NFPA® 130

Standard for Fixed Guideway Transit and Passenger Rail Systems

2023 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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ISBN: 978-145592938-2 (Print)

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NFPA® 130

Standard for

Fixed Guideway Transit and Passenger Rail Systems

2023 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 the NFPA membership during the 2022 NFPA Technical Meeting held June 8-9. It was issued by the Standards Council on August 12, 2022, with an effective date of September 1, 2022, and supersedes all previous editions.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See “Codes & Standards” at www.nfpa.org for more information.

This edition of NFPA 130 was approved as an American National Standard on September 1, 2022.

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 was the potential for the entrapment and injury of the large number 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; fortunately, the loss of life was limited. However, 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 also introduced creepage distance.

The scope of the 1988 edition was expanded to include automated guideway transit (AGT) systems.

The 1990 edition included minor changes to integrate provisions and special requirements for AGT systems into the standard.

Definitions for *enclosed station* and *open station* were added in the 1993 edition.

The 1997 edition included a new chapter on emergency ventilation systems for transit stations and trainways and a new Appendix B addressing ventilation.

The 2000 edition of NFPA 130 addressed passenger rail systems in addition to fixed guideway transit systems. The document was retitled *Standard for Fixed Guideway Transit and Passenger Rail Systems* 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*®.

In the 2003 edition, 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, in addition to changes to the traditional prescriptive-based requirements.

The 2007 edition included revisions for station egress calculations, the use of escalators in the means of egress, vehicle interior fire resistance, and power supplies for 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 2014 edition of NFPA 130 included substantial reorganization of Chapters 5 and 6 for consistency and consolidation of wire and cable requirements into a new Chapter 12. Other changes included reconciliation of terminology related to enclosed trainways and engineering versus fire hazard analyses; revisions to interior finish requirements; revisions to requirements for the prevention of flammable and combustible liquids intrusion in Chapters 5 and 6; and improvements to Annex C.

The 2017 edition of NFPA 130 added several new definitions and modified requirements for materials used as interior wall and ceiling finishes. Requirements were added for enclosed stations to be equipped with fire alarm systems and for stations and enclosed trainways to be equipped with emergency communication systems, as outlined in the revised Chapter 10. A new Annex B provided guidance on establishing noise levels to maintain a minimum level of speech intelligibility through the emergency communications system. In Annex C, modifications were made to the example showing means of egress calculation. A new Annex H provided information on fire scenarios and methodologies used for predicting fire profiles.

The 2020 edition of NFPA 130 added several new definitions, as well as guidance on the concept and permissible uses of limited combustible materials. Chapter 8 provided a testing alternative for miscellaneous, discontinuous small parts; requirements for testing of adhesives and sealants; and requirements for the testing and analysis of vehicles with end frame assemblies. Chapter 9 included requirements for the possibility of multiple concurrent emergencies. A new Annex B consolidated recommendations from Annexes D, G, and H regarding emergency ventilation and a new Annex D consolidated all the non-emergency ventilation provisions from Annexes B, D, G, and H. Other changes include reconciliation of terminology related to enclosed trainways; engineering versus fire hazard analyses and egress; means of egress and exit; clarification of construction types for various station and trainway configurations; and new requirements for the consideration of background noise relating to emergency procedures and the design of emergency communications systems in Chapters 9 and 10.

The 2023 edition has been revised to include two new annex sections. Annex G provides information regarding onboard fire suppression systems; Annex H provides recommendations on the roles and responsibilities of authorities and designers, as well as guidance on projects that span multiple jurisdictions with potentially competing requirements. Additional changes include a new section on stops; clarification of passive and active fire protection requirements; updates on egress requirements and egress component performance; revised platform load calculations, vehicle material testing requirements, and fire alarm system and command center requirements; clarification on ventilation equipment listing, testing, and acceptance requirements; as well as changes to wiring requirements.

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This list represents the membership at the time the Committee was balloted on the final text of this edition. Since that time, changes in the membership may have occurred. A key to classifications is found at the back of the document.

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

Committee Scope: This Committee shall have primary responsibility for documents 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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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. 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 and extracted publications can be found in Chapter 2 and Annex I.

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.

Δ **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 3.3.64.1)* or *passenger rail system (see 3.3.64.2)*

Δ **1.1.4** To the extent that a system, including those listed in 1.1.3(1) through 1.1.3(5), 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 4, *Standard for Integrated Fire Protection and Life Safety System Testing,* 2021 edition.

NFPA 10, *Standard for Portable Fire Extinguishers,* 2022 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2022 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2019 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2018 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2023 edition.

NFPA 70®, National Electrical Code®, 2023 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2022 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids,* 2020 edition.

NFPA *101®*, *Life Safety Code®,* 2021 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 2022 edition.

NFPA 220, *Standard on Types of Building Construction,* 2021 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations,* 2022 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source,* 2019 edition.

NFPA 262, *Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces,* 2019 edition.

NFPA 275, *Standard Method of Fire Tests for the Evaluation of Thermal Barriers,* 2022 edition.

NFPA 286, *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth,* 2019 edition.

NFPA 703, *Standard for Fire-Retardant-Treated Wood and Fire-Retardant Coatings for Building Materials,* 2021 edition.

NFPA 1221, *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems,* 2019 edition.

2.3 Other Publications.

Δ **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*, 2016.

ANSI/AMCA 250, *Laboratory Methods of Testing Jet Tunnel Fans for Performance*, 2012.

ANSI/AMCA 300, *Reverberant Room Method for Sound Testing of Fans*, 2014.

2.3.2 APTA Publications. American Public Transportation Association, 1300 I Street, NW, Suite 1200 East, Washington, DC 20005.

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

2.3.3 ASHRAE Publications. ASHRAE, 180 Technology Parkway NW, Peachtree Corners, GA 30092.

ASHRAEHandbook — Fundamentals, 2021.

ASHRAE 149, *Laboratory Methods of Testing Fans Used to Exhaust Smoke in Smoke Management Systems*, 2013.

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

ASTM C1166, *Standard Test Method for Flame Propagation of Dense and Cellular Elastomeric Gaskets and Accessories,* 2021.

ASTM D2724, *Standard Test Methods for Bonded, Fused, and Laminated Apparel Fabrics*, 2019.

ASTM D3574, *Standard Test Methods for Flexible Cellular Materials — Slab, Bonded, and Molded Urethane Foams*, 2017.

ASTM D3675, *Standard Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source,* 2021a.

ASTM D7568, *Standard Specification for Polyethylene-Based Structural-Grade Plastic Lumber for Outdoor Applications*, 2017.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2021a.

ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 2020.

ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*, 2019a.

ASTM E162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*, 2021.

ASTM E648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source*, 2019a e1.

ASTM E662, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*, 2021a e1.

ASTM E814, *Standard Test Method for Fire Tests of Penetration Firestop Systems*, 2013a (2017).

ASTM E1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 2017.

ASTM E1537, *Standard Test Method for Fire Testing of Upholstered Furniture*, 2016.

ASTM E1590, *Standard Test Method for Fire Testing of Mattresses*, 2017.

ASTM E2061, *Standard Guide for Fire Hazard Assessment of Rail Transportation Vehicles*, 2020.

ASTM E2652, *Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C*, 2018.

2.3.5 California Technical Bulletins. State of California, Department of Consumer Affairs, Bureau of Household Goods and Services, 4244 South Market Court, Suite D, Sacramento, CA 95834-1243.

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 493, Miamitown, OH 45041-9998.

ICEA S-73-532 ANSI/NEMA WC-57, *Standard for Control, Thermocouple Extension, and Instrumentation Cables*, 2014.

ICEA S-95-658 ANSI/NEMA WC-70, *Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy*, 2009.

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.

Δ **2.3.8 IEEE Publications.** IEEE, 3 Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE 11, *Standard for Rotating Electric Machinery for Rail and Road Vehicles*, 2000 (R2006).

IEEE 16, *Standard for Electrical and Electronic Control Apparatus on Rail Vehicles*, 2020.

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

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

UL 44, *Thermoset-Insulated Wires and Cables*, 2018.

UL 83, *Thermoplastic-Insulated Wires and Cables*, 2017.

UL 263, *Fire Tests of Building Construction and Materials*, 2011 (2021).

UL 444, *Communications Cables*, 2017.

UL 723, *Test for Surface Burning Characteristics of Building Materials*, 2018.

UL 1479, *Fire Tests of Penetration Firestops*, 2015.

UL 1685, *Vertical-Tray Fire-Propagation and Smoke-Release Test for Electrical and Optical-Fiber Cables*, 2015.

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

UL 2196, *Tests for Fire Resistive Cables*, 2017.

UL 2556, *Wire and Cable Test Methods*, 2021.

2.3.10 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401-0001.

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.

Δ **2.4 References for Extracts in Mandatory Sections.**

NFPA 72®, National Fire Alarm and Signaling Code®, 2022 edition.

NFPA 92, *Standard for Smoke Control Systems,* 2021 edition.

NFPA *101®, Life Safety Code®,* 2021 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source,* 2019 edition.

NFPA 270, *Standard Test Method for Measurement of Smoke Obscuration Using a Conical Radiant Source in a Single Closed Chamber,* 2018 edition.

NFPA 402, *Guide for Aircraft Rescue and Fire-Fighting Operations,* 2019 edition.

NFPA 470, *Hazardous Materials/Weapons of Mass Destruction (WMD) Standard for Responders,* 2022 edition.

NFPA 502, *Standard for Road Tunnels, Bridges, and Other Limited Access Highways,* 2023 edition.

NFPA 921, *Guide for Fire and Explosion Investigations,* 2021 edition.

NFPA 1994, *Standard on Protective Ensembles for First Responders to Hazardous Materials Emergencies and CBRN Terrorism Incidents,* 2018 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.

3.2.7 Standard. An NFPA standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA manuals of style. When used in a generic sense, such as in the phrases "standards development process" or "standards development activities," the term "standards" includes all NFPA standards, including codes, standards, recommended practices, and guides.

3.3 General Definitions.

3.3.1* Airflow Control Devices. Nontraditional equipment used to minimize airflow in enclosed trainways, including air curtains, barriers, brattices, doors, downstands, enclosures, 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 Certified. A system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of this standard, authorizes the manufacturer to use a label on listed products that comply with the requirements of this standard, and establishes a follow-up program conducted by the certification organization as a check on the methods the manufacturer uses to determine continued compliance with the requirements of this standard. [**1994,** 2018]

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,** 2019]

3.3.9 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.

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

3.3.11 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,** 2019]

3.3.12 Critical Velocity. The minimum steady-state velocity of the ventilation airflow moving toward the fire within an enclosed trainway or enclosed passageway that is required to control backlayering at the fire site, such that a tenable environment is maintained along the path of egress upstream of the fire, and as required for designated points of safety.

3.3.13 Decibel. The logarithmic units associated with sound pressure level.

3.3.13.1 ***A-Weighted Decibel (dBA).*** Decibel values with weighting applied over the frequency range of 20 Hz to 20 kHz to reflect human hearing.

3.3.13.2 ***Unweighted Decibel (dBZ).*** Decibel values without weighting applied.

3.3.14 Emergency Communications System. A system for the protection of life by indicating the existence of an emergency situation and communicating information necessary to facilitate an appropriate response and action. [**72,** 2022]

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

3.3.16* End Frame Assembly. Components at vehicle ends incorporating the structural end frame and necessary nonstructural components at the vehicle interior.

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

3.3.17.1* ***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.

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

3.3.19 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,** 2022]

3.3.20 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 mitigate the condition or situation. [**502,** 2023]

3.3.21 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.

3.3.22 Fire Load.

3.3.22.1* ***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.

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

3.3.23 Fire Profile. For a given fire scenario, the fire carbon monoxide, heat release, and smoke and soot release rates expressed as a function of time.

3.3.24 Fire Scenario. A set of conditions that defines the development of a fire, the spread of combustion products in a fixed guideway transit or passenger rail system, the reaction of people to the fire, and the effects of the products of combustion.

3.3.25 Fire Soot Release Rate. Rate of soot release for a given fire scenario expressed as a function of time (g/sec or lb/sec).

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

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

3.3.28 Green Track. The intentional placement and maintenance of vegetation within a trainway.

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

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

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

3.3.32* Heat Release Rate (HRR). The rate at which heat energy is generated by burning. [**921,** 2021]

3.3.32.1 ***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 E1354 (kW/m^2).

Δ **3.3.32.2*** ***Fire Heat Release Rate.*** Rate of energy release for a given fire scenario or fire test.

Δ **3.3.33 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. [**470,** 2022]

3.3.34 L_{eq}. The average sound level over time on an acoustical energy basis.

3.3.35 Noncombustible (Material). See Section 4.6.

3.3.36 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.

3.3.37 Occupancy.

3.3.37.1 ***Incidental Occupancies Within Stations.*** An occupancy within a station that provides services not directly related to transportation operations or transportation services.

Δ **3.3.37.2*** ***Nonsystem Occupancy.*** An occupancy not under the control of the system authority.

3.3.38 Open Gangway Configuration. A vehicle without fire-resistant separations in the form of vertical assemblies equipped with hinged or sliding doors between adjacent vehicles in an assembled consist.

3.3.39 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.

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

3.3.41 Passenger Load.

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

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

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

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

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

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

3.3.45 Radiant Panel Index (I_s). The product of the flame spread factor (F_s) and the heat evolution factor (Q), as determined in ASTM E162.

3.3.46 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.

3.3.47 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).

3.3.48 Smoke. The airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis or combustion, together with the quantity of air that is entrained or otherwise mixed into the mass. [**92,** 2021]

3.3.49 Smoke Obscuration. The reduction of light transmission by smoke, as measured by light attenuation. [**270,** 2018]

3.3.50 Smoke Release Rate. Rate of smoke release associated with a given fire scenario or a given fire test; it is expressed in terms of a surface area as a function of time [m^2/sec (ft^2/sec)].

