568, Carrollton, GA 30112.

ICEA S-73-532/NEMA WC-57, *Standard for Control, Thermocouple Extension, and Instrumentation Cables*, 2004.

ICEA S-95-658/NEMA WC-70, *Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy*, 1999.

2.3.7 IEC Publications. International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 60331-11, *Tests for electric cables under fire conditions — Circuit integrity — Part 11: Apparatus — Fire alone at a flame temperature of at least 750°C*, 2009.

IEC 62520, *Railway applications electric traction, short primary type linear induction motors (LIM) fed by power converters*, 2011.

2.3.8 IEEE Publications. Institute of Electrical and Electronics Engineers, Three Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE 11, *Standard for Rotating Electric Machinery for Rail and Road Vehicles*, 2000.

IEEE 16, *American Standard for Electric Control Apparatus for Land Transportation Vehicles*, 2004.

IEEE 1202, *Standard for Flame-Propagation Testing of Wire and Cable*, 2006.

2.3.9 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/UL 44, *Standard for Safety Thermoset-Insulated Wires and Cables*, 2010.

ANSI/UL 83, *Standard for Safety Thermoplastic-Insulated Wires and Cables*, 2008.

ANSI/UL 263, *Standard for Fire Tests of Building Construction and Materials,* 2011.

ANSI/UL 1685, *Standard for Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables*, 2007, revised 2010.

UL 1724, *Outline of Investigation for Fire Tests for Electrical Circuit Protective Systems,* 2006.

ANSI/UL 2196, *Standard for Safety for Tests for Fire Resistive Cables*, 2001, revised 2012.

2.3.10 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 14, Code of Federal Regulations, Part 25, Appendix F, Part I, "Vertical Test."

2.3.11 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 72®, National Fire Alarm and Signaling Code, 2013 edition.

NFPA *101®*, *Life Safety Code®,* 2012 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source,* 2011 edition.

NFPA 270, *Standard Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber,* 2013 edition.

NFPA 402, *Guide for Aircraft Rescue and Fire-Fighting Operations,* 2013 edition.

NFPA 472, *Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents,* 2013 edition.

NFPA 502, *Standard for Road Tunnels, Bridges, and Other Limited Access Highways,* 2014 edition.

NFPA 921, *Guide for Fire and Explosion Investigations,* 2011 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

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

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

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.3 General Definitions.

3.3.1* Airflow Control Devices. Nontraditional equipment used to minimize tunnel airflow, including air curtains, barriers, brattices, tunnel doors, downstands, enclosures, tunnel gates, and so forth.

3.3.2 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.

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

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

3.3.5* Blue Light Station. A location along the trainway, indicated by a blue light, where a person can communicate with the operations control center and disconnect traction power.

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

3.3.7 Combustible Load of a Vehicle. The total value of heat energy that can be released through complete combustion of the components of a vehicle or fuel, expressed in joules [British thermal units (Btu)].

3.3.8 Command Post (CP). The location at the scene of an emergency where the incident commander is located and where command, coordination, control, and communications are centralized. [**402,** 2013]

3.3.9 Communications. Radio, telephone, and messenger services throughout the system and particularly at the operations control center and command post.

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

3.3.11* Concourse. Intermediate level(s) or area(s) connecting a station platform(s) to a public way via stairs, escalators, or corridors.

3.3.12 Critical Radiant Flux. The level of incident radiant heat energy in units of W/cm^2 on a floor covering system at the most distant flameout point. [**253,** 2011]

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

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

3.3.15* Engineering Analysis. A system analysis that evaluates all the various factors of relative to specific objectives for system performance.

3.3.15.1* ***Fire Hazard Analysis.*** A specific type of engineering analysis relative to the contribution of a material, component, or assembly to the overall fire hazard and the estimation of the potential severity of fires that can develop under defined fire scenarios.

3.3.16 Equivalency. An alternative means of providing an equal or greater degree of safety than that afforded by strict conformance to prescribed codes and standards.

3.3.17 Fire Command Center. The principal attended or unattended room or area where the status of the detection, alarm communications, control systems, and other emergency systems is displayed and from which the system(s) can be manually controlled. [**72**, 2013]

3.3.18 Fire Emergency. The existence of, or threat of, fire or the development of smoke or fumes, or any combination thereof, that demands immediate action to correct or alleviate the condition or situation. [**502,** 2014]

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

3.3.20 Fire Load.

3.3.20.1* ***Effective Fire Load.*** The portion of the total fire load (in joules or Btu) under a given, specific fire scenario of a certain fuel package that would be expected to be released in a design fire incident.

3.3.20.2* ***Total Fire Load.*** The total heat energy (in joules or Btu) of all combustibles available from the constituent materials of a certain fuel package.

3.3.21 Fire Smoke Release Rate. Rate of smoke release for a given fire scenario expressed as a function of time [in m^2/sec (ft^2/sec)].

3.3.22 Flaming Dripping. Periodic dripping of flaming material from the site of material burning or material installation.

3.3.23 Flaming Running. Continuous flaming material leaving the site of material burning or material installation.

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

3.3.25 Hazard. Real or potential condition that can cause injury.

3.3.26 Headway. The interval of time between the arrivals of consecutive trains at a platform in a station.

3.3.27* Heat Release Rate (HRR). The rate at which heat energy is generated by burning. [**921,** 2011]

3.3.27.1 ***Average Heat Release Rate (HRR_{180}).*** The average heat release rate per unit area, over the time period starting at time to ignition and ending 180 seconds later, as measured in ASTM E 1354 (kW/m^2).

3.3.27.2 ***Fire Heat Release Rate for Ventilation Calculations.*** Rate of energy release for a given fire scenario expressed as a function of time [W (Btu/s)].

3.3.28 Incident Commander (IC). The individual responsible for all incident activities, including the development of strategies and tactics and the ordering and the release of resources. [**472,** 2013]

3.3.29 Noncombustible (Material). See Section 4.7.

3.3.30 Nonmechanical Emergency Ventilation System. A system of smoke reservoirs, smoke vents, and/or dampers that are designed to support the tenability criteria without the use of fans.

3.3.31 Occupancy.

3.3.31.1 ***Incidental Occupancies Within Stations.*** The use of a portion of the station by others who are neither transit system employees nor passengers and where such space remains under the control of the system-operating authority.

3.3.31.2 ***Nonsystem Occupancy.*** An occupancy not under the control of the system-operating authority.

3.3.32 Operations Control Center. The operations center where the authority controls and coordinates the systemwide movement of passengers and trains from which communication is maintained with supervisory and operating personnel of the authority and with participating agencies when required.

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

3.3.34 Passenger Load.

3.3.34.1 ***Detraining Load.*** The number of passengers alighting from a train at a platform.

3.3.34.2 ***Entraining Load.*** The number of passengers boarding a train at a platform.

3.3.34.3 ***Link Load.*** The number of passengers traveling between two stations on board a train or trains.

3.3.35 Point of Safety. A point of safety is one of the following: (1) an enclosed exit that leads to a public way or safe location outside the station, trainway, or vehicle; (2) an at-grade point beyond the vehicle, enclosing station, or trainway; (3) any other approved location.

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

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

3.3.38 Radiant Panel Index (I_s). The product of the flame spread factor (F_s) and the heat evolution factor (Q_s), as determined in ASTM E 162.

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

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

3.3.41 Smoke Obscuration. The reduction of light transmission by smoke, as measured by light attenuation. [**270,** 2013]

3.3.42 Specific Extinction Area. A measure of smoke obscuration potential per unit mass burnt, determined as the product of the specific extinction coefficient and the volumetric mass flow rate, divided by the mass loss rate [m/kg (ft/lb)].

3.3.43 Specific Optical Density (D_s). The optical density, as measured in ASTM E 662, over unit path length within a chamber of unit volume, produced from a specimen of unit surface area, that is irradiated by a heat flux of 2.5 W/cm^2 for a specified period of time.

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

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

3.3.44.2* ***Open Station.*** A station that is constructed such that it is directly open to the atmosphere and smoke and heat are allowed to disperse directly into the atmosphere.

3.3.45 Station Platform. The area of a station immediately adjacent to a guideway, used primarily for loading and unloading passengers.

3.3.46 Structure.

3.3.46.1 ***Elevated Structure.*** Any structure not otherwise defined as a surface or underground structure.

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

3.3.47 System. See 3.3.52.1, Fixed Guideway Transit System, or 3.3.52.2, Passenger Rail System.

3.3.48 Tenable Environment. An environment that permits the self-rescue or survival of occupants.

3.3.49 Tourist, Scenic, Historic, or Excursion Operations. Railroad operations, often using antiquated equipment, that are principally intended to carry passengers traveling for pleasure purposes.

3.3.50 Track.

3.3.50.1 ***Storage Track.*** A portion of the trainway used for temporary storage or light cleaning of trains and not intended to be used for trains occupied by passengers.

3.3.50.2 ***Tail Track.*** A portion of dead-end trainway used for temporary storage, turn-around, or light cleaning of trains and not intended to be used for trains occupied by passengers.

3.3.51 Trainway. That portion of the system in which the vehicles operate.

3.3.52 Transportation Systems.

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

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

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

3.3.53 Vehicle.

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

3.3.53.2 ***Passenger Rail Vehicle.*** A vehicle and/or power unit running on rails used to carry passengers and crew.

Chapter 4 General

4.1 Fire Safety of Systems.

4.1.1 Fire safety of systems shall be achieved through a composite of facility design, operating equipment, hardware, procedures, and software subsystems that are integrated to protect life and property from the effects of fire.

4.1.2 The level of fire safety desired for the whole system shall be achieved by integrating the required levels for each subsystem.

4.2 Goals.

4.2.1* The goals of this standard shall be to provide an environment for occupants of fixed guideway and passenger rail system elements that is safe from fire and similar emergencies to a practical extent based on the following measures:

(1) Protection of occupants not intimate with the initial fire development
(2) Maximizing the survivability of occupants intimate with the initial fire development

4.2.2 This standard is prepared with the intent of providing minimum requirements for those instances where noncombustible materials (as defined in Section 4.7) are not used due to other consideration in the design and construction of the system elements.

4.3 Objectives.

4.3.1 Occupant Protection. Systems shall be designed, constructed, and maintained to protect occupants who are not intimate with the initial fire development for the time needed to evacuate or relocate them or to defend such occupants in place during a fire or fire-related emergency.

4.3.2 Structural Integrity. Structural integrity of stations, trainways, and vehicles shall be maintained for the time needed to evacuate, relocate, or defend in place occupants who are not intimate with the initial fire development.

4.3.3 Systems Effectiveness. Systems utilized to achieve the goals stated in Section 4.2 shall be effective in mitigating the hazard or condition for which they are being used, shall be reliable, shall be maintained to the level at which they were designed to operate, and shall remain operational.

4.4* Assumption of a Single Fire Event. The protection methods described in this standard shall assume a single fire event from a single fire source.

4.5* Shared Use by Freight Systems. Where passenger and freight systems are operated concurrently through or adjacent to stations and trainways, the design of the station and trainway fire-life safety and fire protection systems shall consider the hazards associated with both uses, as approved.

4.6* Fire Scenarios. Design scenarios shall consider the location and size of a fire or a fire-related emergency.

4.7* Noncombustible Material.

4.7.1* A material that complies with any of the following shall be considered a noncombustible material: [**101:**4.6.13.1]

(1) A material that, 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. [**101:**4.6.13.1(1)]
(2) A material that is reported as passing ASTM E 136. [**101:** 4.6.13.1(2)]
(3) A material that is reported as complying with the pass/fail criteria of ASTM E 136 when tested in accordance with the test method and procedure in ASTM E 2652. [**101:**4.6.13.1(3)]

4.8* Fire-Life Safety System Integrity. No part of the fire-life safety system critical to the intended system function that addresses an emergency shall be vulnerable to the emergency that it is supposed to address.

Chapter 5 Stations

5.1 General.

5.1.1 Applicability.

5.1.1.1 This chapter shall apply to all portions of stations.

5.1.2* Relationship to Local Codes.

5.1.2.1 The requirements in this chapter shall supplement the requirements of the locally applicable codes for the design and construction of stations.

5.1.2.2 Where the requirements in this chapter do not address a specific feature of fire protection or life safety, the requirements of the local codes shall be considered applicable.

5.1.3 Use and Occupancy.

5.1.3.1 The primary purpose of a station shall be for the use of the 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 passenger-carrying vehicle or to exit the station after arriving on an incoming passenger-carrying vehicle.

5.1.3.2 Where contiguous nonsystem occupancies share common space with the station, where incidental occupancies are within the station, or where the station is integrated into a building used for nonsystem occupancy of which is for neither fixed guideway transit nor passenger rail, special considerations beyond this standard shall be necessary.

5.1.3.3 A station shall also be for the use of employees whose work assignments require their presence in the station structures.

5.2 Construction.

5.2.1 Safeguards During Construction.

5.2.1.1 During the course of construction, provisions of NFPA 241 shall apply except as modified herein.

5.2.1.2 Where access for fire fighting is restricted, standpipes sized for water flow and pressure for the maximum predicted construction fire load shall be installed to within 61 m (200 ft) of the most remote portion of the station.

5.2.1.3 The flow and pressure required at the outlet shall be approved.

5.2.1.4* Illumination levels within construction areas of enclosed stations shall not be less than 2.7 lx (0.25 ft-candles) at the walking surface.

5.2.2 Construction Type.

5.2.2.1 Building construction for all new enclosed stations shall be not less than Type I or Type II or combinations of Type I and Type II noncombustible construction as defined in NFPA 220, in accordance with the requirements of NFPA *101*, Chapter 12, for the station configuration or as determined by fire hazard analysis of potential fire exposure hazards to the structure.

5.2.2.2 Other types of construction as defined in NFPA 220 shall be permitted for open stations in accordance with the provisions of NFPA *101*, Chapter 12, for corresponding station configurations.

5.2.3 Flammable and Combustible Liquids Intrusion.

5.2.3.1 General. Protection of underground system structures against the accidental intrusion of flammable and combustible liquids shall be provided in accordance with this section.

5.2.3.2 Vehicle Roadway Terminations. Vent or fan shafts utilized for ventilation of underground system structures shall not terminate at grade on any vehicle roadway.

5.2.3.3 Median and Sidewalk Terminations. Vent and fan shafts shall be permitted to terminate in the median strips of divided highways, on sidewalks designed to accept such shafts, or in open space areas, provided that the grade level of the median strips, sidewalk, or open-space meets the following conditions:

(1) It is at a higher elevation than the surrounding grade level.
(2) It is separated from the roadway by a concrete curb at least 150 mm (6 in.) in height.

5.2.4 Compartmentation.

5.2.4.1 Interconnected Floor Levels. Interconnection between floor levels in stations shall be permitted as follows:

(1)*Stairs and escalators used by passengers shall not be required to be fire-separated.
(2) Public areas on different levels in open stations are permitted to be interconnected.
(3) Public areas on different levels in enclosed stations shall be permitted to be interconnected, provided fire separation is not required for smoke control or other fire protection purposes.

5.2.4.2* Separation Between Public and Nonpublic Floor Areas. All public areas shall be fire-separated from adjacent nonpublic areas.

5.2.4.3 Ancillary Spaces. Fire resistance ratings of separations between ancillary occupancies shall be established as required by NFPA *101* and in accordance with ASTM E 119 and ANSI/UL 263.

5.2.4.4* Agents' and Information Booths. Agents' or information booths shall comply with the following:

(1) Agents' or information booths shall be constructed of noncombustible materials.
(2) Booths used only as agents' and information booths shall not be required to be fire-separated from public station areas.

5.2.4.5* Separation Between System and Nonsystem Occupancies. All station public areas shall be fire separated from adjacent non-system occupancies.

5.2.5 Interior Finish.

5.2.5.1 Materials used as interior wall and ceiling finish in enclosed stations shall be noncombustible except as permitted in the following:

(1) Except as required for materials listed in (2), materials exhibiting a flame spread index not exceeding 25 and a smoke developed index not exceeding 450 when tested in accordance with ASTM E 84 shall be permitted as interior wall and ceiling finish in enclosed stations.
(2) The following materials shall not be used as interior wall or ceiling finish, whether exposed or covered by a textile or vinyl facing, unless they are tested in accordance with NFPA 286 and meet the requirements of (3):
    (a) Foam plastic insulation
    (b) Textile wall or ceiling coverings
    (c) Polypropylene
    (d) High-density polyethylene
(3) Materials in accordance with NFPA 286, and meeting the following requirements shall be permitted as interior wall and ceiling finish in enclosed stations.
    (a) Flames shall not spread to the ceiling during the 40 kW (135 kBtu/hr) exposure.
    (b) Flames shall not spread to the outer extremities of the sample on any wall or ceiling.
    (c) Flashover, as described in NFPA 286, shall not occur.
    (d) The peak heat release rate shall not exceed 800 kW (2730 kBtu/hr).
    (e) The total smoke released throughout the test shall not exceed 1000 m^2 (10,764 ft^2).

5.2.5.2 Materials used as interior floor finish materials in enclosed stations shall be noncombustible or shall exhibit a critical radiant flux not less than 0.8 W/cm^2 (0.7 $Btu/ft^2 \cdot sec$) when tested in accordance with ASTM E 648.

5.2.5.3 Materials used as interior finish in open stations shall comply with the requirements of NFPA *101*, Chapter 12.

5.2.6 Combustible Furnishings and Contents.

5.2.6.1* Where combustible furnishings or contents not specifically addressed in this standard are installed in a station, a fire hazard analysis shall be conducted to determine that the level of occupant fire safety is not adversely affected by the furnishings and contents.

5.2.6.2* Permanent rubbish containers in the station shall be manufactured of noncombustible materials.

5.2.6.3 Seating furniture in stations shall be noncombustible, or it shall have limited rates of heat release when tested in accordance with ASTM E 1537, as follows:

(1) The peak rate of heat release for a single seating furniture item shall not exceed 80 kW (270 kBtu/hr).
(2) The total energy released by a single seating furniture item during the first 10 minutes of the test shall not exceed 25 MJ (23,700 Btu).

5.2.6.4 Lockers shall be constructed of noncombustible materials.

5.3* Means of Egress.

5.3.1* General.

5.3.1.1 The provisions for means of egress for a station shall comply with Chapters 7 and 12 of NFPA *101*, except as herein modified.

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

5.3.2 Occupant Load.

5.3.2.1* The occupant load for a station shall be based on the train load of trains simultaneously entering the station on all tracks in normal traffic direction plus the simultaneous entraining load awaiting trains.

(1) The train load shall consider only one train at any one track.
(2) The basis for calculating train and entraining loads shall be the peak period ridership figures as projected for design of a new system or as updated for an operating system.

5.3.2.2* For station(s) servicing areas such as civic centers, sports complexes, and convention centers, the peak ridership figures shall consider events that establish occupant loads not included in normal passenger loads.

5.3.2.3 At multilevel, multiline, or multiplatform stations, occupant loads shall be determined as follows:

(1) The maximum occupant load for each platform shall be considered separately for the purpose of sizing the means of egress from that platform.
(2)*Simultaneous loads shall be considered for all egress routes passing through each level of that station.

5.3.2.4 Where an area within a station is intended for use by other than passengers or employees, the following parameters shall apply:

(1) The occupant load for that area shall be determined in accordance with the provisions of NFPA *101* as appropriate for the use.
(2) The additional occupant load shall be included in determining the required egress from that area.
(3) The additional occupant load shall be permitted to be omitted from the station occupant load where the area has independent means of egress of sufficient number and capacity.

5.3.2.5* Calculation of Platform Occupant Load. The platform occupant load for each platform in a station shall be the maximum peak period occupant load calculated according to the following:

(1) The peak period occupant load for each platform shall be based on the simultaneous evacuation of the entraining load and the train load for that platform in the peak period.
(2) The entraining load for each platform shall be the sum of the entraining loads for each track serving that platform.
(3)*The entraining load for each track shall be based on the entraining load per train headway factored to account for service disruptions and system reaction time.
(4)*Where a platform serves more than one line on one track, the calculation of entraining load shall consider the combined effect of accumulation for each of the lines served.
(5) The train load for each platform shall be the sum of the train loads for each track serving that platform.
(6) The train load for each track shall be based on the train load per train headway factored to account for service disruptions and system reaction time.
(7) The maximum train load at each track shall be the maximum passenger capacity for the largest capacity train operating on that track during the peak period.

5.3.3* Capacity and Location of Means of Egress.

5.3.3.1* Platform Evacuation Time. There shall be sufficient egress capacity to evacuate the platform occupant load as defined in 5.3.2.5 from the station platform in 4 minutes or less.

5.3.3.2* Evacuation Time to a Point of Safety. The station shall be designed to permit evacuation from the most remote point on the platform to a point of safety in 6 minutes or less.

5.3.3.3 For open stations where the concourse is below or protected from the platform by distance or materials as determined by an appropriate engineering analysis, that concourse shall be permitted to be defined as a point of safety.

5.3.3.4 For enclosed stations equipped with an emergency ventilation system designed in accordance with Chapter 7 and where the emergency ventilation system provides protection for the concourse from exposure to the effects of a train fire at the platform as confirmed by engineering analysis, that concourse is permitted to be defined as a point of safety.

5.3.3.5 Travel Distance. The maximum travel distance on the platform to a point at which a means of egress route leaves the platform shall not exceed 100 m (325 ft).

5.3.3.6* Common Path of Travel. A common path of travel from the ends of the platform shall not exceed 25 m (82 ft) or one car length, whichever is greater.

5.3.3.7 Alternate Egress. At least two means of egress remote from each other shall be provided from each station platform as follows:

(1)*A means of egress used as a public circulation route shall be permitted to provide more than 50 percent of the required egress capacity from a station platform or other location.
(2) Means of egress from separate platforms shall be permitted to converge.
(3) Where means of egress routes from separate platforms converge, the subsequent capacity of the egress route shall be sufficient to maintain the required evacuation time from the incident platform.

5.3.3.8* Engineering Analysis. Modification of the evacuation times and travel distances shall be permitted based on an engineering analysis by evaluating material heat release rates, station geometry, and emergency ventilation systems.

5.3.4* Platforms, Corridors, and Ramps.

5.3.4.1* A minimum clear width of 1120 mm (44 in.) shall be provided along all platforms, corridors, and ramps serving as means of egress.

5.3.4.2 In computing the means of egress capacity available on platforms, corridors, and ramps, 300 mm (12 in.) shall be deducted at each sidewall, and 450 mm (18 in.) shall be deducted at platform edges that are open to the trainway.

5.3.4.3 The maximum means of egress capacity of platforms, corridors, and ramps shall be computed at 0.0819 p/mm-min (2.08 p/in.-min).

5.3.4.4* The maximum means of egress travel speed along platforms, corridors, and ramps shall be computed at 37.7 m/min (124 ft/min).

5.3.4.5* The means of egress travel speed for concourses and other areas where a lesser pedestrian density is anticipated shall be computed at 61.0 m/min (200 ft/min).

5.3.5 Stairs and Escalators.

5.3.5.1 Stairs and escalators permitted by 5.2.4.1 to be unenclosed shall be permitted to be counted as contributing to the means of egress capacity in stations as detailed in 5.2.2 and 5.3.3.

5.3.5.2 Stairs in the means of egress shall be a minimum of 1120 mm (44 in.) wide.

5.3.5.3* Capacity and travel speed for stairs and escalators shall be computed as follows:

(1) Capacity — 0.0555 p/mm-min (1.41 p/in.-min)
(2)*Travel speed — 14.6 m/min (48 ft/min) (indicates vertical component of travel speed)

5.3.5.4* Escalators shall not account for more than one-half of the means of egress capacity at any one level except as permitted by 5.3.5.5.

5.3.5.5 Escalators shall be permitted to account for more than one-half of the required means of egress capacity at any one level where the following criteria are met:

(1) The escalators are capable of being remotely brought to a stop in accordance with the requirements of 5.3.5.7(3)(b), 5.3.5.7(4), and 5.3.5.7(5).

(2) A portion of the means of egress capacity from each station level is stairs.
(3) For enclosed stations, at least one enclosed exit stair or exit passageway provides continuous access from the platforms to the public way.

5.3.5.6* In calculating the egress capacity of escalators, the following criteria shall be met:

(1) One escalator at each level shall be considered as being out of service.
(2) The escalator chosen shall be the one having the most adverse effect upon egress capacity.

5.3.5.7 Where escalators are permitted as a means of egress in stations, the following criteria shall be met:

(1)*The escalators shall be constructed of noncombustible materials.
(2)*Escalators running in the direction of egress shall be permitted to remain operating.
(3) Escalators running reverse to the direction of egress shall be capable of being stopped locally and remotely as follows:
   (a) Locally by a manual stopping device at the escalator
   (b) Remotely by one of the following:
      i. A manual stopping device at a remote location
      ii. As part of a pre-planned evacuation response
(4)*Where provision is made for remote stopping of escalators counted as means of egress, one of the following shall apply:
   (a) The stop shall be delayed until it is preceded by a minimum 15-second audible signal or warning message sounded at the escalator
   (b) Where escalators are equipped with the necessary controls to decelerate in a controlled manner under the full rated load, the stop shall be delayed for at least 5 seconds before beginning deceleration, and the deceleration, rate shall be no greater than 0.052 m/sec^2 (0.17 ft/sec^2).
(5) Where an audible signal or warning message is used, the following shall apply:
   (a) The signal or message shall have a sound intensity that is at least 15 dBA above the average ambient sound level for the entire length of the escalator.
   (b) The signal shall be distinct from the fire alarm signal.
   (c) The warning message shall meet audibility and intelligibility requirements.

5.3.5.8 Escalators with or without intermediate landings shall be acceptable as a means of egress, regardless of vertical rise.

5.3.5.9 Escalators exposed to the outdoor environment shall be provided with slip-resistant landing and floor plates, and if they are exposed to freezing temperatures, the landing and floor plates and the steps shall be heated to prevent the accumulation of ice and snow.

5.3.5.10 Stopped escalators shall be permitted to be started in the direction of egress in accordance with the requirements for stopping of escalators described in 5.3.5.7(3), 5.3.5.7(4), and 5.3.5.7(5), provided that the escalators can be restarted in a fully loaded condition and that passengers are given warning.

5.3.6 Elevators.

5.3.6.1 Elevators meeting the requirements of 5.3.6.2 through 5.3.6.4 shall be permitted to account for part of the means of egress capacity in stations.

5.3.6.2 Capacity. Where elevators are counted as contributing to the means of egress capacity, the following shall apply:

(1) They shall account for no more than 50 percent of the required egress capacity.
(2)*At least one elevator shall be considered out of service, and one elevator shall be reserved for fire service.
(3)*The capacity of each elevator shall be the carrying capacity of the elevator within 30 minutes.

5.3.6.3 Holding Area. Elevators counted as contributing to the means of egress capacity from any level of a station shall be accessed via holding areas or lobbies at that level, which shall be designed as follows:

(1) The holding areas or lobbies shall be separated from the platform by a smoketight fire separation having a fire resistance rating of at least 1 hour but not less than the time required to evacuate the holding area occupant load.
(2) At least one stair shall be accessible from the holding area.
(3) The holding area shall be sized to accommodate one person per 0.46 m^2 (5 ft^2).
(4) If the holding area includes portions of the platform, the area within 460 mm (18 in.) of the trainway shall not be considered in the calculation.
(5) Upon activation of smoke control in the platform or adjacent trainway areas, the holding area shall be pressurized to a minimum of 25 Pa (0.1003 in. of water gauge).
(6) The holding area shall be provided with emergency voice alarm devices with two-way communication to the system operations control center.

5.3.6.4 Design Features. Elevators counted as contributing to the means of egress capacity shall be designed as follows:

(1) Shaft enclosures shall be constructed as fire separations having a 2-hour fire resistance rating.
(2)*The design shall limit water flow into the shaft.
(3) No more than two elevators used for means of egress or fire department access shall share the same machine room.
(4) Machine rooms shall be separated from each other by fire separations having a minimum fire resistance rating of 2 hours.
(5) The elevators shall be connected to emergency power.
(6)*During emergency evacuation, the elevators shall travel only between the incident level and a point of safety.
(7)*Provisions for Phase I emergency recall operation shall be based on analysis of fire scenarios on each level served and demonstrate safe egress for those scenarios.

5.3.7* Doors, Gates, and Exit Hatches.

• **5.3.7.1** The egress capacity for doors and gates in a means of egress serving public areas shall be computed as follows:

(1) 60 people per minute (p/min) for single leaf doors and gates
(2)*0.0819 p/mm-min (2.08 p/in.-min) for bi-parting multileaf doors and gates measured for the clear width dimension.

5.3.7.2 Gates in a means of egress shall be designed in accordance with the requirements for doors serving as a means of egress.

5.3.7.3 Where used, exit hatches shall comply with the requirements of 6.3.3.15 through 6.3.3.17.

5.3.8 Fare Barriers.

5.3.8.1 Fare barriers complying with 5.3.8.2 through 5.3.8.5 shall be permitted in the means of egress serving stations.

5.3.8.2* Except as permitted in 5.3.8.3, fare barriers in the required means of egress shall be designed to release, permitting unimpeded travel in the direction of egress under all the following conditions:

(1) Power failure or ground fault condition
(2) Activation of the station fire alarm signal
(3) Manual activation from a switch in a constantly attended location in the station or operations control center

5.3.8.3 Fare barriers that do not comply with the requirements of 5.3.8.2 shall be permitted in the means of egress where barriers in the equipment are designed to provide egress when a horizontal force not exceeding 66N (15lbf) is applied in the egress direction.

5.3.8.4 Gate-type fare barriers in the means of egress shall meet the following criteria:

(1)*Each unit shall provide a minimum of 455 mm (18 in.) clear width at and below a height of 1000 mm (39.5 in.) and 530 mm (21 in.) clear width above that height.
(2) Each unit shall be credited with a capacity of 50 p/min for egress calculations.

5.3.8.5 Turnstile-type fare barriers shall be permitted in accordance with NFPA *101* and shall in the means of egress shall meet the following criteria:

(1) Dimensions shall be in accordance with the requirements of NFPA *101*.
(2) Turnstiles that drop away from the egress opening under the conditions listed in 5.3.8.2 or 5.3.8.3 shall be credited with a capacity of 50 p/min for egress calculations.
(3) Turnstiles that revolve freely in the direction of egress under the conditions listed in 5.3.8.2 shall meet the following criteria:
   (a) Each unit shall be credited with a capacity of 25 p/min for egress calculations.
   (b) The turnstiles shall not account for more than 50 percent of the required egress capacity for each egress route.

5.3.8.6* Fare barriers shall be designed so that their failure to operate properly will not prohibit movement of passengers in the direction of emergency egress.

5.3.9 Horizontal Exits.

5.3.9.1* Horizontal exits compliant with NFPA *101* shall be permitted for up to 100 percent of the number of horizontal exits and required egress capacity provided that not more than 50 percent of the number and required capacity is into a single building.

5.3.10 Platform Screen and Edge Doors.

5.3.10.1 Horizontal sliding platform screen or platform edge doors shall be permitted to separate the platform from the trainway in stations, provided that the following criteria are met:

(1) The doors permit emergency egress from the train to the platform regardless of the stopping position of the train.
(2) The doors provide egress when a force not exceeding 220 N (50 lb) is applied from the train side of the doors.
(3) The doors are designed to withstand positive and negative pressures caused by passing trains.

5.3.11 Means of Egress Lighting.

5.3.11.1 Illumination of the means of egress in stations, including escalators that are considered a means of egress, shall be in accordance with Section 7.8 of NFPA *101*.

5.3.11.2 Means of egress, including escalators considered as means of egress, shall be provided with a system of emergency lighting in accordance with Section 7.9 of NFPA *101*.

5.3.11.3 In addition to the requirements of 5.3.11.1 and 5.3.11.2:

(1) Lighting for stairs and escalators shall be designed to emphasize illumination on the top and bottom steps and landings.
(2) Where newel- and comb-lighting is provided for escalator steps, such lighting shall be on emergency power circuits.

5.4 Fire Protection.

5.4.1* Fire Command Center.

5.4.1.1 Enclosed stations shall be provided with a fire command center in accordance with *NFPA 72*.

5.4.1.2 The ventilation systems at adjacent trainways and stations shall be permitted to be omitted from the controls of the fire command center.

5.4.2 Protective Signaling Systems.

5.4.2.1 Stations equipped with fire alarm devices shall be protected by a proprietary supervising station alarm system as defined in *NFPA 72*.

5.4.2.2* Each station having fire alarm initiating devices shall be provided with a fire alarm annunciator panel at a location that is accessible to emergency response personnel in accordance with *NFPA 72*.

5.4.2.3 The location of the fire alarm annunciator panel shall be approved.

5.4.2.4 Annunciator panels shall announce by audible alarm the activation of any fire alarm initiating device in the station and visually display the location of the actuated device.

5.4.2.5 When activated, all indicator signals for fire alarms, smoke detection, valve switches, and waterflow shall be transmitted simultaneously to the local station and to the operations control center.

5.4.2.6* Separate zones shall be established on local station annunciator panels to monitor waterflow on sprinkler systems and supervise main control valves.

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

5.4.2.8 Fire alarm systems shall be inspected, tested, and maintained in accordance with *NFPA 72*.

5.4.3 Emergency Communication.

5.4.3.1 A public address (PA) system and emergency voice alarm reporting devices, such as emergency telephone boxes or manual fire alarm boxes conforming to *NFPA 72*, shall be required in stations.

5.4.3.2 The operations control center and each system station shall be equipped with an approved emergency voice/alarm communication system so that appropriate announcements can be made regarding fire alarms, including provisions for giving necessary information and directions to the public upon receipt of any manual or automatic fire alarm signal.

5.4.3.3 The notification devices shall be placed in approved locations at each facility.

5.4.3.4 Emergency alarm reporting devices shall be located on passenger platforms and throughout the stations such that the travel distance from any point in the public area shall not exceed 100 m (325 ft) unless otherwise approved.

5.4.3.5 Such emergency devices shall be distinctive in color, and their locations shall be plainly indicated by appropriate signs.

5.4.4 Automatic Fire Suppression Systems.

5.4.4.1* An automatic sprinkler protection system shall be provided in areas of stations used for concessions, in storage areas, in trash rooms, and other similar areas with combustible loadings, except trainways.

5.4.4.2 Sprinkler protection shall be permitted to be omitted in areas of open stations remotely located from public spaces.

5.4.4.3 Installation of sprinkler systems shall comply with NFPA 13 or applicable local codes as required.

5.4.4.4 A sprinkler system waterflow alarm and supervisory signal service shall be installed.

5.4.4.5 Other fire suppression systems, if approved, shall be permitted to be substituted for automatic sprinkler systems in the areas listed in 5.4.4.1.

5.4.4.6 Automatic fire sprinkler systems shall be tested and maintained in accordance with NFPA 25.

5.4.5 Standpipe and Hose Systems.

5.4.5.1* Class I standpipes shall be installed in enclosed stations in accordance with NFPA 14 except as modified herein.

5.4.5.2 Standpipe systems shall not be required to be enclosed in fire-rated construction provided the following conditions are met:

(1) The system is cross-connected or fed from two locations.
(2) Isolation valves are installed not more than 245 m (800 ft) apart.

5.4.5.3 In addition to the usual identification required on fire department connections for standpipes, there shall also be wording to identify the fire department connection as part of the station system.

5.4.5.4* Standpipes shall be permitted to be of the dry type with the approval of the authority having jurisdiction provided the following requirements are met:

(1)*Systems shall be installed in a manner so that the water is delivered to all hose connections on the system in 10 minutes or less.
(2) Combination air relief–vacuum valves shall be installed at each high point on the system.

5.4.5.5 Dry standpipes shall be permitted to be concealed without the piping integrity being monitored with a supervisory air pressure provided they are pressure tested annually.

5.4.5.6 Where enclosed stations include more than one platform level (such as crossover subway lines), there shall be a cross-connection pipe of a minimum size of 100 mm (4 in.) in diameter between each standpipe system, so that supplying water through any fire department connection will furnish water throughout the entire system.

5.4.5.7 Standpipe and hose systems shall be tested and maintained in accordance with NFPA 25.

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

5.4.6.1 Portable fire extinguishers shall be maintained in accordance with NFPA 10.

5.4.7 Ventilation.

5.4.7.1 Emergency ventilation shall be provided in enclosed stations in accordance with Chapter 7.

5.4.8 Emergency Power.

5.4.8.1 Emergency power in accordance with Article 700 of *NFPA 70*, and Chapter 4 of NFPA 110 shall be provided for enclosed stations.

5.4.8.2 The supply system for emergency purposes, in addition to the normal services to the station building, shall be one or more of the types of systems described in 700.12(A) through 700.12(E) of *NFPA 70*.

5.4.8.3 The emergency power system shall have a capacity and rating sufficient to supply all equipment required to be connected by 5.4.8.5.

5.4.8.4 Selective load pickup and load shedding shall be permitted in accordance with *NFPA 70*.

5.4.8.5 Systems connected to the emergency power system shall include the following:

(1) Emergency lighting
(2) Protective signaling systems
(3) Emergency communication system
(4) Fire command center
(5) Elevators providing required egress capacity [see 5.3.6.4(5)]

5.4.8.6 The emergency lighting and communications circuits shall be protected from physical damage by system vehicles or other normal system operations and from fire as described in 12.4.4.

Chapter 6 Trainways

6.1 General.

6.1.1* Applicability. This chapter applies to all portions of the trainway, including pocket storage and tail tracks not intended for occupancy by passengers.

6.1.2 Use and Occupancy.

6.1.2.1 Passengers shall enter the trainways only in the event that it becomes necessary to evacuate a train.

6.1.2.2 Evacuation shall take place only under the guidance and control of authorized, trained system employees or other authorized personnel as warranted under an emergency situation.

6.1.2.3* Warning signs in accordance with 6.3.5.1 shall be posted at locations where unauthorized personnel might trespass.

6.2 Construction.

6.2.1 Safeguards During Construction.

6.2.1.1 A standpipe system shall be installed in enclosed trainways under construction in accordance with NFPA 241.

6.2.1.2 The standpipe system shall be installed before the enclosed trainway has exceeded a length of 61 m (200 ft) beyond any access shaft or portal and shall be extended as work progresses to within 61 m (200 ft) of the most remote portion of the enclosed trainway.

6.2.1.3 Standpipes shall be sized for approved water flow and pressure at the outlet, based upon the maximum predicted fire load.

6.2.1.4 Reducers or adapters shall meet the following criteria:

(1) Be provided and attached for connection to the contractor's hose
(2) Be readily removable through the use of a fire fighter's hose spanner wrench

6.2.1.5 Risers shall meet the following criteria:

(1) Be identified with signs as outlined in 6.4.4.7
(2) Be readily accessible for fire department use
(3) Be protected from accidental damage

6.2.1.6* Illumination levels in enclosed trainways under construction shall not be less than 2.7 lx (0.25 ft-candles) at the walking surface.

6.2.2 Construction Type.

6.2.2.1* Cut and Cover. Where trainway sections are to be constructed by the cut-and-cover method, perimeter walls and related construction shall be not less than Type I or Type II or combinations of Type I or Type II noncombustible construction as defined in NFPA 220, as determined by an engineering analysis of potential fire exposure hazards to the structure.

6.2.2.2 Bored Tunnels. Where trainway sections are to be constructed by a tunneling method through earth, unprotected steel liners, reinforced concrete, shotcrete, or equivalent shall be used.

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

6.2.2.4 Underwater Tubes. Underwater tubes shall be not less than Type II (000) noncombustible construction as defined in NFPA 220, as applicable.

6.2.2.5 Exit and Ventilation Structures. Remote vertical exit shafts and ventilation structures shall be not less than Type I (332) noncombustible construction as defined in NFPA 220.

6.2.2.6 Surface. Construction materials shall be not less than Type II (000) noncombustible material as defined in NFPA 220, as determined by a fire hazard analysis of potential fire exposure hazards to the structure.

6.2.2.7 Elevated. All structures necessary for trainway support and all structures and enclosures on or under trainways shall be of not less than Type I or Type II (000) or combinations of Type I or Type II noncombustible construction as defined in NFPA 220, as determined by a fire hazard analysis of potential fire exposure hazards to the structure.

6.2.3 Flammable and Combustible Liquids Intrusion.

6.2.3.1 General. Protection of underground system structures against the accidental intrusion of flammable and combustible liquids shall meet the requirements of 5.2.3.

6.2.4* Compartmentation.

6.2.4.1 Ancillary areas shall be separated from trainway areas within underwater trainway sections by construction having a minimum 3-hour fire-resistance rating.

6.2.4.2 Ancillary areas shall be separated from trainway areas within enclosed trainway sections by construction having a minimum 2-hour fire-resistance rating.

6.2.5 Combustible Components.

6.2.5.1 Where combustible components not specifically addressed in this standard are installed in a trainway, a fire hazard analysis shall be conducted to determine that the level of occupant fire safety is not adversely affected by the contents.

6.2.5.2 The fire hazard analysis required by 6.2.5.1 shall meet the following criteria:

(1) It shall include, as a minimum, an examination of peak heat release rate for combustible elements, total heat released, ignition temperatures, radiant heating view factors, and behavior of the component during internal or external fire scenarios.
(2) It shall determine that, if a fire propagates beyond involving the component of fire origin, a level of fire safety is provided within an enclosed trainway commensurate with this standard.

6.2.5.3 Computer modeling, material fire testing, or full-scale fire testing shall be conducted to assess performance in potential fire scenarios.

6.2.6 Walking Surfaces.

6.2.6.1 Walking surfaces designated for evacuation of passengers shall be constructed of noncombustible materials.

6.2.7 Coverboard or Protective Material.

6.2.7.1 Coverboard or protective material shall have a flame spread index of not more than 25 and a smoke developed index not exceeding 450 when tested in accordance with ASTM E 84.

6.2.7.2 Coverboard protective material tested in accordance with NFPA 286 shall comply with the following:

(1) Flames shall not spread to the ceiling during the 40 kW (135 kBtu/hr) exposure.
(2) Flames shall not spread to the outer extremities of the sample on any test room wall or ceiling.
(3) Flashover as described in NFPA 286 shall not occur.
(4) The peak heat release rate throughout the test shall not exceed 800 kW (2730 kBtu/hr).
(5) The total smoke released throughout the test shall not exceed 1000 m^2 (10,764 ft^2).

6.2.8 Rail Ties.

6.2.8.1 Rail ties used in enclosed locations shall be noncombustible materials.

6.2.8.2 Rail ties used at switch or crossover locations shall comply with 6.2.8.1 or shall be fire–retardant treated wood in accordance with NFPA 703.

6.2.8.3 Rail ties and tie blocks in enclosed track sections shall be permitted to be of wood encased in concrete such that only the top surface is exposed.

6.3 Emergency Egress.

6.3.1 Location of Egress Routes.

6.3.1.1* The system shall incorporate a walk surface or other approved means for passengers to evacuate a train at any point along the trainway so that they can proceed to the nearest station or other point of safety.

6.3.1.2 Walkway continuity shall be maintained at special track sections (e.g., crossovers, pocket tracks).

6.3.1.3 Walkway continuity shall be provided by crosswalks at track level.

6.3.1.4* Within enclosed trainways, the maximum distance between exits shall not exceed 762 m (2500 ft).

6.3.1.5 Cross-passageways shall be permitted to be used in lieu of emergency exit stairways to the surface where trainways in tunnels are divided by a minimum of 2 hour–rated fire separations or where trainways are in twin bores.

6.3.1.6 Where cross-passageways are utilized in lieu of emergency exit stairways, the following requirements shall apply:

(1) Cross-passageways shall not be farther than 244 m (800 ft) apart.
(2)*Cross-passageways shall not be farther than 244 m (800 ft) from the station or portal of the enclosed trainway.
(3) Cross-passageways shall be separated from the trainway with self-closing fire door assemblies having a fire protection rating of 1½ hours.
(4) A tenable environment shall be maintained in the portion of the trainway that is not involved in an emergency and that is being used for evacuation.
(5) A ventilation system for the incident trainway shall be designed to control smoke in the vicinity of the passengers.
(6) Provisions shall be made for evacuating passengers via the non-incident trainway to a nearby station or other emergency exit.
(7)*The provisions shall include measures to protect passengers from oncoming traffic and from other hazards.

6.3.1.7 Where cross-passageways are used in lieu of emergency exit stairways, the interior of the cross-passage shall not be used for any purpose other than as an area of refuge or for access/egress to the opposite tunnel except under the following conditions:

(1) The use of cross-passages for the installation of noncombustible equipment is permitted.
(2) Installed equipment does not intrude into the required clear width of the cross-passage.

6.3.1.8 In areas where cross-passageways are provided, walkways shall be provided on the cross-passageway side of the trainway for unobstructed access to the cross-passageway.

6.3.1.9 For open-cut trainways, an engineering analysis shall be conducted to evaluate the impact of the trainway configuration on safe egress from a train fire to a point of safety.

6.3.1.10 Where the engineering analysis indicates that the configuration will impact tenability beyond the immediate vicinity of the fire, egress routes shall be provided such that the maximum distance from any point within the open-cut section to a point of egress from the trainway shall not be more than 381 m (1250 ft).

6.3.2 Size of Egress Routes

6.3.2.1* The means of egress within the trainway shall be provided with an unobstructed clear width graduating from 610 mm (24 in.) at the walking surface to 760 mm (30 in.) at 1575 mm (62 in.) above the walking surface to 430 mm (17 in.) at 2025 mm (80 in.) above the walking surface.

6.3.2.2 Cross-passageways shall be a minimum of 1120 mm (44 in.) in clear width and 2100 mm (7 ft) in height.

6.3.2.3* The width of exit stairs shall not be required to exceed 1120 mm (44 in.) for enclosed trainways.

6.3.2.4* Doors in egress routes serving trainways shall have a minimum clear width of 810 mm (32 in.).

6.3.3* Egress Components.

6.3.3.1 Walking surfaces serving as egress routes within guideways shall have a uniform, slip-resistant design.

6.3.3.2 Guideway crosswalks shall have a uniform walking surface at the top of the rail.

6.3.3.3 Where the trainway track bed serves as the emergency egress pathway, it shall be nominally level and free of obstructions.

6.3.3.4 Except as permitted in 6.3.3.3, walking surfaces shall have a uniform, slip-resistant design.

6.3.3.5* Walkways that are more than 760 mm (30 in.) above the floor or grade below shall be provided with a continuous guard to prevent falls over the open side.

6.3.3.6 Guards shall not be required along the trainway side of raised walkways where the bottom of the trainway is closed by a deck or grating.

6.3.3.7 Guards shall not be required on raised walkways that are located between two trainways.

6.3.3.8* Walkways that are more than 760 mm (30 in.) above the floor or grade below shall be provided with a continuous handrail along the side opposite the trainway.

6.3.3.9 Raised walkways that are greater than 1120 mm (44 in.) wide and located between two trainways shall not be required to have a handrail.

6.3.3.10 Exit stairs and doors shall comply with Chapter 7 of NFPA *101*, except as herein modified.

6.3.3.11 Doors in the means of egress, except cross-passageway doors, shall open in the direction of exit travel.

6.3.3.12 Doors in the means of egress shall comply with the following:

(1) Open fully when a force not exceeding 220 N (50 lb) is applied to the latch side of the door
(2) Be adequate to withstand positive and negative pressures caused by passing trains and the emergency ventilation system

6.3.3.13 Horizontal sliding doors shall be permitted in cross-passageways.

6.3.3.14 Platform end gates shall meet the clear width requirements for gate-type fare barriers. *(See Chapter 5.)*

6.3.3.15 Exit hatches shall be permitted in the means of egress, provided the following conditions are met:

(1) Hatches shall be equipped with a manual opening device that can be readily opened from the egress side.
(2) Hatches shall be operable with not more than one releasing operation.
(3) The force required to open the hatch when applied at the opening device shall not exceed 130 N (30 lb).
(4) The hatch shall be equipped with a hold-open device that automatically latches the door in the open position to prevent accidental closure.

6.3.3.16 Exit hatches shall be capable of being opened from the discharge side to permit access by authorized personnel.

6.3.3.17* Exit hatches shall be conspicuously marked on the discharge side to prevent possible blockage.

6.3.4 Traction Power Protection.

6.3.4.1* This subsection shall apply to the traction power subsystem installed in all trainways, which shall include the wayside pothead, the cable between the pothead and the contact (third) rail or overhead contact system (OCS), the contact rail or OCS supports, and special warning and identification devices, as well as electrical appurtenances associated with overhead contact systems.

6.3.4.2 To provide safety isolation from the contact rail, the following requirements shall apply:

(1) Power rail conductor(s) (dc or ac, which supply power to the vehicle for propulsion and other loads) shall be secured to insulating supports, bonded at joints, and protected to prevent contact with personnel.
(2) The design shall include measures to prevent inadvertent contact with the live power rails where such power rails are adjacent to emergency or service walkways and where walkways cross over trainways.
(3) Coverboards, where used, shall be capable of supporting a vertical load of 1125 N (250 lb) at any point with no visible permanent deflection.

6.3.4.3 To provide isolation from the overhead contact system, the following requirements shall apply:

(1) Power conductor(s) (dc or ac, which supply power to the vehicle for propulsion and other loads) shall be secured to insulating supports, bonded at joints, and protected to prevent contact with personnel.
(2) Insulating material for the cable connecting power to the power rail or OCS shall meet the FT4/IEEE 1202 exposure requirements for cable char height, total smoke released, and peak smoke release rate of ANSI/UL 1685.

6.3.5 Signage, Illumination, and Emergency Lighting.

6.3.5.1 Warning signs posted on entrances to the trainway and on fences or barriers adjacent to the trainway shall clearly state the hazard (e.g., DANGER HIGH VOLTAGE — 750 VOLTS) with letter sizes and colors in conformance with *NFPA 70* and Occupational Safety and Health Administration (OSHA) requirements.

6.3.5.2 System egress points shall be illuminated.

6.3.5.3 Points of exit from elevated and enclosed trainways shall be marked with internally or externally illuminated signs.

6.3.5.4 Identification. Emergency exit facilities shall be identified and maintained to allow for their intended use.

6.3.5.5 Enclosed trainways greater in length than the minimum length of one train shall be provided with directional signs as appropriate for the emergency procedures developed for the fixed guideway transit or passenger rail system in accordance with Chapter 9.

6.3.5.6 Directional signs indicating station or portal directions shall be installed at maximum 25 m (82 ft) intervals on either side of the enclosed trainways.

6.3.5.7 Directional signs shall be readily visible by passengers for emergency evacuation.

6.3.5.8 The requirements of 6.3.5.9 through 6.3.5.14 shall apply to all enclosed trainways that are greater than 30.5 m (100 ft) in length or two car lengths, whichever is greater.

6.3.5.9* Lighting systems shall be designed so that, during a period of evacuation, illumination levels of trainway walkways and walking surfaces shall not be less than 2.7 lx (0.25 ft-candles), measured along the path of egress at the walking surface.

6.3.5.10 The emergency lighting system in the trainway shall produce illumination on the walkway that does not exceed a uniformity ratio of 10:1 for the maximum maintained horizontal illuminance to the minimum maintained horizontal illuminance.

6.3.5.11* Point illumination of means of egress elements shall be permitted to exceed the 10:1 uniformity ratio.

6.3.5.12 Lighting systems for enclosed trainways shall be installed in accordance with Sections 7.8 and 7.9 of NFPA *101*, except as otherwise noted in 6.3.5.

6.3.5.13 Exit lights, essential signs, and emergency lights shall be included in the emergency lighting system in accordance with *NFPA 70*.