3.3.51 Soot. Black particles of carbon produced in a flame. [**921,** 2021]

3.3.52 Soot Yield. The mass (weight) of soot emitted per mass (weight) of the fuel consumed: g (oz) of soot emitted per g (oz) of fuel burned.

3.3.53 Sound Pressure Level. The logarithmic ratio of the root-mean squared sound pressure to the reference sound pressure (2.0×10^{-5} Pascals).

3.3.54 Specific Extinction Area. A measure of smoke obscuration potential per unit of mass burned, determined as the product of the specific extinction coefficient and the volumetric mass flow rate, divided by the mass loss rate [m^2/kg (ft^2/lb)].

3.3.55 Specific Optical Density (D_s). The optical density, as measured in ASTM E662, 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.

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Δ **3.3.56 Station.** A building designated for the purpose of loading and unloading passengers, including patron service areas and ancillary spaces.

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

3.3.56.2* ***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.

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

N **3.3.58* Stop.** A place designated for the purpose of loading and unloading passengers that is comprised of a platform configured such that smoke and heat will disperse directly into the atmosphere.

3.3.59 System. See 3.3.64.1, Fixed Guideway Transit System, or 3.3.64.2, Passenger Rail System.

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

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

3.3.62 Track.

3.3.62.1 ***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.

3.3.62.2 ***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.

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

3.3.63.1* ***Enclosed Trainway.*** A trainway or portion thereof that does not meet the definition of an open trainway.

3.3.63.2* ***Open Trainway.*** A trainway that is constructed such that it is directly open to the atmosphere and smoke and heat are allowed to disperse directly into the atmosphere.

3.3.64 Transportation Systems.

3.3.64.1 ***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.

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

3.3.64.2 ***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.

3.3.65 Vehicle.

3.3.65.1 ***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.

3.3.65.2 ***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 4.6) 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 Fire Scenarios.

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

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

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* Noncombustible Material and Limited-Combustible Material.

Δ **4.6.1*** A material that complies with any of the following shall be considered a noncombustible material: [***101:***4.6.13.1]

(1) The material, 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) The material is reported as passing ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Vertical Tube Furnace at 750°C*. [***101:***4.6.13.1(2)]
(3) The material is reported as complying with the pass/fail criteria of ASTM E136, *Standard Test Method for Assessing Combustibility of Materials Using a Tube Furnace with a Cone-shaped Airflow Stabilizer, at 750°C* when tested in accordance with the test method and procedure in ASTM E2652. [***101:***4.6.13.1(3)]

Δ **4.6.2** A material that complies with the requirements in 4.6.14 of NFPA *101* shall be considered a limited-combustible material.

N **4.7 Flammable and Combustible Liquids Intrusion.**

N **4.7.1* General.** Protection against the accidental intrusion of flammable and combustible liquids by any infiltration route at or below grade shall be provided for belowgrade systems, including tunnel, station, and ancillary structures.

N **4.7.2 Vehicle Roadway Terminations.** Vent or fan shafts utilized for the ventilation of belowgrade system structures shall not terminate at grade within any vehicle roadway, driveway, loading area, or parking area.

N **4.7.3 Median and Sidewalk Terminations.** 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, sidewalks, or open space areas meets the following conditions:

(1) Termination is at a higher elevation than the surrounding grade level.
(2) Termination is separated from the roadway, driveway, loading area, or parking area by a concrete curb at least 150 mm (6 in.) in height.
(3) Termination is provided with other protections determined to be required based on an engineering analysis of potential exposures to flammable and combustible liquid spills.

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* General. This chapter shall apply to all portions of stations, except as provided in 5.1.1.2 for stops.

N **5.1.1.2 Stops.** This Chapter shall apply to stops in accordance with the following:

(1)* Where passenger movement to and from the platform area is restricted, the design of the stop shall comply with the applicable requirements of 5.3.1 through 5.3.8, 5.3.11.1, 5.4.3, and 5.4.6.
(2) Where passenger movement to and from the platform area is unrestricted, the requirements of this Chapter shall not apply, except as stipulated in 5.3.1.3.

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 firefighting 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 stations shall be in accordance with Table 5.2.2.1 based on the station configuration.

5.2.2.2 Construction types shall conform to the requirements in NFPA 220, unless otherwise exempted in this standard.

5.2.2.3 Where supported by a fire hazard analysis of potential fire exposure to the structure, alternative construction types shall be permitted.

5.2.3 Flammable and Combustible Liquids Intrusion.

5.2.3.1 General. Protection of belowgrade system structures against the accidental intrusion of flammable and combustible liquids shall be provided in accordance with Section 4.7.

• **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.

Table 5.2.2.1 Minimum Construction Requirements for New Station Structures

Station Configuration	Construction Type†
Stations erected entirely above grade and in a separate building:	
Open stations	Type II (000)
Enclosed station*	Type II (111)
Stations erected entirely or partially below grade:	
Open abovegrade portions of belowgrade structures*	Type II (111)
Belowgrade portions of structures	Type II (222)
Belowgrade structures with occupant loads exceeding 1000	Type I (332)

*Roofs not supporting an occupancy above are not required to have a fire resistance rating.

†Construction types are in accordance with NFPA 220.

(2) Public areas on different levels in open stations shall be 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 E119 or UL 263.

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

(1) They shall be constructed of noncombustible materials.
(2) Where they are used only as agent and information booths, they 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 nonsystem occupancies.

5.2.5 Interior Finish.

5.2.5.1 Materials used as interior wall and ceiling finish in enclosed stations shall comply with one of the following requirements:

(1) The materials shall be noncombustible in accordance with Section 4.6.
(2) The materials shall be limited-combustible in accordance with 4.6.2.
(3) The materials shall comply with the following requirements when tested in accordance with NFPA 286:
    (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).
(4) The materials shall comply with a flame spread index not exceeding 25 and a smoke development index not exceeding 450 when tested in accordance with ASTM E84 or UL 723, except that the materials in 5.2.5.2 shall be required to be tested in accordance with NFPA 286.

5.2.5.2 The following materials shall not be permitted to be used as interior wall and ceiling materials, unless they meet the requirements in 5.2.5.1(3) when tested in accordance with NFPA 286:

(1) Foam plastic insulation, whether exposed or covered by a textile or vinyl facing
(2) Textile wall or ceiling coverings
(3) Solid thermoplastics, including, but not limited to, high-density polyethylene (HDPE), solid polycarbonate, solid polystyrene, and solid acrylic materials that melt and drip when exposed to flame.

5.2.5.3 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·sec) when tested in accordance with ASTM E648.

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

Δ **5.2.6 Insulation.**

Δ **5.2.6.1** Combustible insulation in public circulation areas shall be protected by a thermal barrier complying with NFPA 275 or by 12.7 mm (½ in.) gypsum board or 12.7 mm (½ in.) concrete.

5.2.6.2 Where thermal barriers are required by 5.2.6.1, penetrations shall be firestopped in accordance with ASTM E814.

N **5.2.6.3** Insulation applied to pipes or ducts shall be listed and labeled and exhibit a flame spread index not exceeding 25 and a smoke developed index not exceeding 450 when tested in accordance with ASTM E84 or UL 723.

N **5.2.6.4*** Ceiling spray foam insulation in public circulation areas shall be protected with an approved covering.

5.2.7 Combustible Furnishings and Contents.

5.2.7.1* 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.

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

5.2.7.3 Seating furniture in stations shall be noncombustible, or it shall have limited rates of heat release when tested in accordance with ASTM E1537, 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).

5.2.7.4 Lockers shall be constructed of noncombustible materials.

5.3* Means of Egress.

5.3.1* General.

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

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.

N **5.3.1.3 Stops.** Means of egress serving a stop complying with 5.1.1.2(2) shall be designed in accordance with the following:

(1)* Means of egress components serving the platform area shall be designed in accordance with the requirements of the local applicable building code.
(2) Guards shall be provided in areas raised above the surrounding grade in accordance with the requirements of the locally applicable code, except where the raised areas are adjacent to the track.

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* Peak ridership figures for stations shall consider events that establish occupant loads not included in normal peak period 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.

Δ **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 platform occupant load shall be the sum of the entraining load and the train load for each track that the platform serves.
(2)* The entraining load for each track shall be the entraining load per train headway factored to account for service disruptions and system reaction time.
(3)* Where a platform serves more than one line on one track, the calculation of the entraining load shall consider the combined effect of the accumulating passengers for each of the lines served.
(4)* The calculated train load for each track shall be the train load per train headway factored to account for service disruptions and system reaction time.
(5) The train load at each track shall be the lesser of the calculated train loads as described in 5.3.2.5(4) or the maximum passenger capacity for the trains 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 stations where the concourse is protected from exposure to the effects of a fire at the platform by distance, geometry, fire separation, an emergency ventilation system designed in accordance with Chapter 7, or as determined by an appropriate engineering analysis, that concourse shall be permitted to be defined as a point of safety.

5.3.3.4 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).

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

5.3.3.6 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.

5.3.3.7* Engineering Analysis. Modification of the evacuation times and travel distances shall be permitted where substantiated by an engineering analysis that evaluates factors affecting evacuation times and tenability, such as material heat release rates, station geometry, fire protection systems, 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 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 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 egress travel speed along platforms, corridors, and ramps shall be computed at 37.7 m/min (124 ft/min).

5.3.4.5 The 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 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 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 egress capacity on 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 egress capacity from each station level is accounted for with stairs.
(3)* For enclosed stations, at least one enclosed exit provides continuous access from each platform 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 preplanned 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 egress capacity in stations.

5.3.6.2 Capacity. Where elevators are counted as contributing to the 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 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 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 as 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 multi-leaf doors and gates that do not have a center mullion 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 6.3.3.12 through 6.3.3.14.

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 66 N (15 lbf) 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 in accordance with NFPA *101* shall be permitted in the means of egress and 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. Horizontal exits compliant with NFPA *101* shall be permitted for up to 100 percent of the number of 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 Edge Provisions.

5.3.10.1 Guards shall not be required along the trainway side of platforms.

5.3.10.2 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 design permits 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 133 N (30 lb) is applied to set the door leaf in motion from the train side of the doors.
(3) The doors are designed to withstand positive and negative pressures caused by passing trains or the operation of the emergency ventilation system.

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 designated command post where the status of the fire alarm, communications, and other emergency systems is displayed and from which the system(s) can be controlled.

Δ **5.4.1.2*** The command post shall be designed as a fire command center in accordance with *NFPA 72*® where required by the AHJ.

5.4.2 Fire Alarm Systems.

Δ **5.4.2.1*** Stations shall be protected by fire alarm systems that are designed and installed in accordance with *NFPA 72* where any of the following conditions exist:

(1) An automatic fire suppression system is required by 5.4.4
(2) A standpipe system other than a manual dry standpipe system is required by 5.4.5
(3) An emergency communications system is required by 5.4.3

Δ **5.4.2.2*** Automatic fire detection shall be provided in enclosed stations and enclosed areas of open stations except in the following:

(1) Areas used for public circulation
(2) Trainways within stations
(3) Areas protected by an automatic fire suppression system that initiates a fire alarm signal upon activation

N **5.4.2.3** The fire alarm system shall be initiated by the following:

(1)* Manual activation from the operations control center or station
(2) Activation of an automatic suppression system in accordance with 5.4.4
(3) Activation of a fire detector in accordance with 5.4.2.2

Δ **5.4.2.4*** Annunciation of signals from the fire alarm system shall be provided at an approved location at the station that is accessible to emergency response personnel.

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Δ **5.4.2.5*** Signals from the fire alarm system shall be transmitted to the operations control center.

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

5.4.3 Emergency Communications System. Stations shall be provided with an emergency communications system in accordance with Chapter 10.

5.4.4 Automatic Fire Suppression Systems.

Δ **5.4.4.1*** Automatic sprinkler protection shall be provided in all areas of stations except:

(1) Areas used for public circulation
(2) Trainways within stations

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 Where required, sprinkler systems shall be designed and installed in accordance with NFPA 13.

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.

N **5.4.5.2** Standpipe systems shall be provided with an approved water supply capable of supplying system demand for a minimum of 1 hour.

5.4.5.3 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) The isolation valves are installed not more than 245 m (800 ft) apart.

5.4.5.4 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.

Δ **5.4.5.5*** 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 so that the water is delivered to all the hose connections on the system in 10 minutes or less.
(2) Combination air relief/vacuum valves shall be installed at each high point of the system.

5.4.5.6 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.

Δ **5.4.5.7** Where enclosed stations include more than one platform level (such as crossover subway lines), there shall be a cross-connection pipe of a minimum of 100 mm (4 in.) in diameter between each standpipe system so that water supplied by any fire department connection can furnish water throughout the entire system.

5.4.5.8 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 Where required, portable fire extinguishers shall be selected, installed, inspected, tested, and 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.

5.5 Integrated Testing of Fire Protection Systems.

5.5.1 Where two or more fire protection or life safety systems are interconnected, integrated testing shall comply with NFPA 4.

5.5.2 An integrated test shall be performed prior to revenue service.

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 Occupancy.

6.1.2.1* The system shall be designed to deter passenger entry to the trainway except during an event that requires evacuation of a train.

6.1.2.2* The system shall include provisions for giving guidance to passengers who may be required to evacuate from a train to a trainway.

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

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, the fire resistance ratings of perimeter walls and related construction assemblies shall be not less than those associated with Type I or Type II construction, or combinations of Type I and Type II construction, in accordance with NFPA 220, unless otherwise permitted as a result of a fire hazard 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 constructed of materials or assemblies permitted for use in Type II (000) construction, in accordance with NFPA 220.