6.3.5.14 Emergency fixtures, exit lights, and signs shall be wired separately from emergency distribution panels.

6.4 Fire Protection and Life Safety Systems.

6.4.1 Emergency Access.

6.4.1.1 Except as described herein, points of egress and exits from the guideway shall serve as emergency access routes.

6.4.1.2 If security fences are used along the trainway, access gates shall be provided in security fences, as deemed necessary by the authority having jurisdiction.

6.4.1.3 Access gates shall be a minimum 1120 mm (44 in.) wide and shall be of the hinged or sliding type.

6.4.1.4 Access gates shall be placed as close as practicable to the portals to permit easy access to tunnels.

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

6.4.1.6 Access to the elevated trainway shall be from stations or by mobile ladder equipment from roadways adjacent to the trackway.

6.4.1.7 If no adjacent or crossing roadways exist for the elevated trainway, access roads at a maximum of 762 m (2500 ft) intervals shall be required.

6.4.1.8 Where the configuration of an open-cut trainway prevents or impedes access for firefighting, provisions shall be made to permit fire fighter access to that section of trainway at intervals not exceeding 762 m (2500 ft).

6.4.2 Blue Light Stations.

6.4.2.1* Blue light stations shall be provided at the following locations:

(1) At the ends of station platforms
(2) At cross-passageways
(3) At emergency access points
(4) At traction power substations
(5) In enclosed trainways as approved

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

6.4.2.3 For blue light stations at elevated guideways, the graphics shall be legible from the ground level outside the trackway.

6.4.2.4 In systems with overhead traction power, the requirement to disconnect traction power shall be permitted by an approved alternative means.

6.4.3 Automatic Fire Detection.

6.4.3.1 Heat and smoke detectors shall be installed at traction power substations and signal bungalows and shall be connected to the operations control center.

6.4.3.2 Signals received from such devices shall be identifiable as to the origin of the signals.

6.4.4 Standpipe and Hose Systems.

6.4.4.1 An approved fire standpipe system shall be provided in enclosed trainways where physical factors prevent or impede access to the water supply or fire apparatus, where required by the authority having jurisdiction.

6.4.4.2* Class I standpipe systems shall be installed in trainways in accordance with NFPA 14 except as modified herein.

6.4.4.3 Standpipe systems shall not be required to be enclosed in fire-rated construction, provided the following conditions are met:

(1) The system is cross-connected or fed from two locations.
(2) Isolation valves are installed not more than 244 m (800 ft) apart.

6.4.4.4 Standpipes shall be permitted to be of the dry type with the approval of the authority having jurisdiction provided the following conditions are met:

(1)*Standpipes shall be installed so that the water is delivered to all hose connections on that standpipe in 10 minutes or less.
(2) Combination air relief–vacuum valves shall be installed at each high point on the standpipe.

6.4.4.5 Standpipe systems shall be provided with an approved water supply capable of supplying the system demand for a minimum of 1 hour.

6.4.4.6 Acceptable water supplies shall include the following:

(1) Municipal or privately owned waterworks systems that have adequate pressure, flow rate, and level of integrity
(2) Automatic or manually controlled fire pumps that are connected to water source
(3) Pressure-type or gravity-type storage tanks that are installed in accordance with NFPA 22

6.4.4.7 Identification numbers and letters conforming to the system sectional identification numbers and letters shall be provided at each surface fire department connection and at each hose valve on the standpipe lines.

6.4.4.8 Identifying signs shall be affixed to enclosed trainway walls at each hose outlet valve or shall be painted directly on the standpipe in white letters next to each hose outlet valve.

6.4.4.9 Exposed standpipe lines and identification signs shall be painted as required by the authority having jurisdiction.

6.4.4.10 A fire department access road shall extend to within 30.5 m (100 ft) of the fire department connection.

6.4.5 Portable Fire Extinguishers.

6.4.5.1 Portable fire extinguishers shall be provided in such numbers, sizes, and types and at such locations in enclosed trainways as determined by the authority having jurisdiction.

6.4.6 Ventilation.

6.4.6.1 Except as described in 6.4.6.2 and 6.4.6.3, emergency ventilation shall be provided in enclosed trainways in accordance with Chapter 7.

6.4.6.2* Emergency ventilation meeting the tenability criteria for occupied spaces shall not be required in tail track areas where engineering analysis indicates that a fire on a train in the tail track area will not impact passengers or passenger areas.

6.4.6.3* Emergency ventilation meeting the tenability criteria for occupied areas shall not be required in storage track areas where the storage track has no openings along its length to passenger trainway areas and where an engineering analysis indicates that a fire on a train in the storage track area will not impact passengers or passenger areas.

6.4.7 Emergency Power.

6.4.7.1 Enclosed trainways shall be such that, in the event of failure of the normal supply to or within the system, emergency power shall be provided in accordance with Article 700 of *NFPA 70* and Chapter 4 of NFPA 110. The supply system for emergency purposes, in addition to the normal services to the trainway, shall be one or more of the types of systems described in 700.12(A) through 700.12(E) of *NFPA 70*.

6.4.7.2 The following systems shall be connected to the emergency power system:

(1) Emergency lighting
(2) Protective signaling systems
(3) Emergency communication system
(4) Fire command center

6.4.7.3 The emergency lighting and communications circuits shall be protected from physical damage by system vehicles or other normal system operations and from fire as described in 12.4.4.

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Chapter 7 Emergency Ventilation System

7.1 General.

7.1.1* This chapter defines the requirements for the environmental conditions and the mechanical and nonmechanical ventilation systems used to meet those requirements for a fire emergency in a system station, trainway, or both as required by 5.3.3 and 6.3.2.

7.1.2 The requirement for a mechanical or nonmechanical system intended for the purpose of emergency ventilation shall be determined in accordance with 7.1.2.1 through 7.1.2.4.

7.1.2.1 For length determination, all contiguous enclosed trainway and underground system station segments between portals shall be included.

7.1.2.2* A mechanical emergency ventilation system shall be provided in the following locations:

(1) In an enclosed system station
(2) In a system underground or enclosed trainway that is greater in length than 1000 ft (305 m)

7.1.2.3 A mechanical emergency ventilation system shall not be required in the following locations:

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

7.1.2.4 Where supported by engineering analysis, a nonmechanical emergency ventilation system shall be permitted to be provided in lieu of a mechanical emergency ventilation system in the following locations:

(1) Where the length of the underground or enclosed trainway is less than or equal to 1000 ft (305 m) and greater than 200 ft (61 m)
(2) In an enclosed station where engineering analysis indicates that a nonmechanical emergency ventilation system supports the tenability criteria of the project

7.1.2.5 In the event that an engineering analysis is not conducted or does not support the use of a nonmechanical emergency ventilation system for the configurations described in 7.1.2.4, a mechanical emergency ventilation system shall be provided.

7.1.3 The engineering analysis of the ventilation system shall include a validated subway analytical simulation program augmented as appropriate by a quantitative analysis of airflow dynamics produced in the fire scenario, such as would result from the application of validated computational fluid dynamics (CFD) techniques. The results of the analysis shall include the no-fire (or cold) air velocities that can be measured during commissioning to confirm that a mechanical ventilation system as built meets the requirements determined by the analysis.

7.1.4 Where required by 7.1.2, the mechanical emergency ventilation system shall make provisions for the protection of passengers, employees, and emergency personnel from fire and smoke during a fire emergency.

7.2 Design.

7.2.1 The emergency ventilation system shall be designed to do the following:

(1) Provide a tenable environment along the path of egress from a fire incident in enclosed stations and enclosed trainways
(2) Produce sufficient airflow rates within enclosed trainways to meet critical velocity
(3)*Be capable of reaching full operational mode within 180 seconds
(4) Accommodate the maximum number of trains that could be between ventilation shafts during an emergency
(5) Maintain the required airflow rates for a minimum of 1 hour but not less than the required time of tenability

7.2.1.1 Where the airflow rates required to accomplish 7.2.1(1), 7.2.1(2), or approved alternative performance criteria are dependent upon the unimpaired function of the air distribution system, that system shall be designed to continue operation when exposed to the conditions generated during the design incident for the duration determined as per 7.2.1(5). Although rating is not required, materials or systems that are fire rated for the required duration shall be permitted to be used.

7.2.2 Point-extract ventilation systems shall be permitted subject to an engineering analysis that demonstrates the system will confine the spread of smoke in the tunnel to a length of 150 m (500 ft) or less.

7.2.3 The design shall encompass the following:

(1) The fire heat release rate and fire smoke release rate produced by the combustible load of a vehicle and any combustible materials that could contribute to the fire load at the incident site
(2) The fire growth rate
(3) Station and trainway geometries
(4) The effects of elevation, elevation differences, ambient temperature differences, and ambient wind
(5) A system of fans, shafts, and devices for directing airflow in stations and trainways
(6) A program of predetermined emergency response procedures capable of initiating prompt response from the operations control center in the event of a fire emergency
(7) A ventilation system reliability analysis that, as a minimum, considers the following subsystems:
    (a) Electrical
    (b) Mechanical
    (c) Supervisory control

7.2.4 Criteria for the system reliability analysis in 7.2.3(7) shall be established and approved.

7.2.4.1 The analysis shall consider as a minimum the following events:

(1) Fire in trainway or station
(2) Local incident within the electrical utility that interrupts power to the emergency ventilation system
(3) Derailment

7.2.5* The design and operation of the signaling system, traction power blocks, and ventilation system shall be coordinated to match the total number of trains that could be between ventilation shafts during an emergency.

7.2.6* The time-of-tenability criteria for stations and trainways shall be established and approved. For stations, the time shall be greater than the calculated egress time used to establish egress capacity in 5.3.2.1.

7.2.7 Ventilation air distribution systems shall be permitted to serve more than one trainway.

7.3 Emergency Ventilation Fans.

7.3.1 The ventilation system fans that are designated for use in fire and similar emergencies shall be capable of satisfying the emergency ventilation requirements to move trainway air in either direction as required to provide the needed ventilation response.

7.3.1.1 Individual emergency ventilation fan motors shall be designed to achieve their full operating speed in no more than

30 seconds from a stopped position when started across the line and in no more than 60 seconds for variable-speed motors.

7.3.1.2 The ventilation system designated for use in emergencies shall be capable of operating at full capacity in either the supply mode or exhaust mode to provide the needed ventilation response where dilution of noxious products is to be maximized.

7.3.1.3 The ventilation system designated for use in emergencies shall be capable of being turned off and dampers closed to provide the needed ventilation response where dispersion of noxious products is to be minimized.

7.3.2 Emergency ventilation fans, their motors, and all related components exposed to the exhaust airflow shall be designed to operate at the fan inlet airflow hot temperature condition from the design fan for a minimum of 1 hour.

7.3.2.1 The fan inlet airflow hot temperature shall be determined by an engineering analysis, however, this temperature shall not be less than 150°C (302°F).

7.3.2.2 The fan inlet airflow hot temperature shall be determined using the design fire at a location in the immediate vicinity of the emergency ventilation system track/station inlet(s), as applicable. Airflow rates shall be based upon the tunnel ventilation critical velocity or station tenability requirements, as applicable. These airflow rates will most likely be from location(s) that are different then the location for this hot temperature analysis.

7.3.2.3 Dampers that serve more than one trainway from a common duct system shall not be required to have a fire rating.

7.3.3 Fans shall be rated in accordance with the ANSI/AMCA 210, AMCA 300, AMCA 250, ASHRAE *Handbook — Fundamentals,* and ASHRAE 149.

7.3.4 Local fan motor starters and related operating control devices shall be located away from the direct airstream of the fans to the greatest extent practical.

7.3.4.1 Thermal overload protective devices in motors or on motor controls of fans used for emergency ventilation shall not be permitted.

7.3.5 Fans that are associated only with passenger or employee comfort and that are not designed to function as a part of the emergency ventilation system shall shut down automatically on identification and initiation of a fire emergency ventilation program so as not to jeopardize or conflict with emergency airflows.

7.3.5.1 Nonemergency ventilation airflows that do not impact the emergency ventilation airflows shall be permitted to be left operational where identified in the engineering analysis.

7.3.6 Critical fans required in battery rooms or similar spaces where hydrogen gases or other hazardous gases might be released shall be designed to meet the ventilation requirements of NFPA 91.

7.3.6.1 These fans and other critical fans in automatic train control rooms, communications rooms, and so forth, shall be identified in the engineering analysis and shall remain operational as required during the fire emergency.

7.4 Airflow Control Devices.

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

7.4.2 Devices in the emergency ventilation system that are exposed to the exhaust airflow and are critical to the system's effective functioning in the event of an emergency shall be constructed of materials suitable for operation in an ambient atmosphere at the design condition determined in 7.3.2.

7.4.2.1 Finishes applied to noncombustible devices shall not be required to meet the provisions of 7.4.2.

7.4.3 Other devices shall be designed to operate throughout the anticipated temperature range. Overcurrent elements in devices or on device controls required to support the emergency ventilation shall not be permitted where such overcurrent elements are subject to false operation due to exposure to elevated temperatures during a fire emergency.

7.5 Testing.

7.5.1* Equipment used for emergency ventilation (including fans, dampers, and airflow control devices) shall be listed for the application or shall be approved by the AHJ in accordance with the requirements of a recognized standard for the type of equipment to be installed.

7.5.2* The no-fire (or cold) airflows provided by the installed mechanical ventilation system shall be measured during commissioning to confirm that the airflows meet the requirements determined by the analysis.

7.6 Shafts.

7.6.1 Shafts that penetrate the surface and that are used for intake and discharge in fire or smoke emergencies shall be positioned or protected to prevent recirculation of smoke into the system through surface openings.

7.6.2 If the configuration required by 7.5.1 is not possible, surface openings shall be protected by other means to prevent smoke from re-entering the system.

7.6.3 Adjacent structures and property uses also shall be considered.

7.7 Emergency Ventilation System.

7.7.1 Operation of the emergency ventilation system components shall be initiated from the operations control center.

7.7.1.1 The operations control center shall receive verification of proper response by emergency ventilation fan(s) and an interrelated device(s).

7.7.1.2 Local controls shall be permitted to override the operations control center in all modes in the event the operations control center becomes inoperative or where the operation of the emergency ventilation system components is specifically redirected to another site.

7.7.2 For electrical substations and distribution rooms serving emergency ventilation systems where the local environmental conditions require the use of mechanical ventilation or cooling to maintain the space temperature below the electrical equipment operating limits, such mechanical ventilation or cooling systems shall be designed so that failure of any single air moving or cooling unit does not result in the loss of the electrical supply to the emergency ventilation fans during the specified period of operation.

7.8 Power Supply for Emergency Ventilation Systems.

7.8.1 The design of the power for the emergency ventilation system shall comply with the requirements of Article 700 of *NFPA 70*.

7.8.1.1 Alternatively, the design of the power for the emergency ventilation system shall be permitted to be based upon the results of the electrical reliability analysis according to 7.2.3(7), as approved.

7.8.1.2 The emergency ventilation circuits routed through the station public areas and trainway shall be protected from physical damage by fixed guideway transit or passenger rail vehicles or other normal operations and from fire as described in 12.4.4.

7.8.2 Overcurrent elements that are designed to protect conductors serving motors for both emergency fans and related emergency devices shall not be permitted where such overcurrent elements are subject to false operation due to exposure to elevated temperatures during a fire emergency. All other motor and fan protection devices shall be bypassed during a fire emergency, except for motor overcurrent and excessive vibration.

7.8.3 For electrical substations and distribution rooms serving emergency ventilation systems where the local environmental conditions require the use of mechanical ventilation or cooling to maintain the space temperature below the electrical equipment operating limits, such mechanical ventilation or cooling systems shall be designed so that failure of any single air-moving or air-cooling unit does not result in the loss of the electrical supply to the tunnel ventilation fans during the specified period of operation.

Chapter 8 Vehicles

8.1 Applicability.

8.1.1 New Vehicles. All new passenger-carrying vehicles shall be, at a minimum, designed and constructed to conform to the requirements set forth in this chapter.

8.1.2 Retrofit. Where existing passenger-carrying vehicles are to be retrofitted, the appropriate sections of this standard shall apply only to the extent of such retrofit.

8.2* Compliance Options. Passenger-carrying vehicles shall be designed to meet the prescriptive requirements of Section 8.3 through Section 8.10 or the engineering analysis requirements of Section 8.11.

8.3 Equipment Arrangement.

8.3.1 Equipment posing an ignition threat in vehicles, including associated electrical services, shall be isolated from the combustible materials in the passenger and crew compartments.

8.3.2* Equipment other than comfort heating equipment operating on voltage of greater than 300 V shall be located external to or isolated from passenger and crew compartments to prevent electrical failures from extending into those areas.

8.3.2.1 Vehicles powered by overhead contact shall be designed to prevent arc penetration, ignition, and fire spread growth of the roof assembly.

8.3.3 Methods used to isolate ignition sources from combustible materials shall be demonstrated to the AHJ to be suitable through testing and/or analysis.

8.3.4 Fuel tanks shall be designed to minimize passenger and crew exposure to fuel hazards.

8.4 Flammability and Smoke Emission.

8.4.1* The test procedures and minimum performance for materials and assemblies shall be as detailed in Table 8.4.1.

8.4.1.1* Materials tested for surface flammability shall not exhibit any flaming running or flaming dripping.

8.4.1.2 The ASTM E 662 maximum test limits for smoke emission (specific optical density) shall be based on both the flaming and the nonflaming modes.

8.4.1.3* Testing of a complete seat assembly (including cushions, fabric layers, and upholstery) according to ASTM E 1537 using the pass/fail criteria of California Technical Bulletin 133 and testing of a complete mattress assembly (including foam and ticking) according to ASTM E 1590 using the pass/fail criteria of California Technical Bulletin 129 shall be permitted in lieu of the test methods prescribed herein, provided the assembly component units remain unchanged or new (replacement) assembly components possess fire performance properties equivalent to those of the original components tested.

8.4.1.3.1 A fire hazard analysis shall also be conducted that considers the operating environment within which the seat or mattress assembly will be used in relation to the risk of vandalism, puncture, cutting, introduction of additional combustibles, or other acts that potentially expose the individual components of the assemblies to an ignition source.

8.4.1.3.2 The requirements of 8.4.1.5 through 8.4.1.8 shall be met.

8.4.1.4 Testing shall be performed without upholstery.

8.4.1.5 The surface flammability and smoke emission characteristics shall be demonstrated to be permanent after dynamic testing according to ASTM D 3574, Test I_2 or Test I_3, both using Procedure B, except that the test samples shall be a minimum of 150 mm (6 in.) × 450 mm (18 in.) × the thickness used in end-use configuration, or multiples thereof. If Test I_3 is used, the size of the indentor described in Section 96.2 of ASTM D 3574 shall be modified to accommodate the specified test specimen.

8.4.1.6 The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by washing, if appropriate, in accordance with the manufacturer's recommended procedure. If a washing procedure is not provided by the manufacturer, the fabric shall be washed in accordance with ASTM E 2061, Annex A1.

8.4.1.7 The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by dry cleaning, if appropriate, according to ASTM D 2724.

8.4.1.8 Materials that cannot be washed or dry-cleaned shall be so labeled and shall meet the applicable performance criteria after being cleaned as recommended by the manufacturer.

8.4.1.9 Combustible operational and safety signage shall not be required to meet flame spread or smoke emission requirements if the combustible mass of a single sign does not exceed 500 g (1.1 lb) and the aggregate area of combustible signage does not exceed 1 ft^2 per foot of car length.

Table 8.4.1 Fire Test Procedures and Performance Criteria for Materials and Assemblies

Category	Function of Material	Test Method	Performance Criteria
Cushioning	All individual flexible cushioning materials used in seat cushions, mattresses, mattress pads, armrests, crash pads, and grab rail padding [a–e]	ASTM D 3675	$I_s \leq 25$
		ASTM E 662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 175
Fabrics	Seat upholstery, mattress ticking and covers, curtains, draperies, window shades, and woven seat cushion suspensions[a–c, f–h]	14 CFR 25, Appendix F, Part I (vertical test)	Flame time ≤ 10 sec Burn length ≤ 6 in.
		ASTM E 662	D_s (4.0) ≤ 200
Other vehicle components	Seat and mattress frames, wall and ceiling lining and panels, seat and toilet shrouds, toilet seats, trays and other tables, partitions, shelves, opaque windscreens, combustible signage, end caps, roof housings, articulation bellows, exterior shells, nonmetallic skirts, and component boxes and covers[a,b,i–k]	ASTM E 162	$I_s \leq 35$
		ASTM E 662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Thermal and acoustical insulation[a,b]	ASTM E 162	$I_s \leq 25$
		ASTM E 662	D_s (4.0) ≤ 100
	HVAC ducting[a,b]	ASTM E 162	$I_s \leq 25$
		ASTM E 662	D_s (4.0) ≤ 100
	Floor covering[b,k,l]	ASTM E 648	CRF ≥ 5 kW/m^2
		ASTM E 662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Light diffusers, windows, and transparent plastic windscreens[b,i]	ASTM E 162	$I_s \leq 100$
		ASTM E 662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Adhesives and sealants	ASTM E 162	$I_s \leq 35$
		ASTM E 662	D_s (1.5) ≤ and D_s (4.0) ≤ 200
Elastomers[a,b,i,j]	Window gaskets, door nosings, intercar diaphragms, seat cushion suspension diaphragms, and roof mats	ASTM C 1166	Flame propagation ≤ 100 mm (4 in.)
		ASTM E 662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
Wire and cable	All	See 8.6.7.1.1.1 through 8.6.7.1.3.	See 8.6.7.1.1.1 through 8.6.7.1.3.
Structural components[m]	Flooring,[n] other[o]	ASTM E 119	Pass

[a]See 8.4.1.1.
[b]See 8.4.1.2.
[c]See 8.4.1.3.
[d]See 8.4.1.4.
[e]See 8.4.1.5.
[f]See 8.4.1.6.
[g]See 8.4.1.7.
[h]See 8.4.1.8.
[i]See 8.4.1.9.
[j]See 8.4.1.10.
[k]See 8.4.1.11.
[l]See 8.4.1.12.
[m]See 8.4.1.13.
[n]See 8.4.1.14.
[o]See 8.4.1.15.

8.4.1.10* Materials used to fabricate miscellaneous, discontinuous small parts (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) that will not contribute materially to fire growth in end use configuration shall be exempt from flammability and smoke emission performance requirements, provided that the surface area of any individual small part is less than 100 cm^2 (16 $in.^2$) in end use configuration and an appropriate fire hazard analysis is conducted that addresses the location and quantity of the materials used and the vulnerability of the materials to ignition and contribution to flame spread.

8.4.1.11 Carpeting used as a wall or ceiling covering shall be tested according to ASTM E 162 and ASTM E 662 and shall meet the respective criteria of $I_s \leq 35$, D_s (1.5) ≤ 100, and D_s (4.0) ≤ 200. *(See 8.4.1.1 and 8.4.1.2.)*

8.4.1.12 If padding is used in the actual installation, floor covering shall be tested with padding in accordance with NFPA 253 or ASTM E 648.

8.4.1.13 Penetrations (ducts, etc.) shall be designed against acting as passageways for fire and smoke, and representative penetrations of each type shall be included as part of test assemblies.

8.4.1.14* See Section 8.5.

8.4.1.15* Portions of the vehicle body that separate the major ignition source, energy sources, or sources of fuel load from vehicle interiors shall have fire resistance as determined by a fire hazard analysis acceptable to the authority having jurisdiction that addresses the location and quantity of the materials used, as well as vulnerability of the materials to ignition, flame spread, and smoke generation. These portions shall include equipment-carrying portions of a vehicle's roof and the interior structure separating the levels of a bi-level car but do not include a flooring assembly subject to Section 8.5. In those cases, the use of the NFPA 251 (ASTM E 119) test procedure shall not be required.

8.4.2* Materials intended for use in a limited area of the vehicle and not meeting the requirements of Table 8.4.1 shall be permitted only after an appropriate fire hazard analysis establishes, within the limits of precision, that the material produces a contribution to fire hazard equal to or less than a material meeting the appropriate criteria of Table 8.4.1, where the alternative material is used in the same location to fulfill a function similar to the candidate material.

8.5 Fire Performance.

8.5.1 Assembly Testing.

8.5.1.1 Floor Assembly. All vehicle floor assemblies shall be tested as specified in 8.5.1.3.

8.5.1.1.1 Test Sample Size and Loading.

8.5.1.1.1.1 The size of the exposed portion of the floor assembly shall be at least 3.7 m (12 ft) long by the normal width of the vehicle floor.

8.5.1.1.1.2 The floor assembly shall be tested with a representative loading consistent with the vehicle design.

8.5.1.1.1.3 The loading shall take into consideration the dead weight of items on the floor, dead loads due to equipment above and below the floor, the weight of a crush load of passengers, and other relevant design loads.

8.5.1.2 Roof Assembly.

8.5.1.2.1 Vehicles that contain propulsion equipment or equipment that operates at voltages higher than 600 V on the roof shall demonstrate roof assembly fire resistance testing as specified in 8.5.1.3.

8.5.1.2.2 Vehicles that travel through tunnels and have a roof that is constructed of a combustible material shall require a fire hazard analysis to demonstrate that rapid fire spread to passenger and crew compartments or local roof collapse is not possible during the exposure period.

8.5.1.3 Test Details. Fire resistance testing on assemblies shall be conducted in accordance with NFPA 251 or ASTM E 119.

8.5.1.3.1 Test assemblies shall be representative of the vehicle construction and shall be tested in a configuration to demonstrate that a fire will not extend into the passenger and crew areas during the fire exposure duration.

8.5.1.3.1.1 Unexposed side thermocouples shall be installed in accordance with NFPA 251 or ASTM E 119.

8.5.1.3.1.2 The support of the test sample shall be limited to the transverse ends of the test sample only.

8.5.1.3.1.3 The test assembly shall contain one of each type of penetration included in the assembly construction.

(A) Penetrations shall be installed in the test assembly in accordance with Section 7 of ASTM E 814.

(B) In cases in which there are multiple sizes of the same type of penetration, the penetration determined to be the most likely to allow hot gas or flame passage shall be included in the assembly.

(C) No temperatures shall be required to be measured at the penetrations.

8.5.1.3.2 The minimum fire exposure duration shall be the greater of the following:

(1)*Twice the maximum expected time period under normal circumstances for a vehicle to stop completely and safely from its maximum operating speed, plus the time necessary to evacuate a full load of passengers from the vehicle under approved conditions
(2)*15 minutes for automated guideway transit (AGT) vehicles, 30 minutes for all other passenger-carrying vehicles

8.5.1.3.3 During the entire fire exposure, the following parameters shall apply:

(1) Transmission of heat through the assembly shall not be sufficient to raise the temperature on its unexposed surface more than 139°C (250°F) average and 181°C (325°F) single point.
(2)*The assembly shall not permit the passage of flame or gases hot enough to ignite cotton waste on the unexposed surface of the assembly.
(3) The assembly shall support the representative loading.

8.5.2 Vehicle Sides and Ends. A fire hazard analysis shall be conducted to demonstrate that fires originating outside the vehicle shall not extend into the passenger and crew areas before the vehicle is evacuated.

8.5.3 Equipment Lockers.

8.5.3.1 Portions of the vehicle that separate isolating electric equipment greater than 300 V and related wiring from the passenger and crew areas shall be lined with an arc-resistant lining.

8.5.3.2 Penetrations and access panels located between the locker and the passenger and crew areas shall be tested in accordance with ASTM E 814 and shall have an F rating of 15 minutes.

8.5.3.2.1 The separation assembly shall not allow the passage of flame for the entire exposure duration.

8.6 Electrical Fire Safety.

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

8.6.2 Clearance and Creepage.

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

8.6.2.2* Air Clearance. The air clearance distances between voltage potentials (up to 2000 V) and ground shall comply with the following formula:

$$\text{Clearance (mm)} = 3.175 + (0.0127 \times \text{nominal voltage})$$
$$[\text{Clearance (in.)} = 0.125 + (0.0005 \times \text{nominal voltage})]$$

8.6.2.3 Creepage Distance.

8.6.2.3.1 Creepage distance for voltage potentials (up to 2000 V) to ground in ordinary enclosed environments shall comply with the following formula:

$$\text{Creepage (mm)} = 3.175 + (0.047625 \times \text{nominal voltage})$$
$$[\text{Creepage (in.)} = 0.125 + (0.001875 \times \text{nominal voltage})]$$

8.6.2.3.2* In other than ordinary enclosed environments, creepage distances shall be modified according to the anticipated severity of the environment.

8.6.3 Propulsion Motors.

8.6.3.1 Rotary motors shall be rated and tested in accordance with IEEE 11. Linear induction motors shall be rated and tested in accordance with IEC 62520.

8.6.3.2 Motor leads shall have insulation suitable for the operating environment.

8.6.3.3 Motor leads shall be supported and protected against mechanical damage.

8.6.3.4 Motor leads, where entering the frame, shall be securely clamped and shall fit snugly to prevent moisture from entering the motor case.

8.6.3.5 Drip loops shall be formed in motor leads to minimize water running along the lead onto the motor case.

8.6.3.6 The current value used in determining the minimum size of motor leads shall be no 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.

8.6.3.7 Car-borne propulsion configurations other than those for rotary motors shall be designed and constructed to provide a similar level of rating and testing as that for rotary motors.

8.6.4 Motor Control.

8.6.4.1 Motor control shall be rated and tested in accordance with IEEE 16.

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

8.6.4.3 Metal enclosures that surround arcing devices shall be lined with insulating material unless otherwise permitted in 8.6.4.5.

8.6.4.4 Shields or separations shall be provided to prevent arcing to adjacent equipment and wiring.

8.6.4.5 Metal enclosures shall not be required to be lined where the arc chutes extend through the enclosure and vent the arc to the outside air.

8.6.5 Propulsion and Braking System Resistors.

8.6.5.1* Self-ventilated propulsion and braking resistors shall be mounted to prevent ignition and dissipate heat away from combustible train materials.

8.6.5.2 Heat-resisting barriers of at least 6 mm (¼ in.) noncombustible insulating material or of sheet metal not less than 1 mm (0.04 in.) thick shall be installed extending horizontally beyond resistor supports to ensure protection from overheated resistors.

8.6.5.3 Forced ventilated resistors shall be mounted as follows:

(1) In ducts, enclosures, or compartments of noncombustible material
(2) With air space between the resistor enclosure and combustible materials

8.6.5.4 Provisions shall be made to filter the air where the operating environment is severe.

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

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

8.6.5.6 Resistor elements, resistor frames, and support shall be electrically insulated from each other.

8.6.5.7 The insulation shall be removed from resistor leads a minimum of 75 mm (3 in.) back from their terminals except where such removal introduces potential grounding conditions.

8.6.5.8 Where forced ventilation is provided, the resistor leads shall be separated, secured, and cleated for protection in the event of loss of air circulation of the ventilating system.

8.6.5.9 Leads shall be routed or otherwise protected from resistor heat.

8.6.5.10 The current value used in determining the minimum size of resistor leads shall be no less than 110 percent of the load current seen by the lead under the most severe duty cycle or as determined by rms calculation.

8.6.6 Current Collectors.

8.6.6.1 The minimum size of current collector leads shall be determined by adding the maximum auxiliary loads to the propulsion motor loads.

8.6.6.2 The equivalent regenerative load shall be included in the propulsion system equipped with regenerative capability.

8.6.6.3 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.

8.6.7 Wiring.

8.6.7.1 Electrical Insulation.

8.6.7.1.1 All wires and cables shall be resistant to the spread of fire and shall have reduced smoke emissions by complying with 8.6.7.1.1.1 or 8.6.7.1.1.2.

8.6.7.1.1.1 All wires and cables shall comply with the FT4/ IEEE 1202 exposure requirements for cable char height and with ANSI/UL 1685 for total smoke released and peak smoke release rate.

8.6.7.1.1.2 Wires and cables listed as having adequate fire-resistant and low-smoke-producing characteristics, by having a flame travel distance that does not exceed 1.5 m (5 ft) and generating a maximum peak optical density of smoke of 0.50 and a maximum average optical density of smoke of 0.15 when tested in accordance with NFPA 262, shall be permitted for use instead of the wires and cables specified in 8.6.7.1.1.1.

8.6.7.1.2 Low voltage power and control wires and cables (i.e., less than 100 V ac and 150 V dc) shall comply with 8.6.7.1.1 and either of the following:

(1) The physical, mechanical, and electrical performance requirements of ICEA S-95-658/NEMA WC-70 or ICEA S-73-532/NEMA WC-57, as applicable
(2) The physical, mechanical, and electrical performance requirements of ANSI/UL 44 for thermosetting insulation and ANSI/UL 83 for thermoplastic insulation as applicable.

8.6.7.1.3* Communication and data cables shall comply with 8.6.7.1.1 and the corresponding specifications.

8.6.7.1.4 Wires and cables used for heat, smoke, or other detection system shall comply with 8.6.7.1.1 and one of the following:

(1) Be capable of having 15-minute circuit integrity when tested in accordance with IEC 60331-11
(2) Demonstrate that, if circuit integrity is tested during the vertical flame test, a current continues operating for at least 5 minutes during the test
(3) Have circuit integrity cable in accordance with *NFPA 70*

8.6.7.2 Minimum Wire Size. In no case shall single conductor wire (not part of multi-conductor cable) smaller than the following sizes be used:

(1) 14 AWG (cross-section 2.1 mm^2) for wire pulled through conduits or wireways or installed exposed between enclosures
(2) 22 AWG (cross-section 0.33 mm^2) for all wires, including those used on electronic units, equipment within a rack, cards, card racks, and wire laid in wireways

8.6.7.3 Cable and Wire Sizes.

8.6.7.3.1 Conductor sizes shall be selected on the basis of current-carrying capacity, mechanical strength, temperature and flexibility requirements, and maximum allowable voltage drops.

8.6.7.3.2 Conductors shall be no smaller than the minimum sizes specified in 8.6.7.2.

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

8.6.7.4 Wiring Methods.

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

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

8.6.7.4.2 Firestops shall be provided in raceways.

8.6.7.4.3 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 or unless physical separation is provided.

8.6.7.4.4 Wires connected to electronic control apparatus shall not touch wires connected to a higher voltage source of energy than control voltage.

8.6.7.4.5 Conduits, electrical metallic tubing, nonmetallic ducts or tubing, and all wires with their outer casings shall be installed as follows:

(1) Extended into devices and cases where practicable
(2) Rigidly secured in place by means of cleats, straps, or bushings to prevent vibration or movement and to give environmental protection
(3) Run continuously into junction boxes or enclosing cases and be securely fastened to those devices

8.6.7.4.6 Splices outside of junction boxes shall be approved.

8.6.7.4.7 Connections and terminations shall be made in a manner to ensure their tightness and integrity.

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

8.6.8 Overload Protection.

8.6.8.1 Propulsion Line Breaker.

8.6.8.1.1 A main, automatic circuit line breaker or line switch and overload relay for the protection of the power circuits shall be provided.

8.6.8.1.2 The circuit breaker arc chute shall be vented directly to the outside air.

8.6.8.2 Main Fuse Protection.

8.6.8.2.1 Cartridge-type fuses, if used in addition to the automatic circuit breaker, shall be installed in approved boxes or cabinets.

8.6.8.2.2 Railway-type ribbon fuses, if used, shall be in boxes designed specifically for this purpose and shall be equipped with arc blowout aids.

8.6.8.2.3 Third-rail shoe fuses mounted on the shoe beams shall be mounted to direct the arc away from grounded parts.

8.6.8.3 Auxiliary Circuits.

8.6.8.3.1 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.

8.6.8.3.2 Each circuit or group of circuits shall be provided with at least one circuit breaker, fused switch, or fuse located as near as practicable to the point of connection of the auxiliary circuit.

8.6.8.3.2.1 Protection shall be permitted to be omitted in circuits controlling safety devices.

8.6.9 Battery Installation. Batteries and their associated circuitry shall be installed with the following requirements:

(1) Battery charging systems shall be designed to prevent overcharging of the battery.
(2) The battery shall be designed with an emergency cutoff system.
(3) The battery installation area shall be provided with a heat, smoke, or other fire detection system as appropriate for the environment in which it will operate.
(4) The battery installation area shall be separated from the car interior by the use of materials that are noncombustible, in accordance with the requirements of ASTM E 136.
(5) The battery installation area shall not use materials with hygroscopic properties.
(6) The battery installation area shall be provided with sufficient diffusion and ventilation of the gases from the battery to prevent the accumulation of an explosive mixture.
(7) Battery casing material shall comply with a radiant panel index that does not exceed 35 when tested in accordance with ASTM E 162, with specific optical density of smoke at 4 minutes into the test that does not exceed 200, and with specific optical density at 1.5 minutes that does not exceed 100 when tested in accordance with ASTM E 662 at the thickness of the casing material used in the battery.

8.7 Ventilation. Vehicles shall have provisions to deactivate all ventilation systems manually or automatically.

8.8 Emergency Egress Facilities.

8.8.1* Each vehicle shall be provided with a minimum of two means of emergency egress located on the sides or at the end(s), installed as remotely from each other as practicable.

8.8.1.1* Alternative means of emergency egress, including roof hatches as necessary for the type of vehicle, shall be approved.

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

8.8.3 Emergency Lighting.

8.8.3.1* Emergency lighting facilities shall be provided such that the level of illumination of the means of egress conforms to the following:

(1) A minimum average illumination level of 10 lx (0.93 ft-candle), measured at the floor level adjacent to each interior door, with each interior door providing access to an exterior door (such as a door opening into a vestibule) or other emergency egress facility
(2) A minimum average illumination level of 10 lx (0.93 ft-candle), measured 610 mm (24 in.) above floor level along the center of each aisle and passageway
(3) A minimum illumination level of 1 lx (0.093 ft-candle), measured 610 mm (24 in.) above floor level at any point along the center of each aisle and passageway

8.8.3.2 The emergency lighting system power shall be automatically obtained from storage batteries.

8.8.3.3* The emergency lighting system storage batteries shall have a capacity capable of maintaining the lighting illumination level at not less than 60 percent of the minimum light levels specified in 8.8.3.1 for a period of time to permit evacuation but in no case less than the following periods:

(1) 60 minutes for a fixed guideway transit vehicle
(2) 90 minutes for a passenger rail vehicle

8.8.4* Operation of Means of Emergency Egress. Means of emergency egress using doors, windows, or roof hatches shall be capable of being operated manually from the interior and exterior of the vehicle without special tools.

8.8.5* Marking and Instructions for Operation of Means of Emergency Egress.

8.8.5.1 Interior.

8.8.5.1.1 A sign visible at all lighting levels that clearly and conspicuously identifies the means of emergency egress shall be provided adjacent to the means of emergency egress.

8.8.5.1.2 Instructions for the operation of the vehicle means of emergency egress shall be at or near the means of emergency egress.

8.8.5.1.3 Signs and instructions required by 8.8.5.1.1 and 8.8.5.1.2 shall meet the requirements of APTA SS-PS-002.

8.8.5.2 Exterior. The location and instructions for the operation of vehicle means of emergency access shall be legibly marked on or near the means of egress on the outside of the vehicle with retroreflective material in accordance with APTA SS-PS-002.

8.9 Protective Devices.

8.9.1 General. During normal vehicle operation, protective devices shall not introduce new hazards.

8.9.2 Communications.

8.9.2.1 Each vehicle, except as required in 8.9.2.2, 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 operations control center can make announcements to the passengers
(2) A radio system whereby the train operator can communicate with the operations control center
(3) An intercommunication system whereby the train crew can communicate with one another
(4) At the option of the authority, a device that can be used by passengers to alert the operator of an emergency

8.9.2.2 Each AGT system vehicle shall be equipped with a communication system consisting of the following:

(1) A PA system whereby the operations control center can make announcements to the passengers
(2) A system whereby the passengers can communicate with the operations control center

8.9.2.3 Unauthorized opening of doors or emergency exit facilities on vehicles shall be automatically communicated to the operations control center or train operator.

8.9.3 Portable Fire Extinguishers.

8.9.3.1 Each vehicle or operator's cab shall be equipped with an approved portable fire extinguisher, unless otherwise permitted in 8.9.3.3.

8.9.3.2 Portable fire extinguishers shall be selected, inspected, and maintained in accordance with NFPA 10.

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

8.9.4 Lightning Protection.

8.9.4.1 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.

8.9.4.2 Lightning arresters on vehicles shall have a grounding connection of not less than 6 AWG or cross-section of 13.3 mm^2 and be run in as straight a line as possible to the ground.

8.9.4.2.1 Lightning arresters shall be properly protected against mechanical injury.

8.9.4.2.2 The grounding conductor shall not be run in metal conduit unless such conduit is bonded to the grounding conductor at both ends.

8.9.5 Heater Protection.

8.9.5.1 All heater elements shall incorporate protective devices for the following failures:

(1) Ventilation airflow, if appropriate
(2) Failure of temperature controls or occurrence of overtemperature conditions, as appropriate
(3) Short circuits and overloads in supply wiring

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

8.9.6 Testing and Maintenance.

8.9.6.1 Qualification testing shall be performed by the equipment manufacturer in accordance with the following:

(1) IEEE 16
(2) IEEE 11
(3) Any additional tests specified by the AHJ

8.9.6.2 Periodic maintenance shall be performed in accordance with maintenance manuals furnished by the equipment manufacturer.

8.9.6.2.1 The degree and the frequency of maintenance shall be based on operating experience as determined by the authority.

8.10 Vehicle Support and Guidance System.

8.10.1 The vehicle support and guidance system (i.e., wheels, tires, magnetic or pneumatic levitation) shall be capable of safely supporting and guiding the vehicle in normal service.

8.10.2 Failure of the support, guidance, or levitation system shall not result in a condition that is unsafe to passengers.

8.10.3 Under loss of guideway clearance, the system shall be capable of safe operation until such time that the failure is detected by operation or maintenance personnel and the vehicle is taken out of service.

8.11 Engineering Analysis Option.

8.11.1* General. The requirements of this section shall apply to fixed guideway and passenger rail vehicles designed to meet the engineering analysis option permitted by Section 8.2 and to meet the goals and objectives stated in Sections 4.2 and 4.3.

8.11.1.1 In the application of Section 8.11, engineering analysis design activities shall be carried out by an individual or entity having qualifications acceptable to the authority having jurisdiction.

8.11.1.2 In the application of Section 8.11, the design, engineering analysis, and documentation shall be approved.

8.11.2* Basis for Engineering Analysis.

8.11.2.1 For this engineering analysis option, the broad goals and objectives specified in Sections 4.2 and 4.3 shall be converted into specific performance criteria based on the unique features and operating environment of the vehicle.

8.11.2.2 These specific criteria shall be used as the basis of the engineering analysis.

8.11.3 Retained Prescriptive Requirements. Retained prescriptive requirements shall be those specified in Sections 8.7 through 8.10.

8.11.4 Independent Review. The authority having jurisdiction shall, at its discretion, require an approved, independent third party to review the proposed design to provide an evaluation of the design.

8.11.5 Sources of Data.

8.11.5.1 Data sources used in performance-based design activities shall be identified and documented for each input data requirement that must be met, using a source other than a design fire scenario, an assumption, or a vehicle design specification.

8.11.5.2 The degree of conservatism reflected in such data shall be specified, and a justification for the source shall be provided.

8.11.6 Maintenance of Design Features.

8.11.6.1 Design features required to meet performance goals and objectives of this standard shall be intrinsic to the vehicle design or capable of being maintained throughout the life of the vehicle.

8.11.6.2 All documented assumptions, design specifications, and operating environment criteria shall be complied with throughout the life of the vehicles, such that vehicles continue to satisfy the goals and objectives specified in Sections 4.2 and 4.3.

8.11.6.3 Any variations made to vehicle original design features that affect life safety and fire protection shall be approved prior to the actual change being made.

Chapter 9 Emergency Procedures

9.1 General.

9.1.1 The authority responsible for the safe and efficient operation of a fixed guideway transit or passenger rail system shall anticipate and plan for emergencies that could involve the system.

9.1.2 Participating agencies shall be invited to assist with the preparations of the emergency procedure plan.

9.1.3 The emergency response agencies shall review and approve the emergency procedures plan prior to its implementation.

9.2 Emergency Management.

9.2.1 Operational procedures for the management of emergency situations shall be predefined for situations within the fixed guideway transit or passenger rail system.

9.2.2 Operational procedures shall be recorded, accessible, and managed from a dedicated source at the operations control center.

9.2.3 Passengers shall be advised and informed during an emergency, to discourage panic or stress during adverse circumstances.

9.2.4* Personnel whose duties take them onto the operational system shall be trained for emergency response pending the arrival of jurisdictional personnel.

9.2.5 Emergency personnel training shall be kept current through periodic drills and review courses.

9.3 Emergencies. The emergency management plan shall address the following types of emergencies:

(1) Fire or smoke conditions within the system structures, including stations, guideways (revenue or nonrevenue), and support facilities
(2) Collision or derailment involving the following:
  (a) Rail vehicles on the guideway
  (b) Rail vehicles with privately owned vehicles
  (c) Intrusion into the right-of-way from adjacent roads or properties
(3) Loss of primary power source resulting in stalled trains, loss of illumination, and availability of emergency power
(4) Evacuation of passengers from a train to all right-of-way configurations under circumstances where assistance is required
(5) Passenger panic
(6) Disabled, stalled, or stopped trains due to adverse personnel/passenger emergency conditions
(7) Tunnel flooding from internal or external sources
(8) Disruption of service due to disasters or dangerous conditions adjacent to the system, such as hazardous spills on adjacent roads or police activities or pursuits dangerously close to the operational system
(9) Structural collapse or imminent collapse of the authority property or adjacent property that threatens safe operations of the system
(10) Hazardous materials accidentally or intentionally released into the system
(11) Serious vandalism or criminal acts, including terrorism
(12) First aid or medical care for passengers on trains and in stations
(13) Extreme weather conditions, such as heavy snows, high or low temperatures, sleet, or ice
(14) Earthquake
(15) Any other emergency as determined by the authority having jurisdiction

9.4* Emergency Procedures. Emergency procedures shall be developed to specifically address the various types of emergencies that might be experienced on the system and shall include, but not be limited to, the following:

(1) Identification of the type of emergency, name of authority, and the date the plan was adopted, reviewed, or revised, as applicable
(2) Policy, purpose, scope, and definitions
(3) Participating agencies and areas of responsibility, including governing officials and signatures of executives from each agency
(4) Safety procedures to be implemented specific to each type of emergency operation
(5) Purpose and operations of the operations control center and alternative location(s), as applicable
(6) Command post and auxiliary command post purposes, and operational procedures, as applicable
(7) Communications, types of communications available, procedures to maintain safe operation, and equipment to interface with responding agencies
(8) Fire and smoke emergency information and procedures, including the following:
  (a) Location of fire in station or support facility
  (b) Location of train in enclosed trainway and fire location on train
  (c) Fire detection systems/zones in stations
  (d) Fire protection systems and devices and their locations/points of initiating operation
  (e) Locations of exits from and entrances to the incident site, including vehicular routes
  (f) Emergency ventilation system components and locations of equipment and local controls
  (g) Special equipment locations/cabinets
  (h) Agency(ies) to be notified and their phone numbers
  (i) Agency in command prior to and after the arrival of the local jurisdiction emergency response personnel
  (j) The preplanned mode of ventilation system operation (exhaust or supply)
  (k) Preplanned passenger evacuation direction as coordinated with fan mode operation
  (l) Fire and emergency incidents on adjoining properties
(9) Procedures typically implemented by responding jurisdictions for various types of emergencies as appropriate to site configuration
(10) Maps or plans of complex areas of the system at a minimum, such as underwater tubes, multilevel stations, adjacencies to places of large public assembly, or other unique areas
(11) Any other information or data that participating agencies determine to be necessary to provide effective response

9.5* Participating Agencies. Participating agencies to be summoned by operators of a fixed guideway transit or passenger rail system to cooperate and assist, depending on the nature of the emergency, shall include the following:

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

9.6 Operations Control Center (OCC).

9.6.1 The authority shall operate an OCC for the operation and supervision of the system.

9.6.2 The OCC shall be staffed by trained and qualified personnel.

9.6.3 The OCC shall have the essential apparatus and equipment to communicate with, supervise, and coordinate all personnel and trains operating in the system.

9.6.4 The OCC shall provide the capability to communicate with participating agencies.

9.6.4.1 Agencies such as fire, police, ambulance, and medical service shall have direct telephone lines or designated telephone numbers used for emergencies involving the system.

9.6.5 Equipment shall be available and used for recording radio and telephone communications during an emergency.

9.6.6 OCC personnel shall be thoroughly conversant with the emergency procedure plan and shall be trained to employ it effectively whenever required.

9.6.7 The OCC shall be located in an area separated from other occupancies by 2-hour fire resistance construction.

9.6.8 The area shall be used for the OCC and similar activities and shall not be jeopardized by adjoining or adjacent occupancies.

9.6.9* The OCC shall be protected by fire detection, protection, and extinguishing equipment so that there will be early detection and extinguishment of any fire in the OCC.

9.6.10 Alternative location(s) shall be provided in the event the OCC is out of service for any reason and shall be equipped or have equipment readily available to function as required by the authority.

9.7 Liaison.

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

9.7.2 The listing shall include the full name, title, agency, business telephone number(s), and home telephone number of the liaison and of an alternative liaison.

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

9.8 Command Post.

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

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

9.8.3 Participating agencies shall each assign a liaison to the command post.

9.8.4 Radio, telephone, and messenger service shall be used to communicate with participating agencies operating at an emergency.

9.8.5* Approved markers shall be used to identify the command post.

9.8.6 The emergency procedure plan shall prescribe the specific identification markers to be used for the command post and for personnel assigned thereto.

9.9* Auxiliary Command Post. 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.

9.10 Training, Exercises, Drills, and Critiques.

9.10.1 The authority and participating agency personnel shall be trained to function during an emergency.

9.10.1.1 The training shall cover all aspects of the emergency procedure plan.

9.10.2 Exercises and drills shall be conducted at least twice per year to prepare the authority and participating agency personnel for emergencies.

9.10.3 Critiques shall be held after the exercises, drills, and actual emergencies.

9.10.4 Drills shall be conducted at various locations on the system as well as at various times of the day so as to prepare as many emergency response personnel as possible.

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

9.12 Removing and Restoring Traction Power.

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

9.12.2 The emergency procedure plan shall have a defined procedure for removing and restoring traction power.

9.12.3 Before participating agency personnel operate on the trainway, the traction power shall be removed.

9.12.4 Traction power disconnect devices shall allow quick removal of power from power zones. Emergency shutoff of traction power shall be either by activation of traction power disconnect devices or by communication with OCC to request the traction power be disconnected.

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

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

Chapter 10 Communications

10.1* General. A communication system shall be established in accordance with this chapter.

10.2 Operations Control Center (OCC) and Command Post Relationship.

10.2.1 During normal operations, the OCC shall be the primary control for the system.

10.2.2 During emergency operations, the command post established at the scene of the emergency shall be responsible for controlling, supervising, and coordinating personnel and equipment working to correct or alleviate the emergency.

10.2.3 The command post and OCC shall cooperate and coordinate to have an efficient operation.

10.2.4 The OCC shall be responsible for operation of the system except for the immediate emergency area.

10.3 Radio Communication.

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

10.3.2 Wherever necessary for 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.

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

10.4 Telephone.

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

10.4.2 The system shall have a telephone network of fixed telephone lines and handsets capable of communication with all stations, fire command centers, structures, offices, power stations and substations, control towers, ancillary rooms and spaces, and locations along the trainway in accordance with *NFPA 72*.

10.4.3 The location and spacing of telephones along the trainway shall be determined by the authority having jurisdiction.

10.4.4 Telephones along the trainway shall have distinctive signs or lights or both for identification.

10.4.5 Telephone locations shall be automatically identified in the OCC or other approved location.

10.5 Portable Telephones and Lines.

10.5.1 The authority shall maintain portable communications equipment and arrange for the dispatch to an emergency scene where required for emergency operations or requested by emergency responders.