6.2.2.5 Exit and Ventilation Structures. Remote vertical exit shafts and ventilation structures shall be constructed of materials or assemblies permitted for use in Type I (332) construction, in accordance with NFPA 220.

6.2.2.6 Surface. Construction materials shall be materials or assemblies permitted for use in Type I or Type II construction, in accordance with NFPA 220, unless otherwise permitted 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 constructed of materials or assemblies permitted for use in Type I or Type II (000) construction, or combinations of Type I and Type II construction, in accordance with NFPA 220, unless otherwise permitted 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 belowgrade system structures against the accidental intrusion of flammable and combustible liquids shall be provided in accordance with Section 4.7.

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.

Δ **6.2.5.1** Where combustible components not specifically addressed in this standard are installed in an enclosed trainway, a fire hazard analysis as described in 6.2.5.2 and 6.2.5.3 shall be conducted to ensure that the level of occupant fire safety is not affected by the trainway contents.

Δ **6.2.5.2*** The fire hazard analysis shall use appropriate engineering methods, such as computer modeling, material fire testing, or full-scale fire testing, to assess the design performance in potential fire scenarios commensurate with the proposed location and trainway environment.

6.2.5.3 The fire hazard analysis shall ensure that, if a fire propagates beyond the component of fire origin, a level of fire safety is provided within an enclosed trainway commensurate with this standard.

6.2.6 Walking Surfaces.

6.2.6.1 In enclosed trainways, walking surfaces designated for the 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 comply with 6.2.7.2 or 6.2.7.3.

6.2.7.2 Coverboard or protective material tested in accordance with ASTM E84 or UL 723 shall have a flame spread index of not more than 25 and a smoke developed index not exceeding 450.

6.2.7.3 Coverboard or 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.

Δ **6.2.8.1** Rail ties used in enclosed locations shall be made of noncombustible materials in accordance with 4.6.1.

Δ **6.2.8.2** Rail ties used outdoors at switch or crossover locations shall be made of one of the following types of materials:

(1) Noncombustible materials in accordance with 4.6.1
(2) Fire-retardant-treated wood in accordance with NFPA 703
(3) Pressure-treated wood materials that exhibit a flame spread index of not more than 75 when tested in accordance with ASTM E84 or UL 723
(4) Plastic composite materials that comply with the requirements of ASTM D7568 and exhibit a flame spread index of not more than 75 in accordance with ASTM E84 or UL 723
(5) Limited-combustible materials in accordance with 4.6.2
(6) Wood encased in concrete such that only the top surface is exposed

Δ **6.2.8.3** Rail ties used outdoors at locations other than switch or crossover locations shall be made of one of the following types of materials:

(1) Materials that comply with 6.2.8.2
(2) Pressure-treated wood materials
(3) Plastic composite materials that comply with the requirements of ASTM D7568

6.2.9 Green Track.

6.2.9.1 The type, use, and design of green track shall be as approved.

6.2.9.2 The design of green track shall be based upon an engineering analysis of environmental factors.

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 exits where separate tracks in enclosed trainways 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 exits, 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 exit.
(7)* The provisions shall include measures to protect passengers from oncoming traffic and from other hazards.

6.3.1.7 Determination of exit and cross-passageways spacing shall be determined from the ends of contiguous sections of enclosed trainways. *(See 7.1.2.1.)*

6.3.1.8 Where cross-passageways are used in lieu of exits, the interior of the cross-passageway shall not be used for any purpose other than as an area of refuge or for access/egress to the opposite trainway except under the following conditions:

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

6.3.1.9 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.

6.3.1.10 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.

6.3.1.11 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 a path of egress 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 path of egress, 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, except at the following locations:

(1) Guards shall not be required along the trainway side of walkways where the bottom of the trainway is closed by a deck or grating.
(2) Guards shall not be required on walkways that are located between two trainways where the bottom of the trainway is closed by a deck or grating.

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6.3.3.6* Handrails for walkways shall be provided as follows:

(1) 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.
(2) Walkways that are greater than 1120 mm (44 in.) wide and located between two trainways shall not be required to have a handrail.

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

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

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

(1) Open fully when a force not exceeding 133 N (30 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

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

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

6.3.3.12 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.

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

6.3.3.14* 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) Traction power cables connecting power to the power rail or OCS shall meet the requirements of Chapter 12.

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

6.3.5.14 Emergency light fixtures and exit 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, means of egress and exits from the guideway shall serve as emergency access routes.

N **6.4.1.2*** Surface trainways having security fences, open-cut trainways, and elevated trainways shall provide access for emergency responders at intervals not exceeding 762 m (2500 ft) or as otherwise approved.

6.4.1.3 Where security fences are used along the trainway, access gates shall comply with the following:

(1) Access gates shall be placed as close as practicable to the portals to permit easy access to enclosed trainways.
(2) Access gates shall be a minimum of 1120 mm (44 in.) wide and shall be of the hinged or sliding type.
(3) Information that clearly identifies the route to and location of each gate shall be provided on the gates or adjacent thereto.

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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 Emergency Communications System. Trainways shall be provided with an emergency communications system in accordance with Chapter 10.

6.4.4 Automatic Fire Detection.

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

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

6.4.5 Standpipe and Hose Systems.

6.4.5.1* An approved, Class I fire standpipe system designed in accordance with NFPA 14 shall be provided in enclosed trainways or open trainways where physical factors prevent or impede access to the water supply or fire apparatus, except as modified herein.

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6.4.5.2 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 244 m (800 ft) apart.

6.4.5.3 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.

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

6.4.5.5 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

6.4.5.6 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.

6.4.5.7 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.

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

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

6.4.6 Portable Fire Extinguishers.

6.4.6.1 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.

6.4.6.2 Where required, portable fire extinguishers shall be selected, installed, inspected, tested, and maintained in accordance with NFPA 10.

6.4.7 Ventilation.

6.4.7.1 Except as described in 6.4.7.2 and 6.4.7.3, emergency ventilation shall be provided in enclosed trainways in accordance with Chapter 7.

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

6.4.7.3* 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 a fire hazard analysis indicates that a fire on a train in the storage track area will not impact passengers or passenger areas.

6.4.8 Emergency Power.

6.4.8.1 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*.

6.4.8.2 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

6.4.8.3 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.

6.5 Integrated Testing of Fire Protection Systems.

6.5.1 Where two or more fire protection or life safety systems are interconnected, integrated testing shall comply with NFPA 4.

6.5.2 An integrated test shall be performed prior to revenue service.

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 5.4.7 and 6.4.7.

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 enclosed 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 station
(2) In an 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 station
(2) Where the length of an enclosed 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 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 the 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 the following:

(1) A validated subway analytical simulation program that provides a quantitative analysis of airflow dynamics produced in the fire scenario, a validated computational fluid dynamics (CFD) technique, or both, as approved.
(2) 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 or nonmechanical 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).

7.2.1.2 Where the airflow rates required to accomplish 7.2.1(1), 7.2.1(2), or approved alternative performance criteria are dependent upon the continued integrity of structural and architectural features, those features shall be designed to remain intact when exposed to the conditions generated during the design incident for the duration determined as per 7.2.1(5).

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 emergency ventilation system design shall encompass the following:

(1)* Fire scenarios and fire profiles
(2) Station and trainway geometries
(3) The effects of elevation, elevation differences, ambient temperature differences, and ambient wind
(4) A system of fans, shafts, and devices for directing airflow in stations and trainways
(5) A program of predetermined emergency response procedures capable of initiating a prompt response from the operations control center in the event of a fire emergency
(6) A ventilation system reliability engineering analysis that, at a minimum, considers the following subsystems:
   (a) Electrical
   (b) Mechanical
   (c) Supervisory control
(7)* Vehicle dimensions, configuration, and interconnections

7.2.4 Criteria for the system reliability analysis in 7.2.3(6) 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
(4) The loss of a fan that results in the most adverse effect on the ventilation system performance

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* Time of Tenability.

7.2.6.1 The criteria for tenability and time of tenability for stations and trainways shall be established and approved.

7.2.6.2 For stations, the time shall be greater than the calculated egress time.

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.

Δ **7.3.2** Emergency ventilation fans, their motors, and all their related components that are exposed to the exhaust airflow shall be designed and constructed to operate at the fan inlet airflow temperature resulting from the design fire for a minimum of 1 hour.

N **7.3.2.1** Where fan-related components or portions thereof are not directly exposed to the fan inlet airflow temperature, they shall be designed and constructed to operate in the ambient atmosphere temperature resulting from the design fire for a minimum of 1 hour.

7.3.2.2 The fan inlet airflow temperature and ambient atmosphere temperature shall be determined based on the following:

(1) An engineering analysis shall be performed, though the fan inlet temperature shall not be less than 150°C (302°F).
(2) The design fire shall be used at a location in the immediate vicinity of the emergency ventilation system track/station inlet(s), as applicable.
(3)* The airflow rates shall achieve the critical velocity required for enclosed trainways or meet the station tenability requirements, as applicable.

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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, ANSI/AMCA 300, ANSI/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 fan motors, damper motors, or on motor controls 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.

Δ **7.5.1*** Equipment used for emergency ventilation (including fans, dampers, airflow control devices, and associated electrical equipment) shall be factory acceptance tested for the application with the testing procedures and testing results reviewed and accepted by the responsible design entity.

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 engineering analysis.

7.6 Emergency Ventilation Openings.

7.6.1 Emergency ventilation openings shall be positioned or designed to minimize recirculation of smoke into the station or enclosed trainway through any openings, such that a tenable environment is maintained along the path of egress for the time of tenability and as required for designated points of safety.

7.6.2 Adjacent structures and property uses also shall be considered.

N **7.6.3** Protection of belowgrade systems against the accidental intrusion of flammable and combustible liquids shall be provided in accordance with Section 4.7.

7.7 Emergency Ventilation System.

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

Δ **7.7.1.1** The operations control center shall receive verification of the proper response by emergency ventilation fan(s) and 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, distribution rooms, and rooms containing control equipment 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 engineering analysis according to 7.2.3(6), 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 emergency 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 at a 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 to the roof assembly.

N **8.3.2.2** Vehicles with onboard energy storage systems or any energy storage systems that supply power to operate the primary propulsion system for revenue service shall be designed to prevent arc penetration, ignition, and fire spread growth to the passenger and crew compartments.

8.3.3 Methods used to isolate ignition sources from combustible materials shall be demonstrated to the authority having jurisdiction to be suitable through testing and/or fire hazard 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 E662 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 E1537 using the pass/fail criteria of California Technical Bulletin 133 and testing of a complete mattress assembly (including foam and ticking) according to ASTM E1590 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 D3574, 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 D3574 shall be modified to accommodate the specified test specimen.

Δ 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 D3675≤	$I_s \leq 25$
		ASTM E662	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 E662	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, battery case material, and component boxes and covers[a,b,i–k]	ASTM E162	$I_s \leq 35$
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Thermal and acoustical insulation[a,b]	ASTM E162	$I_s \leq 25$
		ASTM E662	D_s (4.0) ≤ 100
	HVAC ducting[a,b]	ASTM E162	$I_s \leq 25$
		ASTM E662	D_s (4.0) ≤ 100
	Floor covering[b,k,l]	ASTM E648	CRF ≥ 5 kW/m^2
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Light diffusers, windows, and transparent plastic windscreens[a,b,i]	ASTM E162	$I_s \leq 100$
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Adhesives and sealants[a,b,p]	ASTM E162	$I_s \leq 35$
		ASTM E662	D_s (1.5) ≤ 100D_s (4.0) ≤ 200
Elastomers[a,b,i,j]	Window gaskets, door nosings, intercar diaphragms, seat cushion suspension diaphragms, and roof mats	ASTM C1166	Flame propagation ≤ 100 mm (4 in.)
		ASTM E662	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 E119	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.
[p]See 8.4.1.16.

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 E2061, 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 D2724.

8.4.1.8 Materials that cannot be washed or drycleaned 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.

8.4.1.10* Materials used to fabricate miscellaneous, discontinuous small parts (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) where the surface area of any individual small part is less than 100 cm^2 (16 $in.^2$) in end use configuration and that will not contribute materially to fire growth in end use configuration shall comply with either 8.4.1.10.1 or 8.4.1.10.2.

Δ **8.4.1.10.1** The materials shall be exempt from flammability and smoke emission performance requirements provided that 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.

Δ **8.4.1.10.2** The materials shall be tested in accordance with ASTM E1354 at an initial test heat flux of 50 kW/m^2 (4.4 $Btu/sec{\cdot}ft^2$) in the horizontal orientation with a retainer frame and shall meet the performance criteria of a 180-second average heat release rate not exceeding 100 kW/m^2 (8.8 $Btu/sec{\cdot}ft^2$) and a test average smoke extinction area not exceeding 500 m^2/kg (2441.2 ft^2/lb).

8.4.1.11 Carpeting used as a wall or ceiling covering shall be tested according to ASTM E162 and ASTM E662 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 The floor covering shall be tested as installed with padding, adhesives, or a combination of the two, as applicable, in accordance with NFPA 253 or ASTM E648.

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 8.5.1.

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 ASTM E119 or UL 263 test procedure shall not be required.

8.4.1.16 Testing of Adhesives and Sealants. Adhesives and sealants shall be tested in accordance with both ASTM E162 and ASTM E662 by applying the adhesive or sealant to the smooth face of 6.4 mm (¼ in.) thick inorganic, reinforced cement board, nominal density 1762 kg/m^3 ± 160 kg/m^3 (110 lb/ft^3 ± 10 lb/ft^3), using recommended (or practical) application techniques and coverage rates.

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 enclosed trainways 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.

8.5.1.2.3 The roof assembly shall be tested with a representative loading consistent with the vehicle design when the roof is in the normal operational orientation.