10.5.2 The authority having jurisdiction shall approve the type of communications equipment.

10.6 Public Address (PA) System.

10.6.1 All stations, as determined by the authority having jurisdiction, shall have a PA system for communicating with passengers and employees. *(For communication requirements for vehicles, see 8.9.2.)*

10.6.2 The OCC shall have the capability of using the PA system to make announcements throughout stations.

10.6.3 Authority supervisory employees and emergency response personnel at stations shall have the capability of making announcements throughout public areas on the PA system.

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

10.6.5 At times of emergency, the PA system shall be used to communicate with passengers, employees, and participating agency personnel.

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

Chapter 11 Control and Communication System Functionality, Reliability, and Availability

11.1 General.

11.1.1 Scope. This chapter defines requirements for the functionality, reliability and availability of control systems and communication systems when exposed to the effects of smoke and fire.

11.1.2 Application. These systems include the following:

(1) Train control (signaling systems) as described in 7.2.4, 8.9.2.3, and in this chapter
(2) Emergency communication systems as described in 6.4.2, 8.9.2.1, 8.9.2.2, 9.8.4, and 9.9
(3) Traction power systems as described in 6.4.2, 7.2.4, 9.12.4, and 9.12.5
(4) Supervisory control and data acquisition (SCADA) systems as they apply to fire emergencies

11.2 Train Control.

11.2.1* A reliability analysis shall be performed to consider the ability of control systems to maintain communications and the ability to reposition vehicles during a fire emergency.

11.2.2 Systems with and without an onboard operator shall be reviewed for the functionality, reliability, and availability of their control and communication systems during a fire incident.

11.2.3 For fixed guideway and passenger rail systems that do not have an operator on board, the controls shall accommodate the remote repositioning of trains.

11.2.3.1 If a train is immobile and on fire, the ability of the control system to move other trains away from the immobile train in a timely manner, addressing the concerns of passenger life safety, shall be accounted for as part of the overall system design.

11.2.3.2 If a train is exposed to an exterior fire, the ability of the control system to move the train away from the fire in a timely manner, addressing the concerns of passenger life safety, shall be accounted for as part of the overall system design.

11.2.4 For systems with an operator on board, procedures shall be developed to address train movement.

11.2.4.1 If a train is immobile and on fire, the ability of the control system to move other trains away from the immobile train in a timely manner, addressing the concerns of passenger life safety, shall be accounted for as part of the overall system design.

11.2.4.2 If a train is exposed to an exterior fire, the ability of the control system to move the train away from the fire in a timely manner, addressing the concerns of passenger life safety, shall be accounted for as part of the overall system design.

11.3 Functionality, Reliability, and Availability of Control Systems.

11.3.1* Functionality, reliability, and availability of control systems and communications systems during a fire incident shall be considered in addition to normal reliability and availability calculations.

11.3.2* To meet the goals for life safety of the occupants, the effects of single points of failure shall be considered.

11.3.3* In addition to physical protection from incidents, control, data, and communication cables and related components shall continue functionality during a fire and shall be protected from thermal exposure that would affect their function.

Chapter 12 Wire and Cable Requirements

12.1 General.

12.1.1 Scope. This chapter applies to wires and cables in all locations except in those vehicles addressed in Chapter 8.

12.1.2* All wiring materials and installations other than for traction power shall conform to the requirements of *NFPA 70* except as modified herein.

12.2 Flame Spread and Smoke Release.

12.2.1 All wires and cables used shall be listed as being resistant to the spread of fire and shall have reduced smoke emissions, by complying with one of the following:

(1) All wires and cables shall comply with the FT4/IEEE 1202 exposure requirements for cable char height, total smoke released, and peak smoke release rate of ANSI/UL 1685.
(2) Wires and cables listed as having adequate fire-resistant and low-smoke producing characteristics, by having a flame travel distance that does not exceed 1.5 m (5 ft) and generating a maximum peak optical density of smoke of 0.50 and a maximum average optical density of smoke of 0.15 when tested in accordance with NFPA 262, shall be permitted for use instead of the wires and cables specified in item (1).

12.3 Temperature, Moisture, and Grounding Requirements.

12.3.1 Wires and cables shall comply with both of the following temperature and moisture resistance characteristics:

(1) All insulations shall conform to *NFPA 70* and shall be a moisture- and heat-resistant type carrying a temperature rating of 90°C (194°F).
(2) All insulated conductors and cables shall be listed for wet locations.

12.3.2 Ground wires shall comply with the following:

(1) Ground wires installed in a metallic raceway shall be insulated.
(2) In underground stations and trainways, other ground wires shall be permitted to be bare.

12.4 Wiring Installation Methods.

12.4.1 Conduits, raceways, ducts, boxes, cabinets, and equipment enclosures shall be constructed of noncombustible materials. In stations, other materials when encased in concrete shall be acceptable.

12.4.2 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.

12.4.3 Within the emergency ventilation air distribution system, the following wiring methods are acceptable:

(1) Type MI cable without an overall protected nonmetallic covering
(2) Type MC cable employing a smooth or corrugated impervious metal sheath without an overall nonmetallic covering
(3) Conductors in electrical metallic tubing, flexible metallic tubing, intermediate metal conduit, or rigid metal conduit all without an overall nonmetallic covering

12.4.4 The emergency power, emergency lighting, and emergency communications circuits shall be protected from physical damage by system vehicles or other normal system operations and from fires in the system for at least 1 hour, but not less than the time of tenability, when exposed to fire conditions corresponding to the time-temperature curve in the ASTM E 119 fire resistance test by any of the following:

(1) Circuits are embedded in concrete or protected by a fire barrier system in accordance with UL 1724. The cables or conductors shall maintain functionality at the temperature within the embedded conduit or fire barrier system.
(2) Circuits are routed outside the underground portion of the system.
(3) There is diversity in system routing (such as separate redundant circuits or multiple circuits separated by a fire barrier with a fire resistance rating so that a single fire or emergency event will not lead to a failure of the system).
(4) All circuits consist of listed fire-resistive cable systems with a fire resistance rating in accordance with 12.5.

12.5 Fire-Resistive Cables.

12.5.1 Fire-resistive cables shall be certified or listed as having been tested in a totally enclosed furnace using the ASTM E 119 time temperature curve.

12.5.2 The cables shall demonstrate functionality for no less than 1 hour as described in the ANSI/UL 2196 test standard.

12.5.3* The cables and systems shall comply with the following:

(1) Be tested as a complete system of conductors, cables, and raceways, as applicable, using a sample no shorter than 3.0 m (9.84 ft)
(2) For fire-resistive cables intended for installation in a raceway, be tested in the type of raceway in which they are intended to be installed
(3) Have installation instructions that describe the tested assembly, with only the components included in the tested assembly acceptable for installation

Annex A Explanatory Material

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

A.1.1.1 Vehicle maintenance facilities are not addressed by this standard because requirements for that occupancy are provided in other codes and standards. Where vehicle maintenance facilities are integrated or co-located with occupancies covered by this standard, special considerations beyond this standard shall be necessary.

A.1.1.3(6) A shelter stop is a location along a fixed guideway transit or passenger rail system for the loading and unloading of passengers that is located in a public way and is designed for unrestricted movement of passengers. A shelter stop can have a cover but no walls or barriers that would restrict passenger movement.

A.1.3.3 The nature of facility retrofitting should be assessed to determine the degree of applicability of the standard. For example, an upgrading retrofit might be undertaken as part of a due diligence initiative aimed at improving the level of compliance with the intent of the standard, while full compliance with all relevant requirements might not be achievable. Such retrofits should be permitted provided that, as a minimum, they maintain the existing performance level of the facility and specifically do not adversely affect the early warning and evacuation systems, fire separations, structural adequacy, or tenable environment in the facility.

A.1.4 Before a particular mathematical fire model or evaluation system is used, its purpose and limitations need to be known. Technical documentation should clearly identify any assumptions included in the evaluation. Also, it is the intent of this standard to recognize that future editions of this standard are a further refinement of this edition and earlier editions. The changes in future editions will reflect the continuing input of the fire protection/life safety community in its attempt to meet the purpose stated in this standard.

A.1.4.3 An equivalent method of protection provides an equal or greater level of safety. It is not a waiver or deletion of a requirement provided by a standard. The prescriptive provisions of this standard provide specific requirements for broad classifications of structures. These requirements are stated in terms of fixed values, such as maximum travel distance, minimum fire resistance ratings, and minimum features of required systems, such as detection, alarm, suppression, and ventilation, and not in terms of overall station, guideway, or vehicle system performance. However, the equivalency clause in 1.4.3 permits the use of alternative systems, methods, or devices to meet the intent of the prescribed provisions of a standard where approved as being equivalent. Equivalency provides an opportunity for a performance-based design approach. Through the rigor of a performance-based design, it can be demonstrated whether a station, guideway, or vehicle design is satisfactory and complies with the implicit or explicit intent of the applicable requirement provided by a standard. When the equivalency is used, it is important to clearly identify the prescriptive-based standard provision being addressed (scope), to provide an interpretation of the intent of the provision (goals and objectives), to provide an alternative approach (proposed design), and to provide appropriate support for the suggested alternative (evaluation of proposed designs). Performance resulting from proposed designs can be compared with the performance of the design features required by this standard. Using prescribed features as a baseline for comparison, it can then be demonstrated in the evaluation whether a proposed design offers the intended level of performance. A comparison of safety provided can be used as the basis for establishing equivalency.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.1 Airflow Control Devices. Air curtains have been used to minimize tunnel airflow in transit systems. Barriers are similar to life rafts with inflatable rings or collars and could be used to minimize tunnel airflow. Brattices are parachute- or curtain-like devices that have been used in mine headings to minimize airflow. Doors have been used to minimize tunnel airflow in transit systems. Downstands and enclosures have been used to minimize airflow and smoke movement in rail stations. Gates are guillotine-type doors mounted at tunnel portals and have been used in passenger rail tunnels to minimize tunnel airflow.

A.3.3.5 Blue Light Station. The definition states the minimum functional requirements for a blue light station. The design provisions to accomplish those functions, as well as the need for other functions or equipments, should be determined based on emergency response planning for the system.

A.3.3.11 Concourse. A concourse is distinct from a platform because it can be more open, and passenger speeds can be different from those prescribed for a platform, platform stair, or escalator.

A.3.3.15 Engineering Analysis. *Engineering analysis* is a broad term that encompasses a range of different objectives and performance criteria. The complexity of the analysis and the factors requiring consideration are situation dependent and require the user to have sufficient understanding of the objectives, assumptions, and analysis tools being implemented.

General examples from within this document include analysis intended to provide justification for the modification of evacuation time/travel distance requirements, analysis to support the use of a concourse area as a point of safety, and analysis relative to the use of a nonmechanical ventilation system in lieu of a mechanical emergency ventilation system.

A written report of the analysis should be submitted to the authority having jurisdiction, indicating recommended fire protection method(s) that will provide a level of fire safety commensurate with this standard. The objectives, assumptions, sources of data, and degree of conservatism incorporated into the analysis should be addressed.

A.3.3.15.1 Fire Hazard Analysis. The term *fire hazard analysis* generally refers to analyses that are performed relative to the specific fire performance of materials, components, and assemblies for the purposes of addressing the subsequent contribution to the overall fire hazard and the resulting impact on occupant fire safety. A fire hazard analysis can provide an estimate of the potential severity of fires that can develop under defined fire scenarios. This analysis can encompass consideration of factors that include but are not limited to, quantities of materials, vulnerability of materials and components to ignition, propensity for flame spread, and smoke generation.

The formulation of a fire hazard analysis is subjective and dependent upon the expertise of the user. The material provided in Annex E, although specifically addressing fire hazard analysis for vehicles, provides additional guidance relative to the steps that might be involved in a fire hazard analysis. A written report of the analysis should be submitted to the authority having jurisdiction, indicating that a level of fire safety commensurate with this standard will be achieved.

A.3.3.20.1 Effective Fire Load. The effective fire load can include vehicle(s), luggage, fuel, and wayside facilities or structures, that, because of the fuel package configuration, separation, and combustion characteristics, would be expected to be released in a design fire incident.

A.3.3.20.2 Total Fire Load. The total fire load can include vehicle(s), luggage, fuel, and wayside facilities or structures.

A.3.3.27 Heat Release Rate (HRR). The heat release rate of a fuel is related to its chemistry, physical form, and availability of oxidant and is ordinarily expressed as Btu/sec or kilowatts (kW). [**921,** 2011]

A.3.3.44.2 Open Station. Direct dispersion is passing to atmosphere without ducting, without accumulation in occupied areas, and without entering or passing through another occupied level of the station.

A.4.2.1 The fire-life safety concepts in this standard are predicated and achieved by providing tenable conditions for evacuation of passengers described in this standard, as follows:

(1) Fire hazard control through use of fire-hardened materials in stations, tunnels, and trains
(2) Provision of fire detection, alarm notification, communication systems, and evacuation routes
(3) Natural ventilation or mechanical ventilation providing smoke control to maintain tenability
(4) Fire safety system reliability through system redundancy and increased safety in emergency system wires and cables that might be exposed to fire

The inclusion of automatic fire suppression systems in stations, tunnels, or trains provides an active system that can limit fire growth and thereby assist in reducing risk to life and property. Where such systems are provided, variations to requirements in this standard for materials, communications, systems, or reliability can be considered where supported by engineering analysis as permitted by Section 1.4 and in accordance with good fire protection engineering practice.

A.4.4 The standard was created to address the issue of entrapment and injury of large numbers of people who routinely use fixed guideway transit systems as a result of fire in the system. The document has evolved to now include passenger rail systems. The basis of the document — providing the minimum life safety from fire and fire protection requirements — still stands. It is not intended for the document to provide design basis for non-fire events such as explosions or other random acts of sabotage.

A.4.5 Freight operations are typically subject to regulation by others, and are beyond the scope of this standard. Freight operations can affect life safety from fire hazards due to concurrent operations.

The increased hazard includes the potential for rapid fire development to fire heat release rates that can exceed those of a non-freight vehicle, with combustible loads that might support fires that burn for days. The increased hazard also includes non-fire events involving release of materials hazardous to life. The design process should include information exchange and agreement among the freight operator, the passenger services operator and the authority having jurisdiction.

All concurrent freight and passenger uses should be given consideration. More detailed consideration of the relative life safety from fire hazards is strongly recommended when applied to underground facilities, where the confined nature of the space will magnify the hazards. Consideration should include implications of concurrent uses for freight systems operated through or adjacent to passenger stations and concurrent uses for freight systems operated through or adjacent to passenger trainways.

A.4.6 The location and size of a fire can greatly affect the degree of hazard to system occupants. Therefore, the system design must consider specific fire scenarios that could occur. Fire location and size are examples of factors that fire scenarios must consider:

(1) *Interior locations.* This scenario occurs from a fire that originates within a station or trainway or the interior passenger compartment of the vehicle. Examples of interior fire scenarios include the following:
    (a) Fire that begins from an incendiary ignition involving the use of accelerants
    (b) Trash fire
    (c) Electrical fire
    (d) Fire that occurs in a location used for food preparation
    (e) Luggage storage area fire
    (f) Fire that occurs from ignition by small open flame onto bedding in an unoccupied compartment in a vehicle that provides compartments for overnight sleeping
    (g) Fire that occurs where the vehicle rolls over onto its side and ignition occurs
(2) *Exterior locations.* This scenario occurs as a result of a fire originating outside the passenger compartment of the vehicle and penetrating the exterior of the vehicle. Examples of exterior fire scenarios include the following:
    (a) Electrical fire in the station, in the trainway, under the vehicle floor, or on the roof that burns through into the

passenger compartment or that causes the vehicle to stop between stations
   (b) Trash fire or other type of station, trainway, or under-vehicle equipment or floor fire
   (c) Fire that occurs from ignition of a fuel spill adjacent to the station, a trainway, or a vehicle involved in a collision
(3) *Operating environment.* Consequences can increase if a fire occurs when occupants are in the following locations:
   (a) In a station, trainway, or passenger-carrying vehicle that is in a stationary location and unable to move and where egress or rescue access could be hazardous (e.g., underground trainway or station)
   (b) In a passenger-carrying vehicle in motion between stations and at the maximum distance from any station, safe refuge, or point of safety

Fire scenarios that are appropriate for a particular system vehicle and operating environment could not be applicable to another system vehicle and operating environment.

A.4.7 The provisions of Section 4.7 do not require inherently noncombustible materials to be tested in order to be classified as noncombustible materials.

A.4.7.1 Examples of such materials include steel, concrete, masonry, and glass.

A.4.8 Fire-life safety systems comprise interdependent mechanical, electrical, communications, control, fire protection, structural, architectural, and other elements, all of which must function as a system to achieve the designed result. It is critical that all primary and supporting elements are protected to a similar level of reliability for the design incident exposure.

A.5.1.2 This subsection is specifically intended to refer to features that normally would be required in the design and construction of stations. It is not intended to apply to trainways or to invoke requirements that normally would not be applicable in the design of a building similar in size or configuration to a station.

A.5.2.1.4 See A.6.3.4.3.

A.5.2.4.1(1) This requirement is intended to refer to stairs and escalators used for normal revenue service. Fire-separated exit stairs can also be required in order to satisfy the requirements of 5.3.3.7 for alternate egress or 5.3.5.5 for the proportion of escalators counted as means of egress.

A.5.2.4.2 The fire resistance rating of the required fire separation should be determined based on evaluation of such factors as the type of station configuration (open versus enclosed), fire suppression provided in the nonpublic areas, and NFPA *101* requirements for separation of similar occupancies.

A.5.2.4.4 The fire resistance rating of the required fire separation should be determined based on evaluation of such factors as the type of station configuration (open versus enclosed), fire suppression provided in the nonpublic areas, and NFPA *101* requirements for separation of similar occupancies.

A.5.2.4.5 Because of the difference in the potential level of hazard between various stations (e.g., open stations compared to enclosed stations), alternative methods to fire separation could be considered.

A.5.2.6.1 The fire hazard analysis should determine that the fire does not propagate beyond the component of fire origin and that a level of fire safety is provided within the station commensurate with this standard. Computer modeling, material fire testing, or full-scale fire testing should be conducted, as appropriate, to assess fire performance in potential fire scenarios.

A.5.2.6.2 Rubbish containers that are used in the station on a temporary basis (e.g., during cleaning operations) should be manufactured of noncombustible materials or of materials that comply with a peak heat release rate not exceeding 300 kW/m^2 (26.4 $Btu/ft^2{\cdot}sec$) when tested in accordance with ASTM E 1354 at an incident heat flux of 50 kW/m^2 (4.4 $Btu/ft^2{\cdot}sec$), in the horizontal orientation.

A.5.3 Annex C provides additional information and sample calculations relating to means of egress.

A.5.3.1 Where codes other than NFPA *101* are in effect, reference to NFPA *101* can be replaced by reference to relevant requirements in the locally applicable building code.

A.5.3.2.1 In that the peak ridership data are used to determine occupant load (and, consequently, required egress capacity), the basis for those data should be considered carefully.

The term *peak period* is intended to imply the time within the peak hour having the maximum passenger flow rate. For many systems, this period ranges between 10 minutes and 20 minutes in duration. Where peak hour ridership numbers are used, a surge factor should be applied as a distribution curve correction to account for the peak within the hour. Factors of 1.3 to 1.5 are typical for many systems. Other surge factors ranging from 1.15 to 2.75 have been reported.

In new systems, a survey of actual usage should be made within 2 years of completion of the project to verify design predictions. In operating systems, patronage levels should be projected to determine the need for expansion of the system or significant operating changes. Verification by survey should be made following any extension or significant operating change or at a maximum of 5-year intervals.

A.5.3.2.2 Consideration of control of the access to platforms might be necessary so that the station occupant load does not exceed the station egress capacity.

A.5.3.2.3(2) At multilevel, multiline, or multiplatform stations, it can be reasonable to consider only entraining (or entraining plus detraining) loads for nonincident levels for determining required egress capacity at points where egress troutes converge. Nonincident platform loads that do not adversely impact the egress route need not be considered.

A.5.3.2.5 The determination of maximum occupant load at a platform often requires comparison of calculations based on different peak periods. For example, to determine the maximum peak period platform occupant load for stations serving predominantly commuter ridership, the calculations described in 5.3.2.5(1) through 5.3.2.5(7) can be computed based on both the a.m. and the p.m. peak ridership for each platform and then compared to determine the maximum platform occupant load.

A.5.3.2.5(3) It is important that the load/headway capture the potential buildup of passengers that might occur before an emergency event is recognized as requiring evacuation. The determination of the appropriate accumulation factor should reflect system-specific characteristics such as the following:

(1) The type of system (e.g., automated/driverless vs. manually driven)
(2) The amount and type of surveillance
(3) The distance between stations and train headways

For systems with longer headways, a factor of two headways might be adequate to approximate accumulation and response time. For systems with very short headways, a fixed time (e.g., 5 minutes to 10 minutes) might be more appropriate to approximate the potential passenger buildup.

Consideration should also be given to whether the entraining and train loads should be subject to the same accumulation factor.

A.5.3.2.5(4) The nonincident service is not contributing detraining load.

A.5.3.3 The means of egress capacity factors and travel speeds are consistent with observed pedestrian movement within congested areas of passenger stations as represented by level of service E/F in *Pedestrian Planning and Design*, by Fruin. Patronage can vary for different user groups periodically or change over time. Modification could be warranted based on engineering analysis.

A.5.3.3.1 The stipulated time is intended as a baseline for determining the required capacity and maximum travel distances for platform egress routes. It is not intended that this calculation be required to account for delays due to products of combustion or debris along an egress route or delays due to the movement of those who are unable to achieve self-evacuation.

A.5.3.3.2 See A.5.3.3.1.

A.5.3.3.6 The determination of a common path of travel from the ends of a platform should consider the configuration (e.g., width and enclosure) of the platform versus the anticipated exposure to a train on fire at the platform. Where the platform is sufficiently wide to allow passengers to move away from the radiation effects of the train fire, it is reasonable to consider the egress from that platform as not creating a common path of travel.

A.5.3.3.7(1) This requirement is intended to replace the requirement in 7.3.1.1.2 of NFPA *101*, that the loss of one egress route must leave at least 50 percent of the egress capacity available. This approach is in recognition of the following design factors:

(1) Station design inherently requires primary circulation routes to be obvious and readily accessible such that preference for such routes would be anticipated in the event of an emergency evacuation.
(2) Requirements elsewhere in this standard (e.g., emergency ventilation in Chapter 7) require special protection of primary circulation routes from the effects of a train fire in enclosed stations.
(3) In the event of unavailability of one of the primary circulation routes due to another fire condition, the occupant load to be evacuated would be substantially less than that on which the size of the egress routes is determined, that is, the occupant load would not include the train link load.

A.5.3.3.8 Where automated spreadsheet calculations or computer-based software programs are used, the means of egress analysis should include documentation detailing all input parameters and algorithm(s).

A.5.3.4 Ramps are permitted in stations in accordance with NFPA *101* (and other applicable standards), which allows use of ramps with slopes up to 1:12 (8.33 percent)

A.5.3.4.1 The 2003 and previous editions of NFPA 130 required that exit corridors and ramps be a minimum of 1.73 m (5 ft 8 in.) wide. There is no technical basis for the previous minimum. The intent of 5.3.4.1 is to make NFPA 130 consistent with NFPA *101* relative to the minimum 1120 mm (44 in.) corridor width in the means of egress. NFPA 130 addresses means of egress conditions unique to transit/passenger rail facilities such as open platform edges. In NFPA *101*, means of egress facilities are based upon a function of the persons served (units of width/person served). NFPA 130 introduces a unit of time in determining the required egress width. This is necessary to demonstrate compliance with the performance requirements related to platform evacuation time and reaching a point of safety.

Assuming a 1120 mm (44 in.) wide side platform per 5.3.4.1 the effective platform width for egress is as follows:

$$1120 \text{ mm} - 455 \text{ mm } (\text{platform edge}) - 305 \text{ mm } (\text{sidewall}) = 355 \text{ mm}$$
$$[44 \text{ in.} - 18 \text{ in. } (\text{platform edge}) - 12 \text{ in. } (\text{sidewall}) = 14 \text{ in.}]$$

The capacity afforded by the effective 355 mm (14 in.) wide platform is:

$$355 \text{ mm} \times 0.819 \text{ p/mm-min} = 29 \text{ p/min}$$
$$(14 \text{ in.} \times 2.08 \text{ p/in.-min} = 29 \text{ p/min})$$

An effective 1120 mm (44 in.) wide corridor yields:

$$1120 \text{ mm} \times 0.0819 \text{ p/mm-min} = 91 \text{ p/min}$$
$$(44 \text{ in.} \times 2.08 \text{ p/in.-min} = 91 \text{ p/min})$$

It must be recognized that while strict interpretation of 5.3.4.1 indicates a station could be designed using a 1120 mm (44 in.) wide platform with an open edge and sidewall condition, it is impractical to do so, especially when one considers the other requirements of this standard that will affect the platform width, such as the travel distance to the point(s) of egress, the maximum 4-minute platform evacuation time, and the 6-minute point of safety time.

A.5.3.4.4 For ramps, various studies have reported that there were no statistically significant differences or measurable effect on walking speeds due to grades up to 5 or 6 percent, but that there is a gradual linear decline in speed for steeper grades.

A.5.3.4.5 See A.5.3.3 for clarification.

A.5.3.5.3 Where escalators having a nominal width of 1000 mm (40 in.) will be dedicated for operation in the direction of exit travel at speeds of at least 30 m/min (98 ft/min), such escalators can be permitted to be counted as having a capacity of 75 p/min. This should be considered appropriate only in conjunction with other provisions of this standard, such as the requirement to discount one escalator at each station level. Such escalators should also be connected to emergency power. This suggested speed is consistent with the maximum speed permitted in ASME A17.1/CSA B44, a bi-national standard. The suggested capacity is consistent with research reported in the *Elevator World* article "Escalator Handling Capacity" and in *Pedestrian Planning and Design*, by Fruin. Other codes regulating transit station design permit escalator capacity to be based on operating capacity (e.g., *Ontario Building Code*, Section 3.13, "Rapid Transit Stations," and London Underground Ltd., *LUL Station Planning Guidelines*, which both permit a capacity of 100 p/min.). Designers are encouraged to research the latest available data. Unpublished research suggests that where the vertical rise exceeds 15 m (50 ft), the capacity and travel speed for stairs should be adjusted downward by approximately 30 percent to account for fatigue. Additionally, the design should provide enlarged landings to allow pedestrians to rest without impeding egress flow.

A.5.3.5.3(2) The vertical component of travel speed is calculated based on the vertical change in elevation between one station level and the next. [See Figure A.5.3.5.3(2).] See also *Application Guidelines for the Egress Element of the Fire Protection Standard for Fixed Guideway Transit Systems* and the example calculations in Annex C.

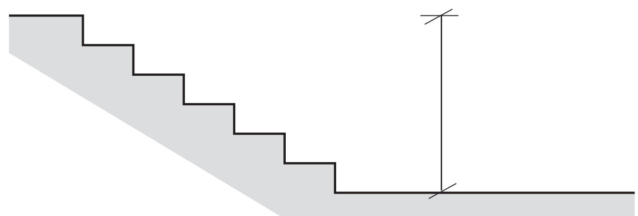

FIGURE A.5.3.5.3(2) Distance Measure for Walk Time Computation.

A.5.3.5.4 See A.5.3.4.1 for clarification.

A.5.3.5.6 Where multiple escalators are provided in the means of egress, the means of egress calculations should consider the potential of more than one escalator on any one level being out of service for repair and therefore impassible.

A.5.3.5.7(1) It is intended that escalators be as noncombustible as possible, with the understanding that certain components such as rollers or headrails might not currently be available in noncombustible materials. The authority having jurisdiction should review each installation proposal for compliance to the greatest extent possible.

A.5.3.5.7(2) The intent is to keep escalators running in the direction of egress in order to provide more efficient evacuation flow. Where escalators are an integral means of egress component in deep stations, the provision of emergency power for the escalators should be considered when supported by risk analysis.

A.5.3.5.7(4) Where required by accessibility regulations, visible message signs should be provided and designed to give pre-warning in accordance with the principles of this section.

A.5.3.6.2(2) Where a station has two elevators or fewer, this requirement should be interpreted as requiring that no elevators are counted as contributing to the available egress capacity.

A.5.3.6.2(3) Elevator capacity can be calculated as described in NIST IR 4730.

A.5.3.6.4(2) See B.4 of NFPA *101* and ASME A17.1/CSA B44 for additional guidance.

A.5.3.6.4(6) The design must also consider and provide for evacuation of other station levels.

A.5.3.6.4(7) Where supported by this analysis, the necessity for emergency recall should be considered.

A.5.3.7 For gates used as fare barriers, refer to 5.3.8. See Chapter 6 for requirements related to platform end gates.

A.5.3.7.1(2) The stated pedestrian capacity value assumes that the bi-parting doors and gates do not have mullions in the middle of the opening. The edge effect described in 5.3.4.2 need not be subtracted from the clear width. Where mullions are incorporated, the flow value for single-leaf doors should be used.

A.5.3.8.2 "Unimpeded travel in the direction of egress" means that any barriers in the equipment (such as paddles, gates, or turnstiles) either drop away to create a clear opening or swing or revolve freely in the direction of egress with no latching mechanism.

A.5.3.8.4(1) "Clear width" means the clear width between any protrusions with the fare gates open. The stipulated clear widths are appropriate where the length of the equipment console is less than 2500 mm in the egress direction. Where the equipment exceeds 2500 mm length, increased widths are recommended, which should be based on the anthropometric body sway data from NFPA *101*, as follows: Each unit should provide a minimum width of 560 mm (22 in.) clear width at and below a height of 1000 mm (39.5 in.) and 760 mm (30 in.) clear width above that height.

A.5.3.8.6 Refer to A.5.3.8.2.

A.5.3.9.1 Transit stations are unique in that many are constructed beneath and enveloped by adjacent buildings. The use of horizontal exits for up to 100 percent of the required capacity provided that not more than 50 percent is into a single building addresses conditions in stations that differ from those in NFPA *101*, which envisions a single building subdivision.

A.5.4.1 Where an underground station is part of another building complex, consideration should be given to creating a combined fire command center.

A.5.4.2.2 Discrete zone indications are desirable for unmanned stations.

A.5.4.2.6 Separate zones on the annunciator panel to monitor main control valves on standpipe systems should be established.

A.5.4.4.1 Escalators constructed of combustible stairs should be protected with an approved automatic sprinkler or fire suppression system installed in the truss area and designed to control or extinguish a fire.

A.5.4.5.1 The authority having jurisdiction might require additional 65 mm (2½ in.) hose connections to be equipped with a 65 mm × 40 mm (2½ × 1½ in.) reducer.

A.5.4.5.4 This requirement is intended to clarify that, with the approval of the local fire department, dry-type systems can be considered in stations regardless of the potential for freezing.

A.5.4.5.4(1) Calculations, including transit and fill times, should be submitted to the authority having jurisdiction to support this requirement.

A.6.1.1 The intent of the standard is to provide a reasonable level of life safety from fire and fire protection to passengers, transit system personnel, authorized visitors, and emergency responders. Generally, protective features such as egress routes in compliance with Chapter 6 are required for these areas, but see 6.4.6.2 for applicable ventilation requirements.

A.6.1.2.3 Locations requiring such signage may include, entrances to the trainway (e.g., station platforms and portals) and fences or barriers adjacent to the trainway.

A.6.2.1.6 See A.6.3.5.9.

A.6.2.2.1 Most tunnels exposed to prolonged fires are heavily damaged or collapse, resulting in service disruptions, significant structural damage, and most important, loss of lives (Both, Wolinsk & Breunese 2003, Khoury 2002, and Tatnall 2002). The structural concrete or shotcrete liner can be designed to withstand the fire load up to a certain period of time while accepting some minor repairable damage to the liner.

The fire resistance rating of the tunnel liners can be analyzed. Prompt operation of the ventilation system can mitigate damage to the liner.

A.6.2.4 The design of ancillary spaces adjacent to the trainway should be in accordance with the requirements of the local building codes except as specifically described in this standard. This would include requirements for egress from within the spaces and for heating, ventilation, and air-conditioning.

A.6.3.1.1 The trainway and the vehicle means of egress should be designed to be compatible. *(See Chapter 8.)*

A.6.3.1.4 Previous editions of NFPA 130 addressed this requirement by prescribing the maximum travel distance to an exit. The intent of this requirement was often misinterpreted. NFPA *101* requires, at a minimum, that two means of egress be provided within a building or structure and prescribes the maximum travel distance to an exit. This same requirement is applied in NFPA 130. Where two means of egress are required, the maximum travel distance to an exit occurs at the midpoint. For example, in a building with two exits, in the event of a fire adjacent to an exit rendering that exit unavailable, NFPA *101* recognizes that an individual in proximity to the affected exit must travel twice the prescribed exit travel distance to the alternative exit. Since two means of egress are required from any one point in an enclosed trainway, the exits cannot be more than twice the travel distance, or 762 m (2500 ft) apart.

A.6.3.1.6(2) The distance from the station should generally be measured to the end of the station platform. However, the distance can also be measured to an area of relative safety that is beyond the end of the platform, such as an exit stair or, where appropriate and based on evaluation of emergency ventilation airflow, a ventilation inlet.

A.6.3.1.6(7) The hazards to be considered include, but are not limited to, potential contact with live traction power distribution equipment.

A.6.3.2.1 Maintaining a clear space above the walking surface is important to ensure that projections do not encroach into the means of egress. The envelope created by the boundary limits defined by this paragraph is intended to gradually change from point to point. With respect to clearances to the vehicle, the measurements should be to the static vehicle envelope. *(See Figure A.6.3.2.1.)*

A.6.3.2.3 With reference to NFPA *101*, Table 7.2.2.2.1.2(B) (where additional width is required for stairs serving an occupant load of 2000 people or more), exit stairs serving trainways are not required to exceed the minimum width, regardless of the occupant load. This is reasonable considering that evacuation flow from a tunnel would be essentially single file, and stairs do not normally converge with other egress routes.

A.6.3.2.4 The stipulated minimum width applies to all means of egress doorways, including those for cross-passages.

A.6.3.3 The egress provided should recognize that for multiple-track tunnels, there exists the possibility of having to evacuate simultaneously the incident train and a non-incident train(s) stranded on the adjacent track(s).

A.6.3.3.5 It is important that guards be configured so that they do not interfere with either the vehicle dynamic envelope or with egress from the train onto the walkway. For that reason, guards are not required on the trainway side of raised walkways, provided that the bottom of the trainway is closed by deck or grating so that persons could not fall through the bottom of the guideway.

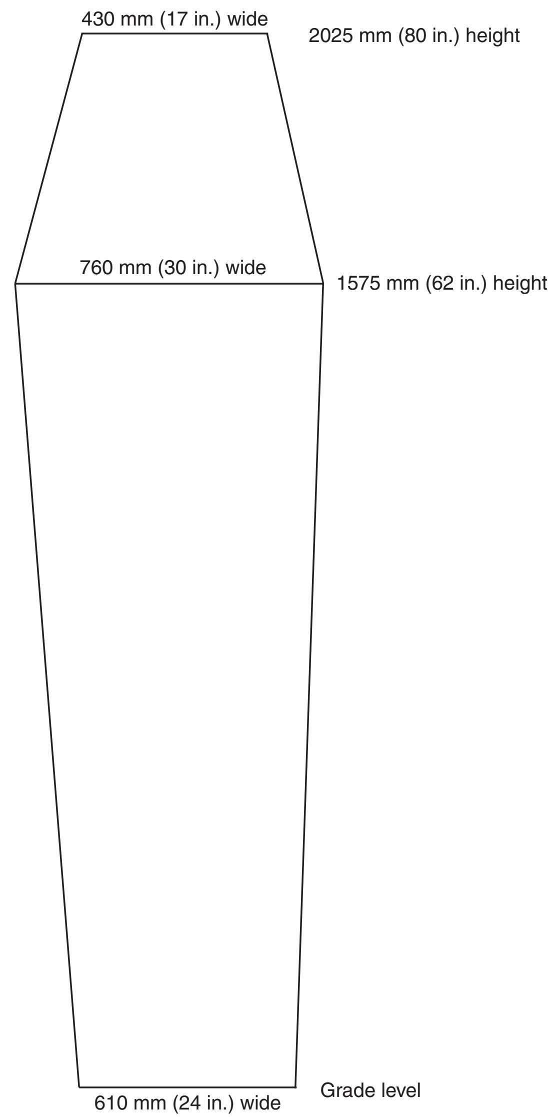

FIGURE A.6.3.2.1 Unobstructed Clear Width for Trainway Walkway.

A.6.3.3.8 It is important that handrails be configured so that they do not interfere with either the vehicle dynamic envelope or with egress from the train onto the walkway. For that reason, handrails are not required on the trainway side of raised walkways. Likewise, raised walkways located between trainways are not required to have handrails, provided they are a minimum width of 1120 mm (44 in.)

A.6.3.3.17 Where exit hatches are installed in spaces such as walkways or access areas, appropriate design features such as readily visible signs, markings, or bollards should be provided to prevent blockage of the exit hatch. In addition, provisions should be included in the design to protect the exterior side of the hatch, including the outside latch, from accumulation of ice and snow, which could render the hatch inoperable.

A.6.3.4.1 The primary hazards presented by the electrified third rail in the trainway are electrical shock to employees and other personnel in the trainway and the heat and smoke generated by the cable or third rail caused by combustion resulting from grounding or arcing.

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.

A.6.3.5.9 This value is a minimum maintained point measured at any location on the walkway, taking into account the total light loss factor (dirt depreciation, lumen depreciation, etc.) that will be experienced by the luminaire. Required lighting levels should be read in the same manner as they would be in other codes or standards without consideration for obscuration by evacuees. The phrase "during a period of evacuation" is intended to clarify that continuous illumination is not required during normal operations.

A.6.3.5.11 Point illumination can be used to accentuate critical elements within the trainway such as change of walkway elevation, steps, and access points.

A.6.4.2.1 The placement of blue light stations at the ends of station platforms should be governed by specific characteristics of the transportation system and its emergency response procedures. For example, an at-grade system that has stations located on streets and overhead power supply might not need blue light stations at the ends of platforms.

A.6.4.4.2 The authority having jurisdiction might additionally require 65 mm (2½ in.) hose connections to be equipped with a 65 mm × 40 mm (2½ × 1½ in.) reducer.

A.6.4.4.4(1) Calculations, including transit and fill times, should be submitted to the authority having jurisdiction to support this requirement.

A.6.4.6.2 The intent of the standard is to provide a reasonable level of life safety for occupants. However, the risk faced in non-passenger areas where trains are merely stored or cleaned is significantly different from that in passenger areas (6.4.6.2 and 6.4.6.3 do not apply to maintenance and yards areas). This is because there are fewer ignition sources and fewer people, and the occupants will be either familiar with their surroundings (in the case of staff) or trained to react in hazardous locations (in the case of emergency responders). The standard continues to require ventilation and all other protective features, including compliant egress from these areas. Paragraphs 6.4.6.2 and 6.4.6.3 eliminate the requirement for the emergency ventilation system to meet the tenability criteria for other occupied areas. The standard permits tenability criteria in these areas to be reduced, provided that an engineering analysis shows that a fire in these areas will not impact areas occupied by passengers.

A.6.4.6.3 See A.6.4.6.2.

A.7.1.1 Separate ventilation systems for tunnels and underground stations can be provided but are not required. Annex B provides information on types of mechanical systems for normal and emergency ventilation of trainways and stations and information for determining a tenable environment.

A.7.1.2.2 Individual project geometries can impose constraints that make the length requirement of 7.1.2.2(2) onerous to meet. Proposals to the AHJ for relief based on engineering analysis might be made to address this. The following elements and performance goals should be considered in the development and justification of an alternative approach. A mechanical system intended for the purpose of emergency ventilation can be considered for waiver from an enclosed trainway if the length of the enclosed trainway is less than or equal to the length of that system's most prevalent train, provided that each vehicle within that most prevalent train permits a protected passenger egress route from each vehicle to the one (or two) adjoining vehicles. A rationale for selection and acceptance of the most prevalent train would be part of the justification. Conversely, a mechanical system intended for the purpose of emergency ventilation should not be waived in an enclosed trainway if the length of the enclosed trainway is equal to or greater than twice the NFPA recommendation *(see 6.2.2.2)* for the maximum distance that an evacuating passenger should have to travel before reaching an emergency exit stairway [381 m (1250 ft)]. The need for a mechanical system intended for the purpose of emergency ventilation should be analyzed further (as approved) if an enclosed trainway meets one of the following criteria:

(1) The length of the enclosed trainway is less than 762 m (2500 ft) but greater than that of the system's most prevalent train.
(2) The length of the enclosed trainway is less than that of the system's most prevalent train and each vehicle within that most prevalent train does not permit a protected passenger egress route from that vehicle to the one (or two) adjoining vehicle(s).

In the event that no analysis is performed or the justification is not approved, the default enclosed trainway design should include an emergency ventilation system.

A.7.2.1(3) The time frame required for achievement of the selected operating mode applies to the ventilation system equipment and not to the establishment of the resultant air flows in the tunnels and stations. This would be the time for the emergency ventilation system to achieve the required speed and direction for all related fans and to reach the required position for all dampers and related emergency devices.

A.7.2.5 Transition from fixed-block to moving-block (cab-based or communication-based) signaling is being made by many properties to increase train throughputs during rush hour operation. Ventilation zones are fixed elements, and the number of trains allowed in a single zone affects both ventilation plant requirements and the effectiveness of the ventilation response. Traction power blocks are fixed elements and affect the ability to extract non-incident trains from the incident ventilation zone. Signal system track circuits are fixed elements and affect the ability to determine the location of incident and non-incident trains in the incident ventilation zone. Signal system reversing capability and rapidness of executing a reversal in an emergency are key to the effective extraction of non-incident trains. Due to the potential for a valid incident ventilation response to move smoke past (and engulf) a non-incident train, the best protection to passengers is to allow no more than one train in a ventilation zone. Failing that, there should be a viable extraction capability to remove non-incident trains in the same time frame as the activation of the ventilation response. This extraction requires coordination of the three system elements in terms of design and operation. Non-incident trains should be capable of being located and removed from the incident area before the de-energization of the traction power prevents train movement for an extended period or the operation of the ventilation system in response to the fire incident involves the trains in the incident. Examples of the provisions necessary to accomplish this capability are the inclusion of traction power segmentation zones within ventilation zones and the inclusion of sufficiently short track signal circuit lengths to ensure all trains are accurately located.

A.7.2.6 The time of tenability should consider the possibility of one or more egress paths being blocked by fire or smoke (as may be demonstrated by analysis) and for other considerations that are not accounted for in the egress capacity calculations. *(See B.2.3 for additional information to be considered.)*

A.7.5.1 Factory approval acceptance testing prior to installation should be performed as follows:

(1) Ventilation equipment should comply with all the requirements of one of the applicable standards, which include those published by the Air Movement and Control Association International, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, the International Organization for Standardization, and or UL (formerly, Underwriters Laboratories). If an appropriate standard does not exist, then a test procedure should be submitted for approval.
(2) Tests can consist of prototype testing or of production testing. Prototype testing should include those tests necessary to ensure that the design of the equipment is acceptable, including tests for design temperature exposure time. Production testing should include those tests necessary to ensure that the equipment as produced meets the requirements of the standard.

A.7.5.2 A test plan should be prepared and submitted to the owner and the AHJ for review and approval prior to the commissioning tests. The test plan should describe the method of testing and identify pass-fail criteria. As a minimum, the test plan should identify the following items:

(1) The commissioning tests should include individual equipment tests [as indicated in items (2) and (3)] and systemwide tests [as indicated in items (4) through (13)].
(2) The individual fans, dampers, and other devices should be operated to confirm their functionality. As a minimum, ventilation equipment operation should be initiated at the local primary location for fan operation such as an emergency management panel or fire management panel.
(3) The individual fan and ventilation plant airflows should be measured to confirm that the intended airflows are being delivered. At least one test should be made to measure the time required for the fan plant airflows to reach steady-state from a zero-flow start, and at least one test should be made to measure the time required for the fan plant airflows to reverse from full-forward to full-reverse operation. Subsequent tests should be conducted from Operations Central Control to verify remote fan and damper operation.
(4) The no-fire (or cold) station and tunnel airflows provided by the built mechanical ventilation system should be measured to confirm that the airflows meet the requirements determined by the analysis.
(5) The systemwide tests should be witnessed by the owner, the AHJ, the designer or the engineer of record, the contractor, and possibly the ventilation equipment suppliers.
(6) The systemwide testing should be done by a qualified airflow measurement specialist or contractor having previous experience in measuring airflows.
(7) Calibrated instruments providing an air velocity measurement accuracy of ±2.5 percent should be used. The number of points to be measured to convert air velocities to airflows should be determined either by the applicable standard used for the factory acceptance preinstallation testing (such as those published by the Air Movement and Control Association International, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, the International Organization for Standardization or UL) or by a CFD analysis. The test data should be electronically recorded for future use.
(8) The fan(s) that are assumed to be operated and not operated by the analysis should be identified for each scenario being tested.
(9) At least one test should be performed to measure the time required for all the fans used in a fire scenario to reach full operating mode.
(10) The tunnel fire scenarios should be assessed and should include the design cases (i.e., those that determine the ventilation equipment functional capacities) and any other scenarios deemed appropriate. The train(s) should be located in the tunnel as per the scenario, and tunnel airflows upstream of the stopped trains should be measured. It is not necessary to test all scenarios.
(11) The station fire scenarios should be assessed and should include the design cases (i.e., those that determine the ventilation equipment's functional capacities) and any other scenarios deemed appropriate. The station geometry can preclude the necessity of locating trains in the station. Airflows through the station entrances and tunnels connected to the station should be measured. It is not necessary to test all scenarios.
(12) The airflows measured should be compared with the "cold flows" predicted by the analysis. If the measured airflows are less than the predicted airflows, the mechanical ventilation system or its operation should be changed and the test repeated until passing results are achieved. Negative tolerances in the results should not be accepted.
(13) The systemwide testing should be documented by one or more reports. The report should include a description of the scenario tested, the instrumentation used, the names and affiliations of those witnessing the tests, and all test results.

A.8.2 Federal Railroad Administration (FRA) requirements for passenger rail car and locomotive cab fire safety are contained in 49 CFR 238.

The requirements of 49 CFR 238, Section 103, are that interior materials be tested and meet certain flammability and smoke criteria and that floor fire endurance be tested. In addition, the requirements contain detailed fire safety analysis requirements for new equipment, to reduce the risk of personal injury and equipment damage caused by a fire to an acceptable level. The fire safety analysis requirements include the use of a formal safety methodology and written documentation of the analysis. In addition, the vehicle design and material selection are required to consider potential ignition sources; the type, quantity, and location of materials; and the availability of rapid and safe egress to the equipment exterior under conditions secure from fire, smoke, and other hazards. The ventilation system is required to not contribute to the lethality of a fire. Passenger railroads are also required to determine the extent to which overheat detection and fire suppression systems must be installed to ensure sufficient time for the safe evacuation of passengers and crew.

In addition to the specific fire safety requirements in 49 CFR 238, Section 103, other sections of the FRA requirements include fire safety–related provisions for passenger rail vehicles. Minimum requirements for fuel tanks for new passenger locomotives are intended to protect the fuel tanks against crushing and puncture in a collision or derailment. Requirements for passenger car electrical systems are also included. Conductor sizes must be selected on the basis of current carrying capacity, temperature, and other characteristics, and power dissipation resistors must be adequately ventilated to prevent overheating and be electrically insulated. The resistors and main battery system must be designed to prevent combustion. Such features can reduce the risk of fire ignition and spread in a collision or derailment and thus affect the necessity for and circumstances of emergency evacuation. Other CFR requirements are for passenger rail car and locomotive crashworthiness, as well as emergency exit and emergency responder access features. Annex E provides guidance relative to fire hazard assessments referenced in Section 8.3 through Section 8.10.

A.8.3.2 The purpose of this requirement is to isolate potential ignition sources from fuel and combustible material and to control fire and smoke propagation.

A.8.4.1 It is recommended that testing be conducted on production batches of materials intended to be used on the vehicle. A record of the performance of these materials should be retained by the authority.

It is recognized that the tests cited in 8.4.1 might not accurately predict the behavior of materials under hostile fire conditions. Therefore, the use of tests that evaluate materials in subassemblies and full-scale configurations is encouraged where such tests are more representative of foreseeable fire sources, heat flux levels, and surface area-to-volume ratios found in vehicles designed in conjunction with this standard.

The key fire property measured in the ASTM D 3675 and ASTM E 162 tests is the radiant panel index (or I_s).

A.8.4.1.1 ASTM E 162 might not be suitable for materials that exhibit flaming running or flaming dripping because the test apparatus is not designed to accommodate this kind of burning behavior. A fire hazard analysis seeking to demonstrate the acceptability of such materials as permitted in 8.4.2 should include not only the contribution to the generation of heat and smoke at the original ignition site but also any contribution resulting from burning material that melts and/or flows away from that site. The fire hazard analysis also should address the risk of spread to and ignition of other car components from either of these potential ignition sources.

A.8.4.1.3 The test methods in ASTM E 1537 [for upholstered furniture, 19 kW/(65 KBtu/hr) exposure] and ASTM E 1590 [for mattresses, 18 kW/(61 KBtu/hr) exposure] are deemed to be adequate procedures for testing individual items of upholstered furniture or mattresses for purposes of fire hazard assessment in some public occupancies. However, such individual stand-alone (not fixed in place) items are not normally found in rail transportation vehicles. Thus, the applicability of the test methods to rail transportation vehicles has not been validated, and they probably are not sufficiently representative of the situation and might require some modifications for better applicability. The use of alternative ignition sources (by varying the location, the gas flow intensity, or the exposure time) for ASTM E 1537 or ASTM E 1590 might be a means of addressing some very high challenge fire scenarios that could potentially occur in rail transportation vehicles. Examples of more powerful ignition sources that could be used include a 50 kW gas burner [Hirschler, 1997], shown to be relevant to detention mattresses or the oil burner used for aircraft seat cushions [FAR 25.853(c)], but the measurements should involve the same fire properties as in ASTM E 1537 or ASTM E 1590. If the ignition source used for a test method is inadequate, the result can be misleading; it has been shown that upholstered furniture and mattresses that are totally consumed when using the appropriate ignition source appear to perform well when using the ignition sources in ASTM E 1537 and ASTM E 1590, respectively.

A.8.4.1.10 If the surface area of any individual small part is less than 100 cm^2 (16 in.^{2}) in end use configuration, materials used to fabricate such a part should be permitted to be tested in accordance with ASTM E 1354 as an alternative to both the ASTM E 162 flammability test procedure or the appropriate flammability test procedure otherwise specified in Table 8.4.1 and the ASTM E 662 smoke generation test procedure. Testing should be at 50 kW/m^2 (4.4 Btu/sec·ft^2) applied heat flux in the horizontal orientation with a retainer frame. Materials tested in accordance with ASTM E 1354 should meet the performance criteria of a 180-second average heat release rate of q''_{180} < 100 kW/m^2 (8.8 Btu/sec·ft^2) and test average smoke extinction area of (F_f) < 500 m^2/kg (2441.2 ft^2/lb).

The typical way in which smoke obscuration test results are reported in the cone calorimeter (ASTM E 1354) is as specific extinction area.

A.8.4.1.14 Only one specimen need be tested. A proportional reduction can be made in the dimensions of the specimen, provided the specimen represents a true test of the ability of the structural flooring assembly to perform as a barrier against undervehicle fires.