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

8.5.1.3 Test Details. Fire resistance testing on assemblies shall be conducted in accordance with ASTM E119 or UL 263.

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.

Δ **8.5.1.3.1.1** Unexposed side thermocouples shall be installed in accordance with ASTM E119 or UL 263.

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 E814 or UL 1479.

(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 greatest 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 and low floor vehicles, 30 minutes for all other passenger-carrying vehicles
(3) 15 minutes for roof assemblies

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.

8.5.2.1 A fire hazard analysis shall be conducted to demonstrate that fires originating outside the vehicle do not extend into either the passenger or crew areas before the vehicle is evacuated.

8.5.2.1.1 For vehicles having end frame assemblies equipped with self-closing hinged or sliding doors, floor fire testing shall be as specified in 8.5.1.3.

8.5.2.1.2 For vehicles equipped with open gangways between adjacent cars, a specimen, including the connection between the cars, shall be floor fire tested as specified in 8.5.1.3.

8.5.2.2 For vehicles equipped with open gangways, a fire hazard analysis shall be conducted to demonstrate that fires originating inside the vehicle do not extend from car to car.

8.5.2.3* For vehicles with open gangways, the design shall include features to deter both smoke and fire spread from car to car.

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 lockers and the passenger and crew areas shall be tested in accordance with ASTM E814 or UL 1479 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 duration of the exposure.

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:
Clearance (mm) = 3.175 + (0.0127 × nominal voltage)
[Clearance (in.) = 0.125 + (0.0005 × 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:
Creepage (mm) = 3.175 + (0.047625 × nominal voltage)
[Creepage (in.) = 0.125 + (0.001875 × 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.

Δ **8.6.7.1.1.1** All wires and cables shall comply with the requirements for char height less than 1.5 m (5 ft) when measured from the lower edge of the burner face, a total smoke release rate over 20 minutes that does not exceed 150 m^2 (1615 ft^2), and a peak smoke release rate that does not exceed 0.40 m^2/sec (4.3 ft^2/sec) when tested to the FT4/IEEE 1202 exposure of UL 1685.

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.

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

8.6.7.1.3* Communication and data cables shall comply with UL 444, 8.6.7.1.1, and their corresponding specifications.

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

(1) Must be capable of 15-minute circuit integrity when tested in accordance with IEC 60331-11
(2) Must have circuit integrity cable in accordance with *NFPA 70*

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

(1) Cross-section 1.23 mm^2 (16 AWG) for wire pulled through conduits or wireways or installed exposed between enclosures
(2) Cross-section 0.33 mm^2 (22 AWG) for all other 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.

Δ **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 4.6.1.
(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 Table 8.4.1.

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 PR-PS-S-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 PR-PS-S-002.

8.9 Protective Devices.

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

Δ **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 egress 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 firefighting 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 surge protection devices (SPDs) for the protection of all electrical circuits.

8.9.4.2 Lightning SPDs 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 SPDs 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 authority having jurisdiction

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) Flooding of enclosed trainways 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) Consideration of background noise levels in tunnel facilities within the system resulting from the operation of emergency systems during various types of incidents, and specific guidance for emergency responders as to what noise levels to expect
(9)* Consideration of the possibility of the need to use systems designed for a single event to address concurrent emergency events
(10) 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
(11) Procedures typically implemented by responding jurisdictions for various types of emergencies as appropriate to site configuration
(12) 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
(13) 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, designed in accordance with Section 10.2.

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

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

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 Operations Control Center (OCC) and Command Post Relationship.

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

9.10.2 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.

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

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

9.11 Training, Exercises, Drills, and Critiques.

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

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

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

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

9.11.4 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.

9.12 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.

9.13 Removing and Restoring Traction Power.

9.13.1 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.

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

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

9.13.4 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.

9.13.5 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.

9.13.6 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 Emergency Communications System

10.1* General.

10.1.1 An emergency communication system shall be provided throughout fixed guideway transit and passenger rail systems in accordance with this chapter.

10.1.2* Emergency voice/alarm communications systems (EVACS) shall be designed, installed, inspected, tested, and maintained in accordance with *NFPA 72*, except as modified herein.

10.1.3 The design of the emergency communications systems shall consider background noise levels within the system resulting from the operation of emergency systems during various types of incidents.

10.1.4 Where a mass notification system is provided, the system shall be designed, installed, inspected, tested, and maintained in accordance with *NFPA 72*, except as modified herein.

10.2 Operations Control Center (OCC).

10.2.1 An OCC shall be provided for the operation and supervision of the system.

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

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

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

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

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

10.2.7 The area shall be used for the OCC and similar activities and shall not be negatively impacted by adjoining or adjacent occupancies.

10.2.8 The OCC shall be protected by fire detection and fire suppression to provide early detection and suppression of any fire in the OCC.

10.2.9 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.

10.3 Public Safety Radio Enhancement System.

10.3.1 Stations and trainways shall be provided with a public radio enhancement system or other approved system where minimum radio signal strength for emergency responder communications cannot be maintained at a level determined by the AHJ.

10.3.2 Radio coverage shall be provided throughout enclosed stations as a percentage of floor area as specified in NFPA 1221.

10.3.3 Radio coverage shall be provided throughout enclosed trainways as a percentage of floor area as specified in this section.

10.3.3.1 Critical areas within enclosed trainways, such as exit stairs, cross-passages, standpipe hose valves, and other areas deemed critical by the authority having jurisdiction, shall be provided with 99 percent floor area radio coverage.

10.3.3.2 General areas throughout enclosed trainways shall be provided with 90 percent floor area radio coverage.

10.4* Two-Way Wired Emergency Services Communication Systems.

10.4.1 Stations and trainways shall be provided with a two-way wired emergency services communication system.

10.4.2 The system shall have a telephone network of fixed telephone lines and handsets capable of communication as required by 10.4.3.

10.4.3 Two-way wired emergency communications system telephone handsets shall be provided at the following locations:

(1) Fire command center, where provided
(2) Operations control center
(3) Traction power substations
(4) Blue light station locations
(5) Ventilation plant control rooms
(6) Ancillary rooms and spaces as determined by the authority having jurisdiction
(7) Other locations along the trainway as determined by the authority having jurisdiction

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

10.5* One-Way Emergency Communications Systems.

10.5.1 All stations shall be provided with a one-way emergency communication system. *(For communication requirements for vehicles, see 8.9.2.)*

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.

Δ **11.1.2 Application.** These systems include the following:

(1) Train control (signaling) systems as described in 7.2.5, 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 Section 9.9
(3) Traction power systems as described in 6.4.2, 7.2.5, 9.13.4, and 9.13.5
(4) Supervisory control and data acquisition (SCADA) systems as they apply to fire emergencies

11.2 Train Control.

11.2.1* A reliability engineering 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 shall apply 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 those for traction power cables shall conform to the requirements of *NFPA 70*, except as modified herein.

Δ **12.1.3** Traction power cables shall be listed and comply with the requirements of Section 12.2 and 12.3.1.

12.2 Flame Spread and Smoke Release.

Δ **12.2.1** Except as permitted in 12.2.2, all wires and cables used in stations and trainways, including traction power cables, shall comply with one of the following:

(1)* Must be listed as being resistant to the spread of fire (FT4) and as having reduced smoke emissions (ST1/LS) by exhibiting a char height of less than 1.5 m (5 ft) when measured from the lower edge of the burner face, a total smoke release rate over 20 minutes that does not exceed 150 m^2 (1615 ft^2), and a peak smoke release rate that does not exceed 0.40 m^2/sec (4.3 ft^2/sec) when tested using the FT4/IEEE 1202 flame test in either UL 1685 or UL 2556.

(2) Must be listed as having adequate fire resistance and low smoke-producing characteristics by exhibiting a flame travel distance that does not exceed 1.5 m (5 ft) and by 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.

N **12.2.2** The requirements of 12.2.1 are not applicable where wires and cables comply with one of the following:

(1)* Circuits are encased in concrete having a thickness of at least 50 mm (2 in.)

(2) Circuits are located in open stations or open trainways

12.3 Temperature, Moisture, and Grounding Requirements.

12.3.1 Wires and cables, except for optical fiber communications cables, shall comply with both of the following temperature and moisture resistance characteristics:

(1) All insulation shall be a moisture- and heat-resistant type with a temperature rating of 90°C (194°F).

(2) All wires and cables shall be listed and identified for use in 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 enclosed 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 for underground trainways or stations, except radio antennas, train control (signaling) cables, and traction power cables, shall be enclosed in their entirety in armor sheaths, conduits, or enclosed raceways, boxes, and cabinets, except in ancillary areas.

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

(1) Type MI cable with or without an overall nonmetallic covering complying with 12.4.1 and 12.4.2

(2) Type MC cable employing a smooth or corrugated impervious metal sheath with or without an overall nonmetallic covering complying with 12.4.1 and 12.4.2

(3) Conductors in electrical metallic tubing, flexible metallic tubing, intermediate metal conduit, or rigid metal conduit all without an overall nonmetallic covering

Δ **12.4.4*** Emergency power, emergency lighting, and emergency communications circuits shall be protected against physical damage caused by normal system operations.

N **12.4.5*** The circuits in 12.4.4 shall be installed in a manner to reduce the likelihood that a single fire or emergency event will lead to failure of the system by using one of or a combination of the following methods:

(1) The circuits shall consist of fire-resistive cable systems that comply with Section 12.5.

(2)* The circuits shall be encased in concrete to provide protection for 1 hour.

(3) The circuits shall be protected by a fire barrier system that complies with the requirements of UL 1724 when tested for 1 hour.

(4)* The circuits shall be redundant such that system operational capability continues.

(5) Multiple circuits shall be separated by a fire barrier with a fire resistance rating of at least 1 hour when tested in accordance with ASTM E119 or UL 263.

12.5* Fire-Resistive Cables.

12.5.1 Fire-resistive cables shall be certified or listed for no less than 1 hour of operation as tested to UL 2196 using the time-temperature curve of ASTM E119 or UL 263.

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12.5.2* The fire-resistive cable systems shall comply with all of the following:

(1) The cables shall be tested as a complete system, in both the vertical and horizontal orientation, including all the conductors, cables, splices, and raceways, as applicable.

(2) For fire-resistive cable systems intended for installation in a raceway, the systems shall be tested in the type of raceway in which they are intended to be installed.

(3) Installation instructions shall describe the assembly to be tested so that only those system components included in the test assembly are installed.

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 might be necessary.

For passenger rail systems, application of requirements in this standard should include due consideration of intent where conditions associated with such systems suggest that variations of the literal requirements are appropriate. Examples include systems where passenger platforms are not within the station building, calculation of occupant load for systems with very long headways, and provisions for fire suppression in very long tunnels in rural areas.

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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.

Δ **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 or procedures, equipment, or materials, the "authority having jurisdiction" may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The "authority having jurisdiction" may also refer to the listings or labeling practices of an organization 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 standards in a broad manner because 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. Devices that have been or could be used to minimize airflow rates in enclosed trainways include air curtains, doors, barriers (similar to life rafts with inflatable rings or collars), and gates (guillotine-type doors mounted at tunnel portals). Brattices are parachute- or curtain-like devices that have been used in mine headings to minimize airflow. Downstands and enclosures have been used to minimize airflow and smoke movement in stations.

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 equipment, should be determined based on emergency response planning for the system.

A.3.3.10 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.3.3.16 End Frame Assembly. These might include components between vehicle ends creating weathertight passageways.

A.3.3.17 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.3.3.17.1 Fire Hazard Analysis. A fire hazard analysis can often be part of, or lead into, a broader engineering 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.3.3.22.1 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.3.3.22.2 Total Fire Load. The total fire load can include vehicle(s), luggage, fuel, and wayside facilities or structures.

A.3.3.32 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,** 2021]

A.3.3.32.2 Fire Heat Release Rate. The rate of energy release can be expressed in absolute terms [in large scale fire tests or in fire modeling, typically in kW (Btu/sec)] or in relative terms, per unit area [in small scale fire tests, typically in kW/m^2 (Btu/ft^2)].

N **A.3.3.37.2 Nonsystem Occupancy.** Nonsystem occupancies include areas that might have direct pedestrian connections to the station, but that might also have access and egress that is independent of the station such that they might be occupied when the station is closed.

A.3.3.42 Point of Safety. Point of safety in this context is intended to refer to an area that will remain tenable for the time required to achieve evacuation of that area. Egress from the point of safety should be sized to permit continuous flow to the exterior of the station.

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A.3.3.56.1 Enclosed Station. This term is intended to apply to public circulation areas and to refer to configurations in which enclosing construction increases the hazard for fire spread or the potential for the effects of a fire to impact tenability in egress routes serving the area of fire origin.

A.3.3.56.2 Open Station. This term is intended to apply to public circulation areas and to refer to configurations in which dispersion to the atmosphere is without ducting, without accumulation in occupied areas, and without impacting tenability in egress routes serving the area of fire origin.

N **A.3.3.58 Stop.** A stop might include a covered shelter within the platform area that has no other associated rooms or spaces.

A.3.3.63.1 Enclosed Trainway. This term is intended to refer to configurations in which enclosing construction increases the hazard for fire spread or the potential for the effects of a fire to impact tenability beyond the area of fire origin.

A.3.3.63.2 Open Trainway. This term is intended to refer to configurations in which dispersion to the atmosphere is without ducting, without accumulation in occupied areas, and without impacting tenability beyond area of fire origin.

N **A.4.1.2** Reference codes and standards (such as the *International Building Code*, NFPA 92, and *NFPA 72*) might require the use of listed fire alarm control units (UL 864) if other subsystem equipment (such as emergency ventilation, traction power, rail vehicle movement, and communication systems) is used as part of the emergency response. It might not be possible to provide listed fire alarm equipment for these systems, which could impair their functionality and performance. Integrated functions are commonly beyond the capability of a fire alarm system (FAS). It's common in rail-based transit systems for the control of each subsystem to be separate and for the necessary interfaces to be provided to perform integrated emergency operations and functions.