A.8.4.1.15 ASTM E 2061 and APTA RP PS-005-01a both describe and discuss passenger-carrying vehicle fire scenarios. *(See also Annex E.)*

A.8.4.2 The greater the anticipated effect of the material on fire performance, the more complex the analysis is likely to be.

A.8.5.1.3.2(1) Computer models typically utilize passenger-carrying vehicle fire heat release rate data to predict the size of a vehicle fire that will occur after an interior fire reaches flashover. Vehicle interior fire computer models assume either that a fire is started on the inside of a vehicle or that an undercar fire penetrates into the vehicle interior, igniting any combustible material in the area of penetration. Typically, a floor fire resistance test is conducted only for the approved length of time. Consideration should be given to extending the floor fire exposure until failure. If a test is conducted until failure, it will give designers a better idea as to the length of time it will take for a fire to penetrate into a vehicle and ignite any combustible materials on the vehicle interior.

A.8.5.1.3.2(2) For determination of the minimum floor exposure time, the operating environment should be considered in addition to the time necessary to evacuate passengers from the vehicle. Typical issues that should be considered are the time necessary to shut down power to the affected portion of the trainway, distance to a cross-passageway, distance to an emergency exit, and availability of adequate light to perform a safe evacuation.

A.8.5.1.3.3(2) Since smoke generation is a factor that has a direct effect on a passenger's ability to evacuate a vehicle, observations should be noted during the length of the floor fire exposure as to the origin and quantity of smoke generated from the fire test sample. These observations should be recorded in the fire test report.

A.8.6.2.2 In selecting air clearance distances, special consideration should be given to the presence of contaminants encroaching on the air clearances.

A.8.6.2.3.2 Appropriate creepage distances can be selected from Annex F.

A.8.6.5.1 Resistors dissipate heat at elevated temperatures and are frequently separated by noncombustible shields to avoid ignition of combustible train materials. Direct contact with combustibles is a fire hazard and minimum spacing should be established if combustible materials are required to be used. The clear spacing will vary depending on location, orientation, and fire characteristics of the combustible train materials.

A.8.6.7.1.3 The electrical properties of data and communication cables should comply with requirements for category cable or local electrical requirements. Different system authorities specify data and communication cables that have specific electrical requirement other than voltage.

A.8.8.1 Since 1980, the Federal Railroad Administration (FRA) has required that each rail passenger car be provided with at least four emergency window exits. In 1999, the FRA issued a passenger equipment rule that required each intercity and commuter rail car to be equipped with a minimum number of two side doors per car and at least four emergency window exits for each main level. Each sleeping compartment must also be provided with an emergency window exit. Because fixed guideway vehicles historically have been provided with at least two sets of bi-leaf side doors, one on each side, emergency exit windows usually are not provided.

A.8.8.1.1 After a collision or derailment, the vehicle might come to a rest in an orientation other than upright. When designing alternative means of emergency egress, consideration should be given to reaching the emergency egress, regardless of vehicle orientation. This can be accomplished by the utilization of fixed appurtenances in the vehicle, ladders, or ramps.

A.8.8.3.1 The level of emergency lighting illumination was previously required to meet the requirements of NFPA *101*. However, research conducted by the John A. Volpe Transportation Systems Center (Volpe Center) for the Federal Railroad Administration (FRA), U.S. Department of Transportation, determined that the level of illumination required by NFPA *101* might not be necessary due to the more limited size [25.9 m (85 ft) long and 3.1 m (10 ft) wide)] and configuration of passenger rail vehicles (and by extension, fixed guideway transit vehicles). The Volpe Center performed numerous detailed measurements of illumination levels provided by emergency light facilities installed on many types and ages of intercity and commuter rail vehicles. The majority of fixed guideway transit and passenger rail vehicle emergency lighting systems use fluorescent light fixtures. However, some systems used incandescent fixtures. While the fluorescent light fixtures typically emit higher levels of illumination and are thus preferred, some incandescent light fixtures (depending on their type, power output and location, and pattern) also provide sufficient illumination to allow passengers to identify, reach, and operate emergency egress facilities.

The Federal Aviation Administration (FAA) has conducted many research studies relating to emergency lighting illumination levels for passenger aircraft. The FAA requires different illumination levels at floor level doors and emergency window locations and along the center aisle. The center aisle illumination levels are measured at the armrest height. Due to the different armrest heights exhibited by passenger rail vehicles, the Volpe Center research resulted in the recommendation for a uniform height of 635 mm (25 in.) above the floor height to perform the aisle measurements.

Accordingly, the FRA issued a passenger equipment regulation on May 12, 1999, that specified the Volpe-recommended minimum illumination level for egress door floor locations, minimum illumination average along the center aisle, and a minimum illumination at any point along the aisle for new equipment.

Moreover, the American Public Transportation Association (APTA) standard APTA SS-E-013 addresses passenger rail vehicle emergency lighting. The APTA standard requires minimum emergency lighting levels for new intercity passenger and commuter rail vehicles that are identical to FRA requirements and contains additional guidance in performing the illumination measurements. The APTA emergency lighting standard was updated in 2007 to provide a detailed test methodology. The APTA standard provides guidance that could be applied to fixed guideway transit vehicles.

A.8.8.3.3 Depending on the location of the train, the time necessary to initiate and complete the evacuation of passengers from the fixed guideway transit or passenger rail vehicle to a point of safety can exceed 1 hour. The minimum period of time for the vehicle emergency lighting system power supply is consistent with NFPA *101*, APTA SS-E-013, and the FRA regulation.

A.8.8.4 Until the 2003 edition, NFPA 130 did not address the manual operation of emergency egress (or access) facilities for the vehicle interior or exterior, the interior and exterior marking of the egress/access facility location, or instructions for the use of the emergency egress/access facilities. Several emergency incidents occurred that demonstrated the necessity of providing passengers with a means to manually operate, without tools, means of emergency egress in the event of a power failure. Operational issues to be considered include the need to discourage use under nonemergency conditions while permitting effective passenger use in an emergency, particularly if members of the train crew are injured or otherwise unavailable.

• **A.8.8.5** The FAA requires the installation of independently powered floor proximity path marking to delineate the path to emergency exits. APTA also has issued a standard that requires this same concept of marking to be installed in intercity and commuter rail cars.

The FRA issued a rule in 1998 that required marking and instructions for the operation of emergency exit windows and doors used for emergency egress. Although the FRA requires that the marking be conspicuous and legible, specific objective performance criteria were not included.

APTA has issued a standard that contains extensive provisions for the marking of and instructions for emergency egress facilities that are operated from inside the vehicle. These minimum performance criteria include letter height, color contrast, and luminance levels.

The APTA standard requires that marking and instructions use either electrically powered or high-performance photo luminescent (HPPL) material. The HPPL material must be charged with adequate light [54 lx (5 ft-candles) for at least 1 hour] but offers the advantage of providing a far greater luminance (brightness) over a far longer time period while not being dependent on emergency power. HPPL material has been certified by the FAA for use as floor proximity path marking on certain aircraft.

A.8.11.1 Annex D provides additional information on the fire hazards associated with burning vehicles and the impact of a burning vehicle on the evacuation of passengers and crew.

A.8.11.2 Section 4.3 includes specific objectives necessary to achieve desired goals. Further guidance relative to the engineering analysis option for compliance could include explanatory material regarding performance-based compliance in other documents, such as NFPA *101*.

A.9.2.4 The following standards might be applicable for training qualification and competency assessment: NFPA 1006, NFPA 472, and NFPA 1670.

A.9.4 Tunnels more than 610 m (2000 ft) in length should be equipped with emergency tunnel evacuation carts (ETECs) at locations to be determined by the authority having jurisdiction.

ETECs should be capable of carrying a capacity of at least four stretchers and a total weight capacity of at least 453.5 kg (1000 lb). ETECs should be constructed of corrosion-resistant materials, be equipped with a "deadman" brake, and safely operate on the rail tracks in the tunnel.

A.9.5 The agencies and their names might vary depending on the governmental structure and laws of the community.

A.9.6.9 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.

A.9.8.1 The command post should be located at a site that is convenient for responding personnel, easily identifiable, and suitable for supervising, coordinating, and communicating with participating agencies.

A.9.8.5 Signs should be designed to be visible day and night and under bad weather conditions.

A.9.9 Any emergency response agency can establish an auxiliary command post to assist with the supervision and coordination of personnel and equipment. This activity is in addition to providing a liaison at the command post.

A.10.1 Comprehensive and dependable communications are essential for an effective and efficiently operated fixed guideway transit system during emergencies.

A.11.2.1 It is desirable that passengers are evacuated directly to a station platform, rather than to a trainway, to avoid the complications of a trainway evacuation.

A.11.3.1 Different situations that can render a system unavailable include data overloads, both intentional or unintentional; loss of data; loss of a control room due to fire; loss of battery power; and circuits shorted or open.

A.11.3.2 Single points of failure that will affect life safety during fires and the mitigation of those single points of failure should be considered during conceptualization.

A.11.3.3 When it is essential that a control, data, or communication system continue to function during a fire, both thermal and physical protection are likely to be required, since a fire resistance–rated element intended to protect the control, data, or communication system might not offer the expected thermal protection to the unexposed side for the duration of the fire resistance rating.

A.12.1.2 The life safety and fire protection requirements for the traction power substations, the breaker station's power distribution, and control cabling are described in other parts of this standard.

A.12.5.3 When selecting a fire-resistive cable, it is important to understand how it will be installed and if it was tested as a complete system, including splices. Cables that are exposed (not embedded in concrete) should be protected by either a raceway or an armor/sheath *(see 12.4.1)*. There are two basic configurations of fire-resistive cables. Cables enclosed by a metallic sheath or armor, such as Type MI or Type MC, are installed without raceways. Cables that are installed in a raceway, such as Type RHW-2, Type TC, or Type CM are tested as a complete system. Regardless of the fire test standard used to evaluate fire-resistive cables that will be installed in a raceway, it is important to consider that the cables are only one part of the system. Other components of the system include but are not limited to: the type of raceway, the size of raceway, raceway support, raceway couplings, boxes, conduit bodies, splices where used, vertical supports, grounds, and pulling lubricants. Each cable type should be tested to demonstrate compatibility. Only those specific types of raceways tested should be acceptable for installation. Each cable type that is intended to be installed in a raceway should be tested in both a horizontal and vertical configuration while demonstrating circuit integrity.

Annex B Ventilation

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

B.1 General. The purpose of this annex is to provide guidelines for the potential compatibility of the emergency ventilation system with the system employed with normal ventilation of trainways and stations. This annex does not present all factors to be considered in the normal ventilation criteria. For normal ventilation, refer to the *Subway Environmental Design Handbook* (*SEDH*) and the ASHRAE handbooks *Fundamentals*, *Applications*, and *Systems and Equipment*.

Current technology is capable of analyzing and evaluating all unique conditions of each property to provide proper ventilation for normal operating conditions and for pre-identified emergency conditions. The same ventilating devices might or might not serve both normal operating conditions and pre-identified emergency requirements. The goals of the subway ventilation system, in addition to addressing fire and smoke emergencies, are to assist in the containment and purging of hazardous gases and aerosols such as those that could result from a chemical/biological release.

B.2 Tenable Environments.

B.2.1 Environmental Conditions. Some factors that should be considered in maintaining a tenable environment for periods of short duration are defined in B.2.1.1 through B.2.1.5.

B.2.1.1 Heat Effects. *(See also H.1.2.11.)* Exposure to heat can lead to life threat in three basic ways:

(1) Hyperthermia
(2) Body surface burns
(3) Respiratory tract burns

For use in the modeling of life threat due to heat exposure in fires, it is necessary to consider only two criteria: the threshold of burning of the skin and the exposure at which hyperthermia is sufficient to cause mental deterioration and thereby threaten survival.

Note that thermal burns to the respiratory tract from inhalation of air containing less than 10 percent by volume of water vapor do not occur in the absence of burns to the skin or the face; thus, tenability limits with regard to skin burns normally are lower than for burns to the respiratory tract. However, thermal burns to the respiratory tract can occur upon inhalation of air above 60°C (140°F) that is saturated with water vapor.

The tenability limit for exposure of skin to radiant heat is approximately 2.5 $kW{\cdot}m^{-2}$. Below this incident heat flux level, exposure can be tolerated for 30 minutes or longer without significantly affecting the time available for escape. Above this threshold value, the time to burning of skin due to radiant heat decreases rapidly according to Equation B.2.1.1a.

$$t_{Irad} = 106q^{-1.35} \quad \textbf{(B.2.1.1a)}$$

where:
t = time in minutes
q = radiant heat flux (kW/m^2)

As with toxic gases, an exposed occupant can be considered to accumulate a dose of radiant heat over a period of time. The fraction equivalent dose (FED) of radiant heat accumulated per minute is the reciprocal of t_{Irad}.

Radiant heat tends to be directional, producing localized heating of particular areas of skin even though the air temperature in contact with other parts of the body might be relatively low. Skin temperature depends on the balance between the rate of heat applied to the skin surface and the removal of heat subcutaneously by the blood. Thus, there is a threshold radiant flux below which significant heating of the skin is prevented but above which rapid heating occurs.

Based on the preceding information, it is estimated that the uncertainty associated with the use of Equation B.2.1.1a is ±25 percent. Moreover, an irradiance of 2.5 $kW{\cdot}m^{-2}$ would correspond to a source surface temperature of approximately 200°C, which is most likely to be exceeded near the fire, where conditions are changing rapidly.

Calculation of the time to incapacitation under conditions of exposure to convected heat from air containing less than 10 percent by volume of water vapor can be made using either Equation B.2.1.1b or Equation B.2.1.1c.

As with toxic gases, an exposed occupant can be considered to accumulate a dose of convected heat over a period of time. The fraction equivalent dose (FED) of convected heat accumulated per minute is the reciprocal of t_{Iconv}.

Convected heat accumulated per minute depends on the extent to which an exposed occupant is clothed and the nature of the clothing. For fully clothed subjects, Equation B.2.1.1b is suggested:

$$t_{Iconv} = \left(4.1\times10^{8}\right) T^{-3.61} \quad \textbf{(B.2.1.1b)}$$

where:
t_{Iconv} = time in minutes
T = temperature (°C)

For unclothed or lightly clothed subjects, it might be more appropriate to use Equation B.2.1.1c:

$$t_{Iconv} = \left(5\times10^{7}\right) T^{-3.4} \quad \textbf{(B.2.1.1c)}$$

where:
t_{Iconv} = time in minutes
T = temperature (°C)

Equations B.2.1.1b and B.2.1.1c are empirical fits to human data. It is estimated that the uncertainty is ±25 percent.

Thermal tolerance data for unprotected human skin suggest a limit of about 120°C (248°F) for convected heat, above which there is, within minutes, onset of considerable pain along with the production of burns. Depending on the length of exposure, convective heat below this temperature can also cause hyperthermia.

The body of an exposed occupant can be regarded as acquiring a "dose" of heat over a period of time. A short exposure to a high radiant heat flux or temperature generally is less tolerable than a longer exposure to a lower temperature or heat flux. A methodology based on additive FEDs similar to that used with toxic gases can be applied. Provided that the temperature in the fire is stable or increasing, the total fractional effective dose of heat acquired during an exposure can be calculated using Equation B.2.1.1d:

$$FED = \sum_{t_1}^{t_2}\left(\frac{1}{t_{Irad}}+\frac{1}{t_{Iconv}}\right)\Delta t \quad \textbf{(B.2.1.1d)}$$

Note 1: In areas within an occupancy where the radiant flux to the skin is under 2.5 $kW \cdot m^{-2}$, the first term in Equation B.2.1.1d is to be set at zero.

Note 2: The uncertainty associated with the use of this last equation would be dependent on the uncertainties with the use of the three earlier equations.

The time at which the FED accumulated sum exceeds an incapacitating threshold value of 0.3 represents the time available for escape for the chosen radiant and convective heat exposures.

As an example, consider the following:

(1) Evacuees lightly clothed
(2) Zero radiant heat flux
(3) Time to FED reduced by 25 percent to allow for uncertainty in Equations B.2.1.1b and B.2.1.1c.
(4) Exposure temperature constant
(5) FED not to exceed 0.3

Equations B.2.1.1c and B.2.1.1d can be manipulated to provide:

$$t_{exp} = \left(1.125\times10^{7}\right)T^{-3.4}$$

where:
t_{exp} = time of exposure (min.) to reach a FED of 0.3

This gives the values in Table B.2.1.1.

Table B.2.1.1 Maximum Exposure Time

Exposure Temperature °C	Exposure Temperature °F	Without Incapacitation (min.)
80	176	3.8
75	167	4.7
70	158	6.0
65	149	7.7
60	140	10.1
55	131	13.6
50	122	18.8
45	113	26.9
40	104	40.2

B.2.1.2 Air Carbon Monoxide Content. An exposed occupant can be considered to accumulate a dose of carbon monoxide over a period of time. This exposure to carbon monoxide can be expressed as a fractional effective dose, according to Equation B.2.1.2a; see B.2.1.2.1, reference [1] [page 6, equation (2)]:

$$FED_{CO} = \sum_{t_1}^{t_2} \frac{[CO]}{35000} \Delta t$$

where:

Δt = time increment in minutes

$[CO]$ = average concentration of CO (ppm) over the time increment Δt

It has been estimated that the uncertainty associated with the use of Equation B.2.1.2a is ±35 percent. The time at which the FED accumulated sum exceeds a chosen incapacitating threshold value represents the time available for escape for the chosen carbon monoxide exposure. As an example, consider the following:

(1) Time to FED reduced by 35 percent to allow for the uncertainty in Equation B.2.1.2a
(2) Exposure concentration constant

This gives the values in Table B.2.1.2 for a range of threshold values.

Table B.2.1.2 Maximum Carbon Monoxide Exposure

Time (min)	Tenability Limit AEGL 2	Tenability Limit 0.3	Tenability Limit 0.5
4	–	1706	2844
6	–	1138	1896
10	420	683	1138
15	–	455	758
30	150	228	379
60	83	114	190
240	33	28	47

A value for the FED threshold limit of 0.5 is typical of healthy adult populations [1], 0.3 is typical in order to provide for escape by the more sensitive populations [1], and the AEGL 2 limits are intended to protect the general population, including susceptible individuals, from irreversible or other serious long-lasting health effects [2].

The selection of the FED threshold limit value should be chosen appropriate for the fire safety design objectives. A value of 0.3 is typical. More conservative criteria may be employed for use by especially susceptible populations. Additional information is available in references [1] and [3].

B.2.1.2.1 The following references are cited in B.2.1.2:

(1) "Life threat from fires — Guidance on the estimation of time available for escape using fire data." ISO/DIS 13571, International Standards Organization, 2006.
(2) "Acute Exposure Guideline Levels for Selected Airborne Chemicals, Volume 8," Committee on Acute Exposure Guideline Levels, Committee on Toxicology, National Research Council. National Academies Press, Washington DC, 2010.
(3) Kuligowski, E. D., "Compilation of Data on the Sublethal Effects of Fire Effluent," Technical Note 1644, National Institute of Standards and Technology, 2009.

B.2.1.3 Smoke Obscuration Levels. Smoke obscuration levels should be maintained below the point at which a sign internally illuminated at 80 lx (7.5 ft-candles) is discernible at 30 m (100 ft) and doors and walls are discernible at 10 m (33 ft).

B.2.1.4 Air Velocities.

B.2.1.4.1 Air velocities in enclosed stations and trainways should be greater than or equal to 0.75 m/sec (150 fpm).

B.2.1.4.2 Air velocities in enclosed stations and trainways that are being used for emergency evacuation or by emergency personnel should not be greater than 11.0 m/sec (2200 fpm).

B.2.1.5 Noise Levels. Noise levels should be a maximum of 115 dBa for a few seconds and a maximum of 92 dBa for the remainder of the exposure.

B.2.2 Geometric Considerations. Some factors that should be considered in establishing a tenable environment in stations are as follows:

(1) The evacuation path requires a height clear of smoke of at least 2 m (6.6 ft). For low-ceiling areas, selection of the modeling method and the criteria to be achieved should address the limitations imposed by ceiling heights below 3 m (9.84 ft). At low-ceiling areas in an evacuation path, beyond the immediate vicinity of a fire, smoke should be excluded to the greatest extent practicable.
(2) The application of tenability criteria at the perimeter of a fire is impractical. The zone of tenability should be defined to apply outside a boundary away from the perimeter of the fire. This distance will be dependent on the fire heat release rate, the fire smoke release rate, local geometry, and ventilation and could be as much as 30 m (100 ft). A critical consideration in determining this distance will be how the resultant radiation exposures and smoke layer temperatures affect egress. This consideration should include the specific geometries of each application, such as vehicle length, fire location, platform width and configuration, and ventilation system effectiveness, among others, and how those factors interact to support or interfere with access to the means of egress.
(3) The beneficial effects of an emergency ventilation system during a fire incident will not become completely available until the system is operated and reaches full capacity. During the time between initiation of a fire incident and the desired ventilation response achieving its full capacity, the smoke can spread into the intended zone of tenability. The ventilation system should have sufficient capacity to counter this

pre-ventilation smoke spread. Whenever possible, the design of the space geometry should consider arrangements to minimize the pre-ventilation smoke spread. The overall extent of pre-ventilation smoke spread should also be considered with respect to its potential effect on egress.

(4) During the emergency ventilation response, short-term transient events due to step-like changes in geometry can momentarily provide a significant boost to the fire heat and smoke release rates. Examples include vehicle doors opening or the failure of vehicle windows. The ventilation system should have sufficient capacity to counter such short-term transients affecting smoke spread.

B.2.3 Time Considerations. Some factors that should be considered in establishing the time of tenability are as follows:

(1) The time for fire to ignite and become established
(2) The time for fire to be noticed and reported
(3) The time for the entity receiving the fire report to confirm existence of fire and initiate response
(4) The time for all people who can self-rescue to evacuate to a point of safety
(5) The time for emergency personnel to arrive at the station platform
(6) The time for emergency personnel to search for, locate, and evacuate all those who cannot self-rescue
(7) The time for fire fighters to begin to suppress the fire

B.2.4 Modeling Accuracy. Where modeling is used to determine factors such as temperature, visibility, and smoke layer height, an appropriate sensitivity analysis should be performed.

B.3 Configurations. Configurations can vary among properties, but engineering principles remain constant. The application of those principles should reflect the unique geometries and characteristics of each property.

Enclosed stations and trainways might be configured with the following characteristics:

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

B.4 Draft Control.

B.4.1 For patron comfort in stations, the air velocities induced by train motion should be evaluated carefully by designers. Infrequent exposure to higher velocities can be tolerated briefly but are to be avoided wherever possible. Refer to the *Subway Environmental Design Handbook* (*SEDH*), the *ASHRAE Handbook — Fundamentals,* and the *Beaufort Scale.*

B.4.2 Draft control can be achieved by the placement of shafts along the tunnel length between stations. Shafts can be arranged with the fan shafts at the ends of stations, with vent shafts midtunnel if required or with vent shafts at the ends of stations and fan shafts midtunnel. End-of-station shaft configurations should be related to the station geometries in the consideration of patron comfort in the station relative to train piston draft effects.

B.5 Temperature Control.

B.5.1 Temperature control for patron comfort in the station can be achieved by circulating ambient air in moderate climates or by providing heating and/or cooling in more extreme regions. Preferred temperature goals should be defined in the criteria developed for the design of an individual property relative to the local climate and the length of station occupancy, such as train headways specific to the property during which the patron would be exposed to the station temperatures.

B.5.2 Temperature control and ventilation for ancillary areas housing special equipment should reflect the optimum operating conditions for the specific equipment to ensure the availability of critical equipment and should also give consideration for intermittent occupancy by maintenance personnel. These systems should be separate from the emergency ventilation system for stations and tunnels and should be considered in the design of the emergency ventilation system.

B.6 Under-Platform Ventilation System.

B.6.1 An under-platform ventilation system should be considered for the extraction of heat from traction and braking devices. Intakes should be provided below the platform level and should be situated relative to the heat-producing devices on a train berthed in a station.

B.6.2 Ceiling ventilation, by powered or gravity design, to aid in the removal of smoke and/or heat should be considered.

B.7 Platform Edge and Screen Doors.

B.7.1 Platform edge doors and platform screen doors are sometimes incorporated into stations for various reasons, such as climate control, separation between passengers and trainway hazards (especially in driverless systems), and ventilation control in enclosed trainways. When used, these system walls and doors should provide resistance rating structural strength relative to the train and ventilation system pressures.

B.7.2 In a tunnel-to-station evacuation scenario, access to the platform level from the trainway should be considered.

B.8 Non-Emergency Ventilation for Enclosed Trainways.

B.8.1 Congested Operations. Where trains might be stopped or delayed in an enclosed trainway for a period of time, the vehicle ventilation system should be capable of maintaining an acceptable level of patron comfort. If not operating in a fire or other emergency scenario, the emergency ventilation fans can be used to augment the vehicle system capability.

B.8.2 Maintenance Activities. Maintenance activities within station and tunnel areas can include heat-, dust-, or fume-producing operations such as grinding, welding, or painting; operation of fuel-powered vehicles or equipment; and other operations that affect tunnel air quality or temperature. If not operating in a fire or other emergency scenario, the tunnel ventilation fans can be used to address the safety and comfort of employees working in the affected tunnel and station areas. In such cases, velocities should consider the comfort levels of employees required to be in the tunnels.