Rail-based transit systems commonly utilize a supervisory control and data acquisition (SCADA) system or another similar system to monitor and control transit facilities, operations, and functional subsystems that form part of their safe operating environment. Fire alarm control units (FACU) should interface with the SCADA system for event detection, alarm initiation, and supervisory messages. The number of data points exported from an FACU to a SCADA system should be sufficient to enable the user of the SCADA system to determine the condition of the fire alarm system (FAS), the occurrence of an event, the extent of the event, and the successful initiation of alarms and event response where automated.

For passenger stations, unstaffed technical rooms (whether at the station or remote), and structures within tunnels, event detection and any local response to an event should be initiated by an FACU. The FACU should, in turn, communicate with the SCADA and any central FAS monitoring location that might be used by or within the transit system.

Functional safety should be assessed using standards for life safety control systems, such as IEC 61508, MIL-STD 882E, or EN 50126. Where IEC 61508 is utilized, it is common to use a minimum safety integrity level (SIL) of 2 for the safety functions. When an integrated solution is utilized, it is commonplace for it to be used to conduct many functions across the railway. An assessment should first be performed to determine which functions are safety functions and the required level of integrity of those functions.

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, enclosed trainways, 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, enclosed trainways, 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 an engineering analysis as permitted by Section 1.4 and in accordance with good fire protection engineering practice.

A.4.4.1 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.4.4.2 The location and size of a fire can greatly affect the degree of hazard to system occupants. Therefore, specific fire scenarios that could occur must be considered for a system design, such as the following:

(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., enclosed 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.4.5 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 enclosed 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 provisions of Section 4.6 do not require inherently noncombustible materials to be tested in order to be classified as noncombustible materials.

A.4.6.1 Examples of such materials include steel, concrete, masonry, and glass.

N **A.4.7.1** All surface terminations of entrances and other shafts serving belowgrade system elements that are exposed to potential flammable and combustible fluids intrusion should be evaluated for the applicable protections.

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.

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N **A.5.1.1.1** For stations serving passenger rail systems, refer also to the second paragraph in A.1.1.1. The factors for consideration include but are not limited to the following:

(1) Occupant load inputs (e.g., nonapplication of surge and service delay factors) for systems having very long headways
(2) Means of egress configuration (e.g., travel distances and number and location of egress routes) for very long platforms that would permit passengers to move away from the fire location
(3) Platform and station clearance times
(4) Communication and fire alarm systems
(5) Provisions for fire protection systems (e.g., fire hydrant or standpipe coverage)
(6) Station configurations where the application of this chapter should be limited to the platform areas

N **A.5.1.1.2(1)** This refers to configurations where the available path of pedestrian flow to and from the platform area is constrained by obstacles such as walls, barriers, elevation changes, or traffic lanes.

A.5.2.1.4 See A.6.3.5.9.

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 5.3.3.6 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 This section refers to rooms or enclosures used by system personnel to dispense information and tickets to passengers. The anticipated maximum size for such units is 18.6 m^2 (200 ft^2). Where such booths are not fire-separated from public areas in accordance with the provisions of this section, they should be considered part of the public area for the purposes of the fire separation required by 5.2.4.2 between public and nonpublic areas and 5.2.4.5 between public areas and nonsystem occupancies. The restrictions for booth sizes are related to the possible fuel loads of these spaces and practices that are currently in place restricting the sizes of these spaces.

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.

N **A.5.2.6.4** Approved coverings for ceiling spray foam insulation include the following:

(1) Gypsum board at least 12.7 mm (½ in.) thick
(2) Cement-based millboard at least 6.4 mm (¼ in.) thick
(3) Batts or blankets of mineral wool or mineral fiber installed so as to remain in place

A.5.2.7.1 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.5.2.7.2 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·sec) when tested in accordance with ASTM E1354 at an incident heat flux of 50 kW/m^2 (4.4 Btu/ft^2·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.

N **A.5.3.1.3(1)** This refers to design requirements such as rise and run, handrails, and guards. Where passenger movement to and from a stop is unrestricted, the calculations of the occupant load and required egress capacity are not applicable.

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 Stations might service areas near civic centers, sports complexes, malls, excursion destinations, gathering places, and convention centers, which could impose a large influx of system passengers outside of the a.m. or p.m. peak periods.

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 paths of egress converge. Nonincident platform loads that do not adversely impact the egress route need not be considered.

Δ **A.5.3.2.5** Refer to A.5.3.2.1 regarding peak period ridership.

The NFPA 130 requirements for calculating platform occupant load were developed to estimate the maximum number of passengers that might need to be evacuated in the event of a train fire emergency. The methodology replaces calculations based on floor area and assumed occupant density with calculations based on ridership and train operations.

The determination of the of maximum occupant load on a platform requires the 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 should be performed based on both the a.m. and p.m. peak ridership for each platform and then compared to determine the maximum platform occupant load to be used to determine the required emergency egress capacity.

A.5.3.2.5(2) It is important that the occupant load calculations capture the potential buildup of passengers that might occur before an emergency event is recognized as requiring evacuation. In 5.3.2.5(2) and 5.3.2.5(4), the headway interval is generally used as the accumulation factor to account for that buildup, with a doubled headway in the incident direction applied to account for a potential service disruption coincident with the emergency requiring evacuation. The incident track is the headway that results in the highest platform occupant load when the missed headway factor is applied. Determination of the entraining load per headway should account for the surge factor described in A.5.3.2.1.

For passenger rail systems with longer headways, a factor of two headways might be inappropriate. For systems with very short headways, a fixed time interval might be more suitable for the approximate potential passenger buildup.

Variation of the accumulation factor could be considered based on system-specific characteristics such as the following:

(1) The type of system (e.g., automated/driverless vs. manually driven, fixed guideway transit vs. passenger rail)
(2) The amount and type of surveillance
(3) The distance between stations
(4) Train headways
(5) Service demand operational characteristics

For the purposes of calculating the simultaneous occupant loads of center platforms, the service disruption factor should be applied only to the direction of the train headway that results in the highest platform occupant load during the peak periods. For side platform stations, it is necessary to evaluate each platform separately to determine the maximum platform occupant load. However, for simultaneous station evacuation, the principles for center platforms apply — i.e., the simultaneous peak/off-peak loads that yield the highest value should be used.

For terminus stations, where the incoming train is also the train that will load in the outbound direction, an inbound service disruption (link load) could result in additional accumulation of the outbound entraining load. Other operational strategies to consider at terminus stations include alternating train arrivals at different platforms.

For all of the above, the calculation results should be evaluated to confirm that the values do not exceed the system service capacity.

A.5.3.2.5(3) This criteria recognizes that, while entraining passengers for a non-incident service might cause accumulation on the platform prior to the arrival of the incident train, the same is not true for passengers on board trains for non-incident service.

Δ **A.5.3.2.5(4)** Explanatory notes for entraining load calculations are equally applicable for trainload calculations. *[See A.5.3.2.5(2).]*

A.5.3.3 The 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, considering only the occupant load calculated in accordance with 5.3.2.5 against the egress capacities and travel speeds stipulated in 5.3.4 and 5.3.5. It is not intended that this calculation be required to account for factors that would be considered in engineering analysis such as delays due to premovement time, products of combustion or debris along an egress route, or the movement of those who are unable to achieve self-evacuation.

A.5.3.3.2 See A.5.3.3.1.

A.5.3.3.3 The use of point of safety in this context is intended to imply that the design of the station egress routes permits continued egress from the concourse to the exterior of the station.

Δ **A.5.3.3.5** The term *common path of travel* in this context is intended to refer to a dead-end condition on a platform(i.e., the length of the platform having egress in only one direction). The determination of a common path of travel from each end of a platform should consider the configuration (e.g., the width and enclosure) of the platform versus the anticipated exposure to a train fire at the platform. Where the platform is sufficiently wide to allow passengers to move away from potential exposure to the effects of a train fire, it is reasonable to consider egress from that platform as not creating a common path of travel.

A.5.3.3.6(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.5.3.3.7 Where automated spreadsheet calculations or computer-based software programs are used, the 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 for means of egress. NFPA 130 addresses conditions unique to transit/passenger rail facilities such as open platform edges. In NFPA *101*, the capacity of means of egress facilities is 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:

[A.5.3.4.1a]

$$1120 \text{ mm} - 455 \text{ mm (platform edge)} - 305 \text{ mm (sidewall)} = 355 \text{ mm}$$
$$[44 \text{ in.} - 18 \text{ in. (platform edge)} - 12 \text{ in. (sidewall)} = 14 \text{ in.}]$$

The egress capacity afforded by the effective 355 mm (14 in.) wide platform is:

[A.5.3.4.1b]

$$355 \text{ mm} \times 0.819 \text{ p/mm-min} = 29 \text{ p/min}$$
$$(14 \text{ in.} \times 2.08 \text{ p/in.-min} = 29 \text{ p/min})$$

An effective 1120 mm (44 in.) wide corridor yields:

[A.5.3.4.1c]

$$1120 \text{ mm} \times 0.0819 \text{ p/mm-min} = 91 \text{ p/min}$$
$$(44 \text{ in.} \times 2.08 \text{ p/in.-min} = 91 \text{ p/min})$$

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.5.3.5.3 For escalators, contribution to the egress capacity can be calculated based on one of the following:

(1) The width used to calculate the capacity of stopped escalators should be based on the tread width plus the width permitted for intrusion of handrails per NFPA *101* — for a 1000 mm (40 in.) tread width, the width used to determine egress capacity will be 1228 mm (48 in.).
(2) Where escalators having a nominal width of 1000 mm (40 in.) will be dedicated for operation in the direction of egress 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).

For upward movement on stairs, designers are encouraged to research the latest available data, such as publications from the Conference in Pedestrian and Evacuation Dynamics 2014. 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.

N **A.5.3.5.5(3)** Center platforms might use a single exit.

A.5.3.5.6 Where multiple escalators are provided in the means of egress, the egress capacity 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 an engineering analysis.

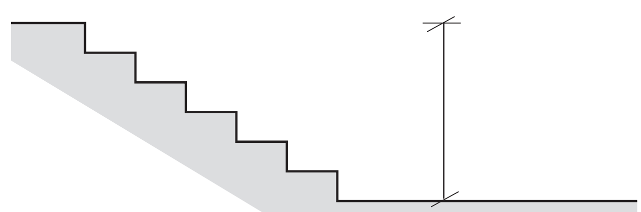


FIGURE A.5.3.5.3(2) Distance Measure for Walk Time Computation.

A.5.3.5.7(4) Where required by accessibility regulations, visible message signs should be provided and designed to give prewarning in accordance with the principles of this section.

N **A.5.3.6.1** The use of elevators in the means of egress as permitted herein is not explicitly intended to address the requirements for accessible means of egress as might be required by the relevant statute. Alternative measures for the provision of accessible means of egress are described in 7.5.4 of NFPA *101*.

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 an unobstructed width when the multi-leaf doors and gates are in the open position. 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 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.

It is recognized that arrangements might exist in which the entire occupant load must exit through what would be considered a single building. In such cases, appropriate fire and smoke separation should be provided so as to maintain remoteness of the horizontal exits.

A.5.3.10 Tactile and visual warning should be provided along the trainway side of platforms except where such edges are protected by platform edge screens or doors.

A.5.4.1 Where an enclosed station is part of another building complex, consideration should be given to creating a combined fire command center.

N **A.5.4.1.1** The ventilation systems at adjacent trainways and stations are permitted to be omitted from the controls.

N **A.5.4.1.2** This section anticipates that a fire command center might be appropriate for larger and more complicated enclosed stations. Where an enclosed station is part of another building complex, consideration should be given to creating a combined fire command center.

N **A.5.4.2.1** The intent is to provide detection, notification, and warning when a coordinated response is required to facilitate evacuation. Alternative methods and means that meet this functional requirement are not precluded but should be demonstrated via the equivalency provisions of this standard.

See Figure A.5.4.2.1.

N **A.5.4.2.2** The location of the annunciator should be coordinated with emergency response personnel. The location should not obstruct emergency egress flow, should avoid emergency ventilation system airflow, and should be coordinated with other emergency system control panels, such as emergency ventilation. Annunciator panels that have the ability to reset alarms are available and can help reduce delays associated with resetting the fire alarm control panel where stations might be unmanned or there is limited access to secure areas. The use of such panels should be decided upon based on operational protocols and the responding authority's needs.

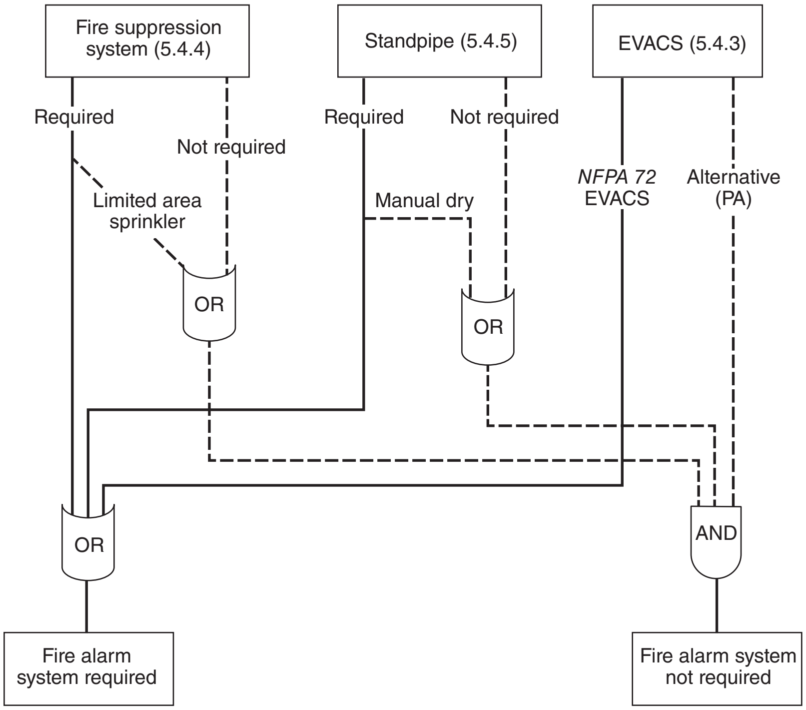
N **A.5.4.2.3(1)** Activation from the station might be from the annunciator location, fire alarm control unit, or another location accessible to system personnel or emergency responders as appropriate for the system based on its emergency response protocols.