B.8.3 Tunnels in Gassy Ground. Tunnels in gassy ground could be subject to ingress of flammable or other hazardous gases. Gases of concern include hydrogen sulfide (H_2S) and methane (CH_4). The ventilation system should be designed to satisfy two objectives:

(1) To avoid pockets of gases forming
(2) To achieve dilution of gas inflows through a design crack

The ventilation design should be coordinated with the gas detection and alarm system type and the activation levels selected. The design should consider two general conditions:

(1) Ongoing or periodic ventilation requirements to meet expected average gas ingress rates
(2) Reaction to potential abrupt increases in gas ingress, such as might result from future construction, climate events, or seismic activity

Annex C Means of Egress Calculations for Stations

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

C.1 Station Occupant Load. The station platform dimensions are a function of the length of trains served and the train load. Thus the length of a platform at an outlying station might be equal to those of central business district transit stations where the train loads are significantly higher. Consequently, the platform and station occupant loads are a function of the train load and the simultaneous entraining load. This concept differs from that of NFPA *101*, in which the occupant load is determined by dividing the floor area by an occupant load factor assigned to that use. Applying the NFPA *101* approach to determine the station platform occupant load is inappropriate.

C.1.1 Calculating Occupant Load. Projected ridership figures serve as the basis for determining transit system design. Per this standard, the methodology used to determine ridership figures must also include peak ridership figures for new transit systems and existing operating systems. Events at stations such as civic centers, sports complexes, and convention centers that establish occupant loads not included in normal passenger loads must also be included. These ridership figures serve as the basis for calculating train and entraining loads and the station occupant load. The methodology used for determining passenger ridership figures can vary by transit system. The use of statistical methods for determining *calculated train loads* and *calculated entraining loads* will provide a more accurate indication of the required means of egress facilities within a station.

C.1.2 Calculating Evacuation Time. The total evacuation time is the sum of the walking travel time for the longest exit route plus the waiting times at the various circulation elements. The trainway can be considered as an auxiliary exit from the station under certain fire scenarios.

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

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

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

T = total walking travel time for the longest exit route

T_p = walking travel time on the platform

T_X = walking travel time for the Xth segment of the exit route

F_p = platform exits flow time

F_{fb} = fare barrier flow time

F_c = concourse exits flow time

F_N = flow time for any additional circulation element

$W_p = F_p - T_p$ = waiting time at platform exits

$W_{fb} = F_{fb} - F_p$ = waiting time at fare barriers

$W_c = F_c - \max(F_p \text{ or } F_{fb})$ = waiting time at concourse exits

$W_N = F_N - \max(F_c, F_{fb}, \text{ or } F_p)$ = waiting time at any additional circulation element

Note that the waiting time at any circulation element cannot be less than zero.

C.1.3 Center-Platform Station Sample Calculation. The sample center-platform station is an elevated station with the platform above the concourse, which is at grade *(see Figure C.1.3)*. The platform is 183 m (600 ft) long to accommodate the train length. The vertical distance from the platform to the concourse is 9.1 m (30 ft).

The sample station has one paid area separated from the outside by a fare array containing four electronic fare gates and one 1220 mm (48 in.) handicapped/service gate. In addition, two 1830 mm (72 in.) wide emergency exits are provided. Six open wells communicate between the platform and the concourse. Each well contains one stair or one escalator. Station ancillary spaces are located at the concourse level.

Elevators (not shown in Figure C.1.3) are provided for use by handicapped persons or service personnel. Open emergency stairs are provided at each end of the platform and discharge directly to grade through grille doors with panic hardware.

Escalators are nominal 1220 mm (48 in.) wide. Stairs regularly used by patrons are 1830 mm (72 in.) wide, and emergency stairs are 1220 mm (48 in.) wide. Gates to emergency stairs are 1220 mm (48 in.) wide.

The station occupant load is 2314 persons.

Table C.1.3 lists the data for the exiting analysis of the sample center-platform station.

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

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

$$F_p = \frac{2314}{609}$$

$$F_p = 3.80 \text{ minutes}$$

In Test No. 1, the time to clear the platform is found to be 3.80 minutes. This meets the requirement of 5.3.3.1.

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

W_p (waiting time at platform exits) = $F_p - T_1$

$W_p = 3.80 - 1.09 = 2.71$ minutes

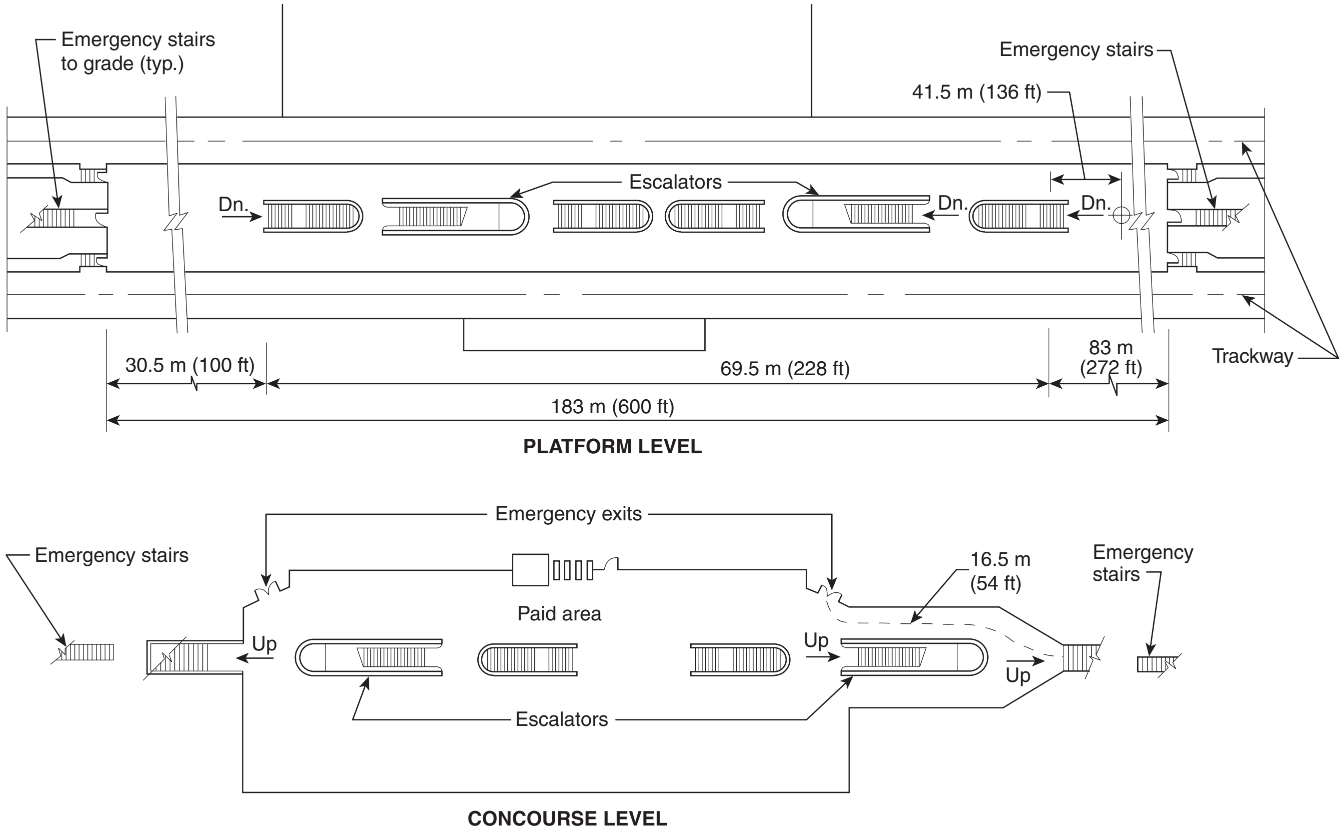

FIGURE C.1.3 Center-Platform Station.

Concourse occupant load = Platform occupant load − (F_p × emergency stair capacity)

Concourse occupant load = 2314 − 513 = 1801 persons

W_{fb} (waiting time at fare barriers) = $F_f - F_p$

$$F_{fb}\left(\text{fare barrier flow time}\right) = \frac{\text{Concourse occupant load}}{\text{Fare barrier exit capacity}}$$

$$F_{fb} = \frac{1801}{560} = 3.22 \text{ minutes}$$

$W_c = F_{fb} - F_p$

$W_{fb} = 3.22 - 3.80 = 0.000$ minutes

W_c (waiting time at concourse exits) = $[F_c - \max\ (F_{fb} \text{ or } F_p)]$

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

$$F_c = \frac{1801}{0} = 0.000 \text{ minutes}$$

$W_c = F_c - \max(F_{fb} \text{ or } F_p)$

$W_c = 0.000 - 3.80 = 0.000$ minutes

Total exit time = $T + W_p + W_{fb} + W_c$

Total exit time = 2.23 + 2.71 + 0.000 + 0.000

Total exit time = 4.94 minutes

In Test No. 2, the time to reach a point outside any enclosing structure is found to be 4.94 minutes. This meets the requirement of 5.3.3.2.

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

C.1.4 Side-Platform Station Sample Calculation. The sample side-platform station is an enclosed station with a concourse above the platform level but below grade. *(See Figure C.1.4.)* The platform is 183 m (600 ft) long to accommodate the train length. The vertical distance from grade to concourse is 8 m (26 ft). The concourse is 5.5 m (18 ft) above the platform.

The sample station has two entrances normally used by patrons, each containing one escalator and one stair. The entrances are covered at grade level to a point 3.05 m (10 ft) beyond the top of the stairs.

The concourse is divided into two free areas and one paid area separated by fare arrays. Each fare array contains 12 fare gates of the turnstile type and one swinging service gate, 1220 mm (48 in.) wide, equipped with panic hardware for use by handicapped persons and service personnel.

Three open wells, containing two stairs and one escalator, communicate between each platform and the concourse.

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

Enclosed emergency stairs that discharge directly to grade are provided at both ends of each platform. Escalators are nominal

Table C.1.3 Sample Calculations — Center-Platform Station

Egress Element	mm	in.	p/mm-min	pim	p/min
Platform to concourse (downward)					
Stairs (4)	7320	288	0.0555	1.41	406
Escalators (2*)	1220	48	0.0555	1.41	68
Emergency stairs (2)	2440	96	0.0555	1.41	135
Escalator test: 8.67% (Not > 50%)					609
Through fare barriers					
Fare gates (4) (capacity = 50 per gate)					200
Service gates (1)	1 gate	1 gate	60p/gate/min	60p/gate/min	60
Emergency exit doors (2 x double doors)	3660	144	0.0819	2.08	300
					560
Fare barriers to safe area (fare barriers discharge to outside)					
Stairs	0	0	0.0555	1.41	0
Escalators	0	0	0.0555	1.41	0
Emergency stairs	0	0	0.0555	1.41	0
Escalator test: 0.00% (Not > 50%)					0
Walking Time for Longest Exit Route	**m**	**ft**	**m/min**	**fpm**	**min**
Platform to safe area					
On platform, T_1	41.5	136	37.7	124	1.09
Platform to concourse, T_2	9.1	30	14.6	48	0.62
On concourse, T_3	16.5	54	37.7	124	0.44
Concourse to grade, T_4	0	0	14.6	48	0
On grade to safe area, T_5	3.05	10	37.7	124	0.08
Total walking time, $T = T_1 + T_2 + T_3 + T_4 + T_5$					2.23

*One escalator discounted.

1220 mm (48 in.) wide. Stairs regularly used by patrons are 1830 mm (72 in.) wide. Emergency stairs are 1220 mm (48 in.) wide. Doors to emergency stairs are 1220 mm (48 in.) wide.

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

Table C.1.4 lists the data for the exiting analysis of the sample side-platform station.

The egress capacity from platform to concourse meets the criteria of 5.3.3.1 in Test No. 1, where the time to clear the platform is found to be 3.38 minutes for the inbound platform and 0.56 minute for the outbound platform.

In Test No. 2, the total exit time (i.e., the maximum exit time for the two paths examined) is found to be 5.85 minutes. This meets the criteria of 5.3.3.2.

Evacuate platform occupant load(s) from platform(s) in 4 minutes or less.

Inbound platform:

$$F_{p-i}(\text{time to clear platform}) = \frac{\text{Platform occupant load}}{\text{Platform egress capacity}}$$

$$F_{p-i} = \frac{1372}{406}$$

$$F_{p-i} = 3.38 \text{ minutes}$$

Outbound platform:

$$F_{p-o}(\text{time to clear platform}) = \frac{\text{Platform occupant load}}{\text{Platform egress capacity}}$$

$$F_{p-o} = \frac{228}{406}$$

$$F_{p-o} = 0.56 \text{ minutes}$$

F_p for inbound and outbound occupant loads satisfies the criterion of 4 minutes.

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

Inbound platform:

W_{p-i} (waiting time at platform egress elements) = $F_{p-i} - T_{1_{p-i}}$

$W_{p-i} = 3.38 - 1.33 = 2.05$ minutes

Concourse occupant load = Platform occupant load – (F_{p-i} × emergency stair capacity)

Concourse occupant load = 1372 – 456 = 916 persons

Outbound platform:

W_{p-o} (waiting time at platform egress elements) = $F_{p-o} - T_{1_{p-o}}$

$W_{p-o} = 0.56 - 0.49 = 0.07$ minute

Concourse occupant load = Platform occupant load – (F_{p-o} × emergency stair capacity)

Concourse occupant load = 228 – 76 = 152 persons

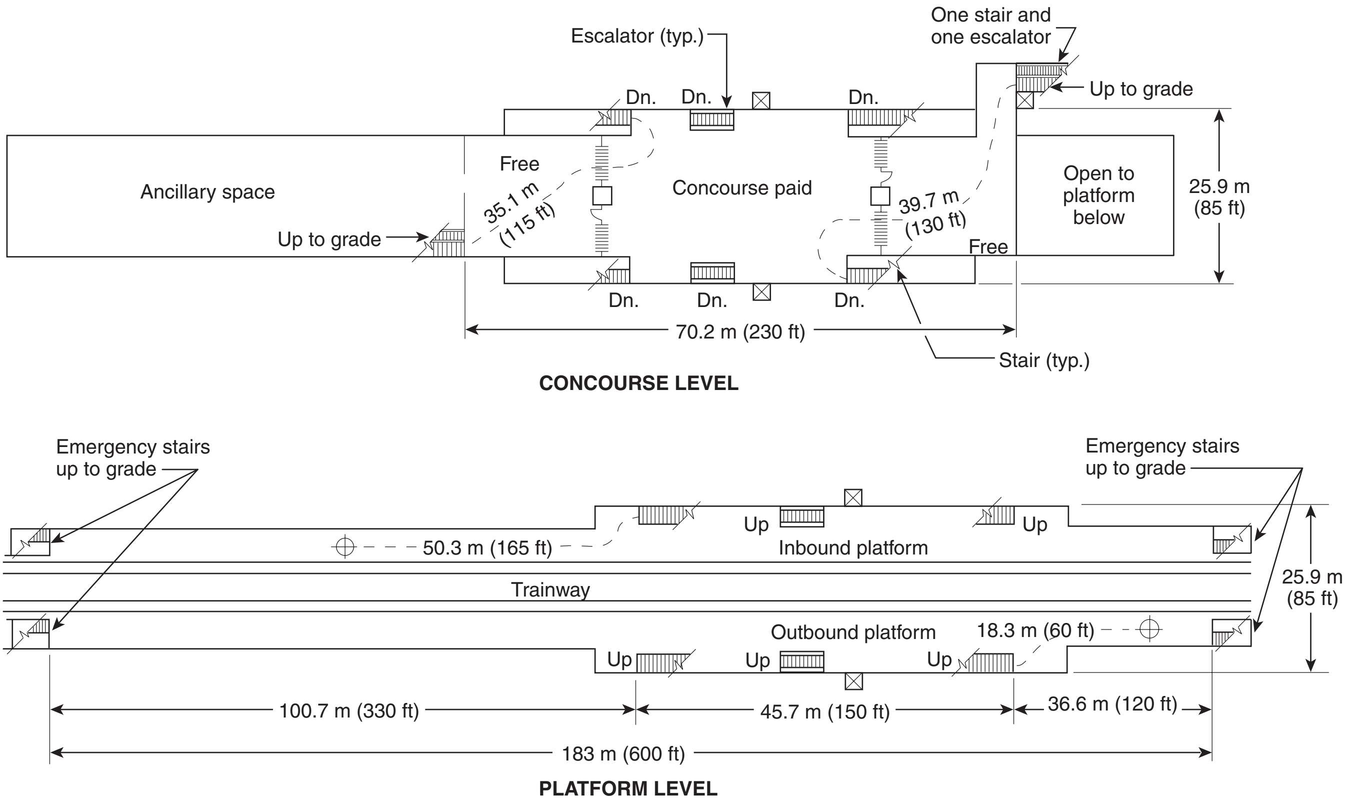

FIGURE C.1.4 Side-Platform Station.

Total concourse occupant load = Concourse load (inbound) + Concourse load (outbound)

Total concourse occupant load = 916 – 152 = 1068 persons

Inbound platform:

W_{fb} (waiting time at fare barriers) = $F_{fb} - F_{p-i}$

$$F_{fb} = \frac{\text{Concourse occupant load}}{\text{Fare barrier egress capacity}}$$

$$F_{fb} = \frac{533}{399}$$

$F_{fb} = 1.34$ minutes

$W_{fb} = F_{fb} - F_{p-i}$

$W_{fb} = 1.34 - 3.66 = 0.00$ minutes

W_c (waiting time at concourse egress elements) = $F_c - \max(F_{fb} \text{ or } F_{p-i})$

$$F_c\left(\text{concourse flow time}\right) = \frac{\text{Concourse occupant load}}{\text{Concourse egress capacity}}$$

$$F_c = \frac{533}{94}$$

$F_c = 5.68$ minutes

$W_c = F_c - \max(F_{fb} \text{ or } F_{p-i})$

$W_c = 5.68 - 3.66 = 2.02$ minutes

Outbound platform:

W_{fb} (waiting time at fare barriers) = $F_{fb} - F_{p-o}$

$$F_{fb} = \frac{\text{Concourse occupant load}}{\text{Fare barrier egress capacity}}$$

$$F_{fb} = \frac{533}{399}$$

$F_{fb} = 1.34$ minutes

$W_{fb} = F_{fb} - F_{p-o}$

$W_{fb} = 1.34 - 0.61 = 0.73$

W_c (waiting time at concourse egress elements) = $F_c - \max(F_{fb} \text{ or } F_{p-o})$

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

$$F_c = \frac{533}{156}$$

$F_c = 3.42$ minutes

$W_c = F_c - \max(F_{fb} \text{ or } F_{p-o})$

$W_c = 3.42 - 1.34 = 2.08$ minutes

Total egress time = $T + W_p + W_{fg} + W_c$

Inbound platform:

Total = 3.49 + 2.32 + 0.00 + 2.02

Total = 7.83 minutes

Outbound platform:

Total = 2.76 + 0.12 + 0.73 + 2.08

Total = 5.69 minutes

Table C.1.4 Sample Calculations — Side-Platform Station

Egress Element	mm	in.	p/mm-min	pim	p/min
Inbound platform to concourse (upward)					
Stairs (2)	3660	144	0.0555	1.41	203
Escalators (1*)	1220	48	0.0555	1.41	68
Emergency stairs (2)	2440	96	0.0555	1.41	135
					406
Walking Time for Longest Exit Route	**m**	**ft**	**m/min**	**fpm**	**min**
Inbound platform					
On platform, T_1	50.3	165	37.7	124	1.33
Platform to concourse, T_2	5.5	18	14.6	48	0.38
On concourse, T_3	35.1	115	37.7	124	0.94
Concourse to grade, T_4	7.9	26	14.6	48	0.54
On grade to safe area, T_5	3.05	10	37.7	124	0.08
Total walking time, $T = T_1 + T_2 + T_3 + T_4 + T_5$					3.26
Element	**mm**	**in.**	**p/mm-min**	**pim**	**p/min**
Outbound platform to concourse (upward)					
Stairs (2)	3660	144	0.0555	1.41	203
Escalators (1*)	1220	48	0.0555	1.41	68
Emergency stairs (2)	2440	96	0.0555	1.41	135
					406
Walking Time for Longest Exit Route	**m**	**ft**	**m/min**	**fpm**	**min**
Outbound platform					
On platform, T_1	18.2	60	37.7	124	0.49
Platform to concourse, T_2	5.5	18	14.6	48	0.38
On concourse, T_3	39.6	130	37.7	124	1.05
Concourse to grade, T_4	7.9	26	14.6	48	0.54
On grade to safe area, T_5	3.05	10	37.7	124	0.08
Total walking time, $T = T_1 + T_2 + T_3 + T_4 + T_5$					2.54
Concourse:					
Throughfare barriers					
Turnstiles (12) capacity = 25 p/min					300
Service gate (1)	1 gate	1 gate	60p/gate/min	60p/gate/min	60
					360
Fare barriers to safe areas					
Stairs (2)	3660	72	0.0555	1.41	204
Escalator (2*)	1220	48	0.0555	1.41	68
					272

*One escalator discounted (5.3.6).

C.1.5 Multilevel-Platform Stations. The procedures for calculating exiting times for multilevel platform stations are similar to the sample calculations in C.1.3 and C.1.4. The changes in the exiting calculations are for multilevel-platform stations primarily a function of the concurrent occupant load determinations for the two platform levels.

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

(1) Calculate the occupant load for each platform level as in the appropriate examples in C.1.3 and C.1.4 for the same assumed time(s) of day. Refer also to 5.3.2.3(2) and A.5.3.2.3(2).

(2) If the fire is on the upper-level platform (for an underground station), an assumption can be made as to the percentage of occupants who might be expected to evacuate the lower level through the normal egress routes versus the percentage who might be expected to exit via emergency stairs. These assumptions will be unique for each system as a function of various parameters, including physical configuration of stations, means of egress, and location of emergency exits; communications facilities to advise passengers, both verbal and signing; level of transit personnel working in stations; and transit personnel emergency procedure responsibilities established for the transit operating authority.
(3) The upper-level occupant load is increased by the people evacuating from the lower level through the normal egress routes in accordance with C.1.5(2).
(4) For a fire on the lower level, appropriate assumptions relative to the distribution of the occupant loads to the available means of egress are calculated in a fashion similar to the procedures described above.

The remainder of the exiting calculations essentially are unchanged from the other sample calculations in C.1.3 and C.1.4.

C.2 Escalators. ANSI/ASME A17.1/CSA B44 is generally recognized as the standard governing the installation and maintenance of escalators.

However, considering the critical operational nature of the escalators in stations, specially designed units with additional safety features should be provided.

The number of flat steps at the upper landings should be increased in proportion to the vertical rise of the escalator. For a rise up to 6.1 m (20 ft), there should be two flat steps, the ANSI/ASME A17.1/CSA B44 minimum number of flat steps; from 6.1 m (20 ft) to 18.3 m (60 ft) rise, three flat steps; and over 18.3 m (60 ft) rise, four flat steps.

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

(1) Direction of travel
(2) Operating speed (if more than one)
(3) Out-of-service status
(4) Flashing light that indicates the escalator is stopped because of activation of a safety device

Annex D Rail Vehicle Fires

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

D.1 Introduction. This annex provides additional information on the hazards associated with burning vehicles and the impact of a burning vehicle on the evacuation of passengers and crew to a point of safety. Emergency evacuation from a vehicle containing a fire could include exiting a vehicle containing the fire to an adjacent vehicle, exiting the train into the operating environment (station, tunnel, etc.) where the train is located, and moving through the operating environment to the point of safety. Chapter 8 contains minimum prescriptive requirements that are intended to provide sufficient time for passengers and crew to safely evacuate from a train containing a fire. This annex provides guidance for designing and evaluating train fire performance. A fire involving a train will have an impact on the conditions in the operating environment, and this type of fire is often used to design emergency systems in operating environments. Chapters 5 through 7 provide requirements on design of the operating environment to ensure that passengers can safely egress to a point of safety.

D.2 Initial Fire Development Inside Vehicles. The development of a fire inside a vehicle is dependent on the fire performance of interior finish materials, the size and location of the initiating fire, the size of the enclosure where the fire is located, and the ventilation into the enclosure.

D.2.1 Material fire performance is most often considered in the evaluation of fire performance of the vehicle. Material fire performance is measured in terms of ignitibility, heat release rate, and smoke and toxic gas production. Flame spread and fire development are dependent on the material's ignitibility and heat release rate as well as the severity of the initiating fire and surrounding environment.

D.2.1.1 The ignitibility, heat release rate, and smoke and toxic gas production can be measured in the ASTM E 1354 cone calorimeter. It is recommended that all combustible materials on a train be tested in the cone calorimeter. At a minimum, tests should be conducted at a heat flux of 50 kW/m^2 in duplicate. For a more detailed evaluation of the material performance, cone calorimeter tests should be performed at three different heat fluxes where the material ignites (e.g., 25, 50, and 75 kW/m^2). The cone calorimeter can also be used to measure the critical heat flux of the material, which is the lowest heat flux at which the material will ignite. The critical heat flux can be used to determine the ignition temperature of the material. Analysis to predict flame spread along materials will require the more detailed set of cone calorimeter data along with the critical heat flux of the material.

D.2.1.2 In Chapter 8, the minimum fire performance of many interior finish materials is required to be measured using the ASTM E 162 flame spread test. Though this downward flame spread test will screen out many poorly performing materials, the test does not provide a measure of wind-aided flame spread (i.e., upward flame spread or flame spread along a ceiling). Wind-aided flame spread is the fastest type of flame spread and is the type of flame spread that will cause the maximum surface area of material to become involved in the fire. The amount of upward flame spread is affected by the size of the initiating fire and the material fire performance. Some materials might not exhibit any flame spread when exposed to a small fire (e.g., a newspaper fire), but when exposed to something slightly larger (e.g., burning bag of trash with paper and plastic) will readily spread flame.

D.2.1.3 Smoke and toxic gas production can have an impact on the operating environment through which passengers will need to evacuate. Some materials naturally produce more smoke and toxic gases. Some fire-retardant additives can cause more smoke and toxic gases to be produced compared to untreated materials. The amount of smoke and toxic gas produced will be a function of the amount of material burning. Therefore, limiting fire propagation on materials will also help limit the amount of smoke and toxic gas production.

D.2.2 The size and location of the initiating fire will have a significant impact on whether materials become ignited and spread flame. Materials exposed to higher levels of heat (heat fluxes)