Δ **A.5.4.2.4** Discrete zone indications are desirable.

The location(s) for annunciation should be coordinated with emergency response personnel. The location(s) should not obstruct emergency egress flows, should avoid emergency ventilation system airflows, and should be coordinated with other emergency system control panels, such as emergency ventilation. Annunciator panels that have the ability to reset alarms are available and can help reduce the delays associated with resetting the FACP where stations might be unmanned or there is limited access to secure areas. The use of such panels should be considered based on operational protocols and the responding authority's needs.

N **A.5.4.2.5** Where a supervising station alarm system is provided, the alarm signal should also be transmitted to the supervising station unless the operations control center is designated as such. The intent of this requirement is to include all types of signals, including supervisory, trouble, and alarm signals. *(See also Chapter 10.)*

A.5.4.4.1 Public circulation areas, as addressed in 5.4.4.1, include concourses (mezzanines), platforms, and stairs and escalators as described in 5.2.4.1 and 5.3.5. Sprinkler protection is not required in areas used for public circulation in consideration of other methods of fire protection in those



N **FIGURE A.5.4.2.1 Conditions for Fire Alarm System Requirements**

areas, including limitations on the permitted types of construction (5.2.2), limitations on the permitted types of interior finishes and furnishings (5.2.5, 5.2.6, and 5.2.7), and requirements for fire separation of other occupancies from circulation areas (5.2.4), as well as the requirement that other areas be equipped with automatic fire suppression (5.4.4.1). For trainways, protection in the event of a train fire in an enclosed station is provided by the requirements for an emergency ventilation system (Chapter 7). Refer also to A.4.2.1 regarding the potential for reconsideration of these requirements where sprinkler protection in addition to that specified in 5.4.4.1 is provided.

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.

Δ **A.5.4.5.1** The authority having jurisdiction might require additional 65 mm (2 ½ in.) hose connections to be equipped with 65 mm × 40 mm (2 ½ × 1 ½ in.) reducers.

A.5.4.5.5 This requirement is intended to clarify that, with the approval of the local fire department, dry-type systems can be considered for stations regardless of the potential for freezing.

A.5.4.5.5(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 6.4.7.2 for applicable ventilation requirements.

A.6.1.2.1 This requirement refers to the design of both designated and potential points of entry to the trainway at stations and elsewhere along the guideway as well as system vehicles.

A.6.1.2.2 Evacuation should take place only under the guidance and control of authorized, trained system employees or other authorized personnel as warranted under an emergency situation. Where authorized personnel might not be physically present during the evacuation (such as for fully automated trains), other means to provide guidance that should be considered include passive and active signage and voice communication. In all cases, prior to evacuation, train movements in the vicinity should be halted and traction power between the train and the point of exit from the trainway should be de-energized.

Δ **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.6.2.2.1 For enclosed trainways, exposure to prolonged fires leads to heavy damage or collapse, resulting in service disruptions, and most important, loss of lives (Bothe, Wolinski, and Breunese 2003; Khoury 2002; and Tatnall 2002). Structural concrete or shotcrete liners can be designed to meet an appropriate fire-resistance rating while accepting some minor repairable damage. Prompt operation of an emergency ventilation system can also 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.

N **A.6.2.5.2** The fire hazard analysis should include an examination of the peak heat release rates of combustible elements, the total heat released, ignition temperatures, radiant heating view factors, and the behavior of the components during internal or external fire scenarios.

A.6.3.1.1 The trainway and the vehicle means of egress should be designed to be compatible. *(See Chapter 8.)*

Δ **A.6.3.1.4** See also A.6.3.1.6(2).

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 more than the prescribed 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.

The distance between exits can be modified where supported by an engineering analysis that considers the following factors:

(1) Probability of a design fire event
(2) Probability of a train evacuation being conducted other than at a point of safety
(3) Probability that another compartment in the train is a point of safety for the design fire event
(4) Fire growth rate during the evacuation phase of the design fire event
(5) Maximum expected fire load during the evacuation phase of the design fire event
(6) Expected fire resistance characteristics of the rolling stock
(7) Maximum time necessary to evacuate the train after immobilization of the train
(8) Maximum time necessary for all passengers to reach the nearest station or point of safety
(9) Ability of the tunnel vent system to provide a tenable environment along the path to the nearest station or other point of safety
(10) Firefighter response capabilities (e.g., SCBA limitations) and incident response procedures as determined through consultation with the responding fire service prior to final design

The special safety risks of the collapse of cross-passages and exit shafts during construction might justify varying the exact location of these points of safety as long as equivalency of performance at the revised locations is demonstrated.

Other factors considered relevant can be included in this analysis.

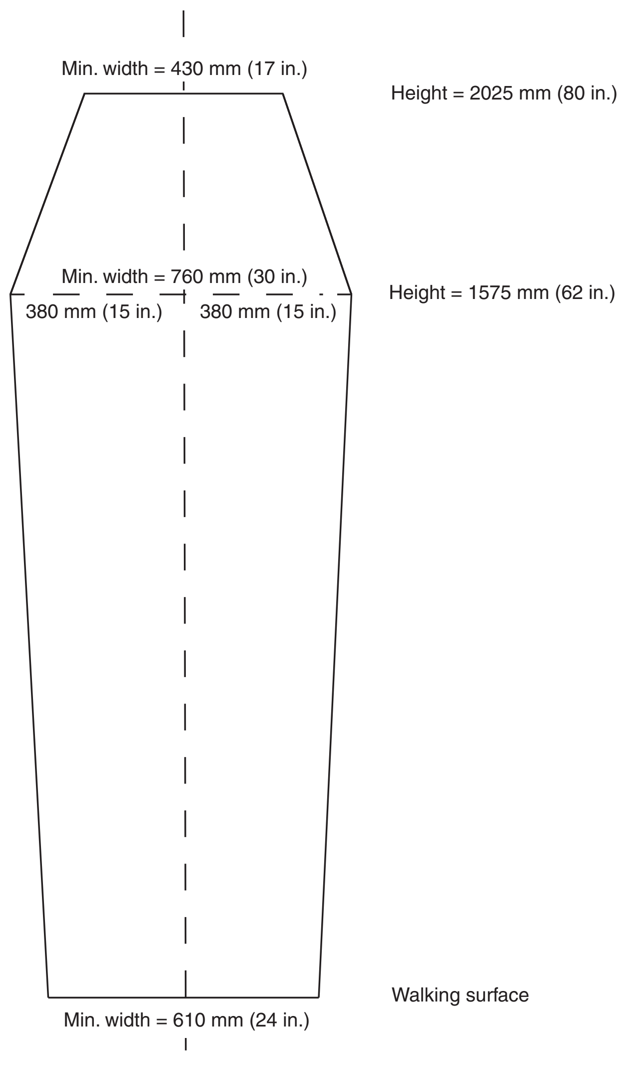
A.6.3.1.6 See also A.6.3.1.4 regarding the use of an engineering analysis to support increases in the prescribed distance between cross-passages used as exits.

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 change gradually and symmetrically 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 evacua-



Δ **FIGURE A.6.3.2.1 Unobstructed Clear Width for Trainway Walkway.**

tion flow from an enclosed trainway 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 egress doorways, including those for cross-passages.

A.6.3.3 The egress provided should recognize that for multiple-track enclosed trainways, there exists the possibility of having to simultaneously evacuate the incident train and a nonincident train(s) stranded on the adjacent track(s).

Δ **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 egress from the train onto the walkway. For that reason, guards are not required on the trainway side of walkways, provided that the bottom of the trainway is closed by a deck or grating so that persons cannot fall through the bottom of the guideway. Small gaps in the continuity of the guards located on the sides of walkways opposite the trainway — as might be required for expansion joints — might be considered acceptable provided the gaps do not exceed the dimensions permitted for openings in guards by the locally applicable building code.

Δ **A.6.3.3.6** Handrails along horizontal walkways are intended for guidance and support and should, therefore, be continuous to the extent practicable, but gaps to facilitate access to emergency equipment and egress doors could be acceptable. 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 walkways. Likewise, walkways located between trainways are not required to have handrails, provided they are a minimum of 1120 mm (44 in.) wide.

A.6.3.3.14 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.

N **A.6.4.1.2** Trainway access can include any combination of the following:

(1) Fixed facilities, including stations, dedicated access stairs, walking paths, access doors, or gates.
(2) Use of mobile equipment, such as handheld and aerial ladders from adjacent or dedicated roads.

The access requirement facilitates the need for responding agencies to reach an emergency at any point along a system while allowing for increased distances where system limitations preclude direct compliance. Practical considerations that warrant increased access distance include river crossings or other geographical, topographical, or logistical constraints. When increasing the distance between access points, the logistics of an emergency response should be considered, such as emergency responder travel distance, displacement of emergency equipment while responding to emergencies, availability of water supply, the system's operational response methods and procedures, and the potential for inclement weather relative to different types of emergencies. In some instances, a reduction in access spacing might be appropriate based on the authority having jurisdiction’s operating protocols, response capabilities, and resources.

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.6.4.5.1 The authority having jurisdiction might additionally require 65 mm (2 ½ in.) hose connections to be equipped with a 65 mm × 40 mm (2 ½ in. × 1 ½ in.) reducer.

Securing the isolation valves in the open position with a chain and padlock could be acceptable in lieu of fire alarm monitoring.

A.6.4.5.3(1) Calculations, including transit and fill times, should be submitted to the authority having jurisdiction to support this requirement.

A.6.4.7.2 The intent of the standard is to provide a reasonable level of life safety for occupants. However, the fire risk faced in nonpassenger areas where trains are merely stored or cleaned is significantly different from that in passenger areas. (Paragraphs 6.4.7.2 and 6.4.7.3 do not apply to maintenance and yard 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 6.4.7.2 and 6.4.7.3 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 a fire hazard analysis shows that a fire in these areas will not impact areas occupied by passengers.

A.6.4.7.3 See A.6.4.7.2.

A.7.1 Annex B provides additional guidance relating to design of the emergency ventilation system.

A.7.1.1 Separate ventilation systems for enclosed trainways and 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.7.1.2.1 Segments should be considered contiguous where an opening at the top is less than 15 m (50 ft) in length. An engineering analysis to determine the aerodynamic coupling between the segments should be performed where the segments are separated by an opening less than the full width of the segment or are between 15 m (50 ft) and 100 m (328 ft) in length. For segments to be considered separate, the engineering analysis should confirm that the separation between segments is adequate to prevent migration of smoke into the adjacent segment.

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 authority having jurisdiction 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 engineering 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 enclosed trainways 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.7.2.1(5) This is an equipment exposure duration requirement, not a tenability requirement. Emergency ventilation fans, their motors, and all related components should be designed to remain operational for a minimum of 1 hour. If the required time of tenability exceeds 1 hour, then the emergency ventilation system should remain operational for that longer period of time. *(See 7.2.1.1.)*

Δ **A.7.2.3(1)** Annex E presents background and approaches to the development of fire scenarios and fire profiles.

N **A.7.2.3(7)** The development of NFPA 130 was based on the compartmentation provided by individual vehicles within a train, which is not inherent to the open gangway configuration.

Compartmentation serves to limit internal smoke and fire spread along the train.

Open gangway configurations also introduce the following risks:

(1) Increased design fire heat release rate due to fire extension from car to car
(2) Additional smoke migration through the interconnected cars
(3) Passenger movement between compartments during egress

The effectiveness and integration of open gangway and vehicle mitigations with systems designed based on other chapters should be included in the engineering analyses.

Where additional measures are needed to address onboard fire and smoke spread, examples of mitigation strategies might include deployable doors or fire shutters, onboard fire suppression, vehicle HVAC control, or other methods alone or in combination.

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 with the train operation plans and emergency response plans with respect to how the trains will be operated and how the designed systems will be used during emergency 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 available time of tenability should consider the possibility of one or more egress paths being blocked by fire or smoke (as can be demonstrated by engineering analysis) and for other considerations that are not accounted for in the egress capacity calculations. *(See B.3 for additional information to be considered.)*

A.7.3.2.2(3) The airflow rates necessary to meet the tenability requirements will most likely be from location(s) that are different from the location for the fan inlet and ambient atmosphere temperature analysis.

N **A.7.4.2** For factory-mounted damper wiring, see A.12.5.

Δ **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; the Institute of Electrical and Electronics Engineers; and UL (formerly Underwriters Laboratories). If an appropriate standard does not exist, then a test procedure should be submitted for approval.
(2) Review and acceptance of testing procedures and results are generally performed by the responsible design entity and can include input from the authority or AHJ. The testing procedures and pass-fail criteria should demonstrate that the equipment meets the design objectives.
(3) Testing of emergency ventilation equipment should be performed to meet reviewed and accepted test criteria and procedures established in advance and should be witnessed by the responsible design entity.
(4) Tests can consist of prototype testing or production testing. Prototype testing should include those tests necessary to ensure that the design of the equipment is acceptable, such as tests for the 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 authority having jurisdiction for review and approval prior to the commissioning tests. The test plan should describe the method of testing and identify pass-fail criteria. At 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. At 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 enclosed trainway airflows provided by the built mechanical ventilation system should be measured to confirm that the airflows meet the requirements determined by the engineering analysis.
(5) The systemwide tests should be witnessed by the owner, the authority having jurisdiction, 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 ASHRAE, the International Organization for Standardization (ISO), 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 engineering 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 enclosed trainway 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 enclosed trainway as per the scenario, and enclosed trainway 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 sections of enclosed trainways 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 engineering 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.

N **A.7.7.1** See A.4.1.2.

Δ **A.8.2** Federal Railroad Administration (FRA) requirements for passenger railcar and locomotive cab fire safety are contained in 49 CFR 238.

The requirements of 49 CFR 238, Section 103 state that interior materials must be tested and meet certain flammability and smoke criteria and that floor fire resistance must also be tested. In addition, the requirements contain detailed fire hazard 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 hazard analysis requirements include the use of a formal safety methodology and written documentation of the analysis. In addition, vehicle design and material selection are required to consider potential ignition sources; the type, quantity, and location of materials; and the rapid and safe egress to the equipment exterior under conditions secure from fire, smoke, and other hazards. The ventilation system cannot contribute to the lethality of a fire. Passenger railroads also need to determine the extent to which overheat detection and fire suppression systems must be used 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 included and are intended to protect fuel tanks against crushing and puncture in a collision or derailment. Requirements for passenger car electrical systems are included, as well, and require that conductor sizes be selected on the basis of current carrying capacity, temperature, and other characteristics, and power dissipation resistors be adequately ventilated and electrically insulated to prevent overheating. The requirements also state that the resistors and main battery system should 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 railcar and locomotive crashworthiness, as well as emergency egress and emergency responder access features. Annex E provides guidance relative to the fire hazard assessments referenced in Section 8.3 through Section 8.10.

A.8.3.1 Onboard energized electrical equipment not subject to regulation in other sections of this standard should be subject to a fire hazard analysis. Where such equipment is listed and/or labeled by a certified listing agency, conditions of that listing should be reviewed in conducting the fire hazard analysis to determine the degree to which further analyses of the fire performance of such equipment should be conducted and approved.

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 D3675 and ASTM E162 tests is the radiant panel index (or I_s).

A.8.4.1.1 ASTM E162 is not suitable for materials that exhibit flaming running or flaming dripping because the test apparatus is not designed to accommodate this kind of burning behavior. ASTM E162 states that, if during a test of one or more of the test specimens, materials exhibit rapid running or dripping of flaming material due to melting and the steep inclination of the specimen, these occurrences are to be noted within the test report and no radiant panel index is to be reported for that test. 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 E1537 [for upholstered furniture, 19 kW (65 KBtu/hr) exposure] and ASTM E1590 [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 E1537 or ASTM E1590 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 (171 KBtu/hr) 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 E1537 or ASTM E1590. If the ignition source used for a test method is inadequate, the result can be misleading, for example, if the upholstery materials melt or drip and, thus, avoid full exposure to the ignition source. It has been shown that, in some such cases, 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 E1537 and ASTM E1590, respectively.

N **A.8.4.1.10** Clusters of individual discontinuous small parts should be evaluated based on the total weight and volume of the grouping.

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 E2061 and APTA PR-PS-RP-005-00 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 fire hazard 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.

N **A.8.5.2.3** See A.7.2.3(7).

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.

N **A.8.6.7.1.2** This paragraph does not apply to communication and Ethernet cables including but not limited to CAT 5, CAT 5E, CAT 6, CAT 6A, CAT 7, MVB, WTB, CANBUS, and RS-485. Communication and Ethernet cables use thin insulation and jackets that do not comply with the thickness and performance requirements of the standards listed in 8.6.7.1.2. In addition, some communication cables use foam insulation, which is not addressed by the referenced standards.

A.8.6.7.1.3 The electrical properties of data and communication cables should comply with the requirements for the applicable cable category or with the applicable local electrical requirements. Different system authorities specify data and communication cables that have specific electrical requirements other than voltage. Some examples of designations for cables potentially used in rail transportation vehicles include CAT 5, CAT 5E, CAT 6, CAT 6A, CAT 7, MVB, WTB, CANBUS, and RS-485.

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), US 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 PR-E-S-013-99 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 PR-E-S-013-99, 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 window exits 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 2500.

A.9.4 Enclosed trainways 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 enclosed trainway.

A.9.4(9) Although the design for protection measures assumes a single event, it is possible a second event could occur within the system. The operator(s) should have guidance for emergency procedures using the systems designed for a single event in the case of additional concurrent events, based upon a risk assessment.

A.9.5 The agencies and their names might vary depending on the governmental structure and laws of the community.

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.

N **A.10.1.2** See A.4.2.1.

A.10.4 Two-way emergency communications systems are divided into two categories: those systems that are anticipated to be used by building occupants and those systems that are to be used by firefighters, police, and other emergency services personnel. Two-way emergency communications systems are used both to exchange information and to communicate information such as, but not limited to, instructions, acknowledgement of receipt of messages, condition of local environment, and condition of persons, and to give assurance that help is on the way.

A.10.5 One-way emergency communications systems are intended to broadcast information, in an emergency, to people in one or more specified indoor or outdoor areas. It is intended that emergency messages be conveyed either by audible, visible, or textual means, or any combination thereof.

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.12.2.1(1) Testing the same test specimen provides char length and smoke measurement information.

N **A.12.2.2(1)** The term *circuits* is intended to include the wires, cables, and insulated conductors that are routed through a raceway that is encased in concrete.

A.12.4.2 Radio antenna cables are commonly called leaky coax, leaky feeder, radiating cable, or radio emitting cables. It is acceptable to install train control (signal) cables on a messenger when approved by the AHJ and in accordance with local installation practices.

N **A.12.4.4** The intent of this requirement is to provide physical protection of the circuits from incidental damage, such as the scrubbing effects of the ventilation system.

N **A.12.4.5** Where connections of the main feeds are configured such that the loss of a device or a cable connecting the device does not result in failure of the main feed, that connection might not require protection. However, consideration of the appropriate protection of the circuit connection to the main feed is necessary to prevent failure.

N **A.12.4.5(2)** Further information on concrete encasement can be found in the 2018 Fire Protection Research Foundation Report, *Fire Resistance of Concrete for Electrical Conductors*.

N **A.12.4.5(4)** See Figure A.12.4.5(4).

N **A.12.5** The intent of the fire-resistive cable testing requirements are to ensure continued operation for at least 1 hour of the emergency ventilation system, including its fans, dampers, power supply, and controls that are exposed to the design fire and elevated temperatures. The factory-mounted cables between actuators, position switches, and the single point connection junction box factory-mounted on the damper might not need to comply with UL 2196. The required ratings for factory-mounted, on-damper cables and field-mounted, off-damper cables should be based on the project-specific ventilation design, resulting temperature exposures, and need for continued damper operation during a fire response.

Δ **A.12.5.2** 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 sheath/armor *(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 the raceway, the raceway support, the 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 installed. 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.

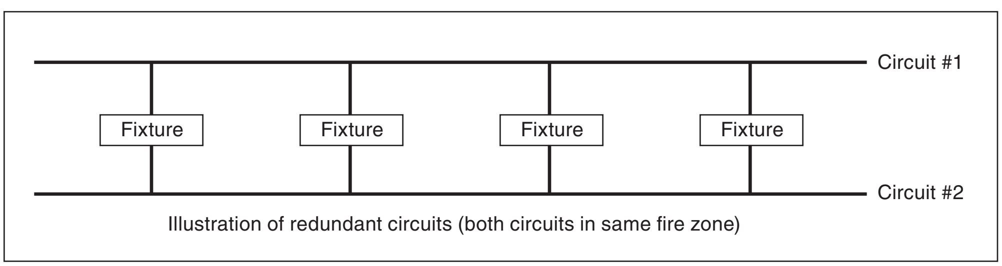
Annex B Emergency Ventilation and Fire Risk

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 guidance relative to evaluation of fire risk and assessment of emergency ventilation system performance. This annex does not present all factors that might need to be considered in an emergency ventilation system analysis.

B.2 Emergency Ventilation.

B.2.1 Station Emergency Ventilation. The fundamental objective of an emergency ventilation system for stations is to provide a tenable environment along the path of egress for the time of tenability.



Sketch A
A diagrammatic representation of redundant circuits serving each light fixture such that each fixture is provided with two sources of power.

N **FIGURE A.12.4.5(4) Redundant Circuits Serving Each Light Fixture.**

A baseline egress requirement was established that station egress elements be designed to achieve evacuation of the platform occupant load within 4 minutes. Documents recording the development of the standard indicate that the original intent was for the 4-minute platform clearance test to provide egress capacity for evacuating occupants away from potential exposure to a train fire. The evacuation time can be modified based on an engineering analysis as stated in 5.3.3.7.

The stipulated time is intended as a baseline for determining the required minimum egress capacity of egress elements and maximum travel distances for platform egress routes, considering only the platform occupant load against the egress capacities and travel speeds. This calculation does not take into account delays due to the presence of products of combustion or debris along an egress route or delays due to the movement of those who are unable to self-rescue.

In coordinating the baseline egress requirement with the tenability requirements, the intent is for tenability to be evaluated along the path of egress to a point of safety. This applies to the time of tenability, even if the egress capacity complies with the required 4-minute and 6-minute clearance time tests. The tenability evaluation is also for the purposes of confirming that a tenable environment is provided for the time of tenability if one or more paths of egress were blocked by fire or smoke and for other considerations that are not accounted for in the egress capacity calculations.

Several references [1], [2] provide an overview of typical ventilation concepts for station emergency ventilation. Tenability in stations is often predicted by use of computational fluid dynamics (CFD) programs. The design fire profile is one of many inputs to the CFD programs, which predict temperatures, visibilities, and carbon monoxide concentrations as a function of many parameters, including the three-dimensional location in the station and the time since the initiation of the fire. Any combustible materials that could contribute to the fire load at the incident site should be evaluated. Smoke migration results should be reviewed with the egress movement to confirm whether a tenable environment is available for evacuation.

B.2.2 Enclosed Trainway Emergency Ventilation. Provisions for smoke control in enclosed trainways relate to train fires and other design fire scenarios, which might include third rail and other wayside electrical fires.

The fundamental objectives of an emergency ventilation system for enclosed trainways are typically to provide sufficient airflow rates to control or limit smoke backlayering, and to maintain a tenable environment along the path of egress for the time of tenability, or both.

Several references [1], [2] provide an overview of typical ventilation concepts for enclosed trainway emergency ventilation. Critical velocity is the criterion for determining the required enclosed trainway airflow for longitudinal ventilation approaches, and hence, the ventilation system fan capacities required for ventilation responses to enclosed trainway fire incidents. Air velocity in enclosed trainways is usually predicted by use of the Subway Environment Simulation (SES) program [1]. The peak fire heat release rate is a primary fire input to the SES program, which simulates aerodynamic and thermodynamic behavior to predict whether air velocity resulting from a particular ventilation response and system geometry would meet the critical velocity.

B.3 Tenable Environments. This section describes factors often used in assessing tenable environments in an enclosed station or enclosed trainway. These factors should be considered as guidelines to be applied after due consideration of the parameters in Annex B.

B.3.1 Tenability Criteria Considerations. Table B.3.1 outlines commonly applied tenability criteria considerations, which are discussed in further detail in B.3.2 through B.3.5. Methods for establishing tenability criteria and estimating the accumulated heat effects and smoke toxicity using additive Fractional effective dose (FED) can be found in reference [3].

Some factors that should be considered in maintaining a tenable environment for periods of short duration are defined in B.3.2 through B.3.6.

B.3.2 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). This visibility guideline is applied to the location where occupants need the wayfinding capacity to evacuate.

The required wayfinding capacity is not as critical as the survivability criteria based on heat effects or smoke toxicity in circumstances such as occupants queuing at the base of vertical circulation elements or evacuating along egress walkways in enclosed trainways. In these circumstances, smoke obscuration could be maintained at a reduced level, to the point at which an exit sign is discernible at no less than 10 m (33 ft) and doors and walls are discernible at no less than 3.75 m (12 ft) [34]. Other survivability criteria affecting tenability such as heat effects and smoke toxicity should also be evaluated.

B.3.3 Heat Effects. Exposure to heat can lead to life threat in the following three basic ways:

(1) Hyperthermia
(2) Body surface burns
(3) Respiratory tract burns

Heat exposure of occupants during fires is a function of exposure temperature and radiant heat flux.

Table B.3.1 Tenability Criteria Considerations

Criteria	Value
Smoke obscuration	Internally illuminated sign 80 lx (7.5 ft-candles) discernable at 30 m (100 ft) Walls and doors or externally illuminated sign discernable at 10 m (33 ft)
Heat effects	Exposure temperature (occupied zone) ≤60°C (≤140°F) for 10 min Radiant heat exposure ≤2.5 kW/m^2 (≤792 Btu/hr-ft^2) for several min
Carbon monoxide	FED <0.3
Velocity	≤11 m/sec (≤2200 fpm) air velocity along the path of egress

B.3.3.1 Exposure Temperature. Exposure temperature refers to the conditions in the occupied zone that can contact the skin or be breathed in. 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. [3]

B.3.3.2 Radiant Heat. Radiant heat exposures refer to those experienced on occupants' surfaces in the occupied zone below or adjacent to the smoke layer. The tenability limit for exposure of skin to radiant heat is approximately 1.7 kW·m^{-2}. Below this incident heat flux level, exposure can be tolerated almost indefinitely without significantly affecting the time available for escape. Exposure to radiant heat fluxes of 2.5 kW·m^{-2} can be tolerated for several minutes [3], and above this threshold value, the time to burning of skin due to radiant heat decreases rapidly according to Equation B.3.3.2.

[B.3.3.2]

$$t_{Irad} = 1.33q^{-1.35}$$

where:
t = time in minutes
q = radiant heat flux (kW/m^2)

For situations where occupants are required to pass under a hot smoke layer in order to escape, this radiant flux corresponds approximately to a hot layer temperature of 200°C (392°F) [3].

B.3.3.3 Accumulated Heat Effects. 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 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.

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 Equation B.3.3.3a.

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 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 unclothed or lightly clothed subjects, it is appropriate to use Equation B.3.3.3a:

[B.3.3.3a]

$$t_{Iconv} = \left(5\times10^{7}\right) T^{-3.4}$$

where:
t_{Iconv} = time in minutes
T = temperature (°C)

Equation B.3.3.3a is an empirical fit 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 FED of heat acquired during an exposure can be calculated using Equation B.3.3.3b:

[B.3.3.3b]

$$FED = \sum_{t_1}^{t_2}\left(\frac{1}{t_{Irad}}+\frac{1}{t_{Iconv}}\right)\Delta t$$

where:
t_{Iconv} = time in minutes

As an example, the values in Table B.3.1 are determined using the FED methodology in reference [3] with the following assumptions:

(1) Evacuees are lightly clothed.
(2) Radiant heat flux is zero. (The accumulated radiation term tends to be 0 where radiant heat flux is below 2.5 kW·m^{-2}.)
(3) Time to FED is reduced by 25 percent to allow for uncertainty in the equations estimating accumulated convective heat. *(See Equation B.3.3.3a.)*
(4) Exposure temperature is constant.
(5) FED is not to exceed 0.3, consistent with the recommended design limit that is more conservative to allow for sensitive members of the exposed population.

Equations B.3.3.3a and B.3.3.3b can be manipulated to provide Equation B.3.3.3c:

[B.3.3.3c]

$$t_{exp} = \left(1.125\times10^{7}\right)T^{-3.4}$$

where:
t_{exp} = time of exposure (min.) to reach a FED of 0.3

Table B.3.3.3 provides time in minutes to incapacitation.

Table B.3.3.3 Maximum Exposure Time

Exposure Temperature		Without Incapacitation (min)
°C	°F	
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.3.4 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 FED, according to the methodology outlined in reference [4] [p. 6, equation (2)], as shown in Equation B.3.4:

[B.3.4]

$$FED_{CO} = \sum_{t_1}^{t_2} \frac{[CO]}{35000} \Delta t$$

where:

Δt = time increment in minutes

$[CO]$ = average concentration of CO (ppm) over the time increment Δt

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, the range of threshold values in Table B.3.1 are determined considering the following:

(1) Time to FED reduced by 35 percent to allow for the uncertainty in the equation for FED. *(See Equation B.3.4.)*
(2) Exposure concentration is constant.

The values in Table B.3.4 are derived from Equation B.3.4 for a range of threshold values.

A value for the FED threshold limit of 0.5 is typical of healthy adult populations [4]; 0.3 is typical in order to provide for escape by the more sensitive populations [4]; and the AEGL 2 limits are intended to protect the general population, including susceptible individuals, from irreversible or other serious long-lasting health effects [5].

The selection of the FED threshold limit value should be made in a manner appropriate for the fire safety design objectives. A value of 0.3 is typical. More conservative criteria can be employed for use by especially susceptible populations. Additional information is available in references [4] and [6].

B.3.5 Air Velocities.

B.3.5.1 The air velocities should be greater than or equal to 0.75 m/sec (150 fpm) where smoke management is designed for the protection of egress paths in enclosed stations and trainways.

Table B.3.4 Maximum Carbon Monoxide Exposure

Time (min)	Tenability Limit		
	AEGL 2	0.3	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

B.3.5.2 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) when occupants are present. Maximum air velocities in enclosed stations and trainways should not be averaged over large cross-sectional areas of concourses, platforms, corridors, or stair/escalator openings, but should address the occupied zone.

B.3.6 Noise Levels. Speech intelligibility during an emergency should be considered in the development of the system's design and emergency response plan. During an emergency, in addition to emergency responder activities, noise levels resulting from operation of emergency systems such as fixed firefighting and ventilation systems will affect the ability to communicate. The concern is that at least a minimum level of speech intelligibility be maintained along the emergency evacuation paths to allow for effective communication among first responders and between first responders and evacuating passengers.

Criteria for noise levels should be established for the various situations and potential exposures particular to the environments addressed by this standard. Speech intelligibility becomes difficult in background sound pressure levels of 85 dBA or greater.

The emergency conditions and response could create regions where voice intelligibility would be difficult or impossible to achieve. Addressing this might require additional noise control measures and acoustical treatment. Alternatively, exceptions for reasons of cost and feasibility could be required for defined limited distances along the evacuation path that are near active noise sources and if necessary, other means of reliable communication might be applied such as strobes or wayfinding signaling to support emergency communication and egress.

In cases where the emergency response plan relies upon voice communication, starting points for various design scenarios as integrated with the emergency response plan could be considered as follows:

(1) Where reliance on unamplified speech is part of the emergency response within an enclosed trainway, the sound pressure level during emergency response from all active systems measured along the path of evacuation at any point 1.52 m (5 ft) above the walking surface should not exceed 85 dBA starting at a project-determined distance from the noise sources. An upper limit of 90 dBA at any point 1.52 m (5 ft) above the evacuation path

walking surface could be considered where needed to accommodate challenging locations near noise sources.

(2) For intelligible communication between emergency evacuation responders and the public, where reliance on amplified speech is used as part of the emergency response within a station, refer to *NFPA 72*.

(3) Where reliance on amplified speech is part of the emergency response within an enclosed trainway, the sound pressure level from all active systems measured inside an enclosed trainway along the path of evacuation at any point 1.52 m (5 ft) above the walking surface should be designed to support speech intelligibility of fixed voice communication systems to achieve a measured speech transmission index (STI) of not less than 0.45 [0.65 common intelligibility scale (CIS)] and an average STI of not less than 0.5 (0.7 CIS) as per D.2.4.1 of *NFPA 72*. Refer to Annex D of *NFPA 72* for further information on speech intelligibility for voice communication systems.

B.4 Evaluation of Tenability. The tenability criteria are established based upon considerations of wayfinding (visibility) and survivability (heat effects and smoke toxicity) for evacuating occupants.

B.4.1 Occupants Able to Self-Rescue. For the evacuation of occupants who are able to self-rescue, visibility is generally the most onerous tenability criterion. The visibility criterion is most critical where occupants are located and moving towards vertical circulation elements (VCEs) or exits, but it applies all along the path of egress.

For platforms that are designed in accordance with the baseline egress requirements, travel times to VCEs or exits are typically short and the majority of the platform clearance time will be driven by queueing. If occupants are queued at the base of VCEs or exits, the required wayfinding capability might not be as critical as the survivability criteria of heat effects and smoke toxicity. Similarly, the required wayfinding capability for egress in enclosed trainways is not as critical as the survivability criteria.

B.4.2 Occupants Unable to Self-Rescue. Occupants who are unable to self-rescue will require assistance from fellow occupants or emergency personnel in order to evacuate to a point of safety. Evaluation of tenability for these occupants will depend upon the design measures that are implemented, such as the following:

(1) Maintaining the survivability criteria for the time of tenability by emergency ventilation in areas located in a path of travel leading to a public way without smoke barriers
(2) Using smoke barriers to provide a tenable environment in areas that are protected from the effects of fire
(3) Maintaining a tenable environment that facilitates the limited or supervised use of elevators as part of a formal or informal evacuation plan

B.5 Considerations for Establishing a Tenable Environment.

B.5.1 Geometric Considerations. Some factors that should be considered in establishing a tenable environment in stations are as follows:

(1) Tenability of the path of egress should be evaluated at a height clear of smoke of at least 2 m (6.6 ft) from the walking surface. Tenability of the entire path of egress including VCEs should be evaluated. 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) Upon activation of emergency ventilation fans, the resulting airflow characteristics and turbulent mixing could disrupt smoke stratification. Accordingly, tenability should not be evaluated using the concept of a defined smoke layer height.

(3) The application of tenability criteria at the perimeter of a fire is impractical. The area immediately proximate to the fire will unavoidably create untenable conditions. The requirement to maintain tenability should be defined to apply outside a boundary away from the immediate perimeter of the fire vehicle, maintaining context on protecting the use of the path of egress. This distance should be developed on a project-specific basis, and that determination will be dependent on the fire heat and smoke release rates, local and overall station geometry, train and vehicle dimensions and configuration, required and achievable egress time, and ventilation system capacity and arrangement. The thermal conditions might be untenable within as much as 30 m (100 ft) from the perimeter of the fire based on train configurations with fire-rated end doors between cars; however, this should be established on a project basis. A key consideration in determining this area and the duration within which it applies will be how the resultant radiation exposures and smoke layer temperatures affect the path of egress. This consideration should include the specific geometries of each application, such as vehicle length, number of vehicles open to each other, 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.

(4) The beneficial effects of an emergency ventilation system during a fire incident require the system to be operated and to reach full capacity. During the time between initiation of a fire incident and when the desired ventilation response achieves full capacity, the smoke can spread into the area where it is intended to maintain tenability. The ventilation system should have sufficient capacity to counter this preventilation smoke spread. The design should consider passive arrangements to minimize the preventilation smoke spread. The extent of preventilation smoke spread should also be considered with respect to its potential effect on egress.

(5) 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 the opening of vehicle doors or the failure of vehicle windows. The ventilation system should have sufficient capacity to counter such short-term transients affecting smoke spread.

B.6 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 firefighters to begin to suppress the fire

Context for the response and deployment time for emergency personnel, such as professional fire departments, should be evaluated on the information contained in documents and standards such as NFPA 1710 [7] and NFPA 1720 [8] and input from the appropriate fire departments or emergency response personnel.

B.7 Modeling Accuracy Considerations. Computational fluid dynamics (CFD) simulations and modeling are often used to predict factors during a fire event and the ventilation response that affects tenability and evacuation. Computerized simulations do not generate design solutions, but the simulations are used to predict the performance of a ventilation design and operating scenario applied to a design geometry.

These simulations are used to evaluate and adjust systems and design geometry to satisfy the acceptance criteria. A sensitivity analysis should be performed for key design parameters that would significantly affect the simulation results. Some key design parameters include, but are not limited to, soot yield, heat of combustion, and mass extinction coefficient.

The accuracy of the model predictions is also dependent on the dimensions and types of computational grids used to construct the simulation domain that represents the volumes being modeled. Simulation sensitivity analysis should be performed to demonstrate that the results are grid-independent.

B.8 Fire Risk.

Δ **B.8.1 Performance-Based Design.** Analysis and design of emergency ventilation systems for enclosed stations and enclosed trainways incorporate some elements of performance-based design. Engineering analyses are conducted for a developed set of defined scenarios, and the results of the analyses are evaluated against established criteria. In a given project, the assumptions of analysis method, design fires, model parameters, and acceptance criteria contribute to the underlying level of risk that is incorporated into the design.

The *SFPE Engineering Guide to Performance-Based Fire Protection* [9] presents a process for performance-based design, and provides guidance relative to establishing credible fire scenarios and considering the potential impact on the design given the associated risk context: "A design fire scenario that is highly improbable and too conservative can lead to an uneconomical building design, which can cause the building not to be built or be functional. On the other hand, a design fire scenario developed using a non-conservative approach, e.g., a long incipient phase or a slow rate of fire growth, could lead to a building design in which there is an unacceptably high risk to occupants."

Design fire scenarios that are appropriate to a project will depend on what is considered as an acceptable level of risk for the purposes of design, which might vary depending on the jurisdiction or project. The understanding of what the risks are and the acceptable risk might vary among the key stakeholders involved on a specific project. The development of the risks to be designed for and to what level requires input and understanding among all the stakeholders. Establishing analysis assumptions and performance criteria that are based upon specific objectives is fundamentally linked to understanding the level of risk that is being designed to.

The approach to codes and standards use and enforcement varies in different world geographies, as does the culturally, legally, and financially acceptable level of risk.

The approach to code compliance in North America (which is adopted in whole or in part in some other regions of the world) provides a balance of prescriptive and performance requirements, the satisfaction of which must be demonstrated to and accepted by the authority having jurisdiction. The requirements of the various codes are adopted by statute, usually at the state or local level, making conformance legally mandatory. The acceptable level of risk is embedded within the codes that were developed by experience over time. The performance-based elements allowed by the codes are often judged in terms of equivalence to the prescriptive requirements.

The code approach in the United Kingdom and European Union center on the development of a safety case, which provides a project-specific development of risks, criteria, and mitigations based on various standards, the whole to be accepted as a project's compliance target. The safety case approach uses a more overt development of the probability and consequences of project risks and how they are to be addressed. Lacking a direct legal mandate to follow specific codes, there tends to be much more reliance on project-specific judgments as opposed to mandatory criteria developed over time.

There are projects in some regions where both methods are specified together, and this requires great care in the reconciliation of incompatible parts of the two approaches, which include fundamentally different terminology on how establishment and enforcement of requirements are accomplished.

B.8.2 Risk Assessment. The risk associated with a design fire, as with any other hazard, is a product of the probability of occurrence and the potential consequence. Risk analysis might require input data that is not reliably obtainable or truly representative of a given project's actual hazard. There is a potential for very low probability — but still credible — events with a high consequence level to be perceived as too "extreme" for use as design scenarios, leading to conclusions that omit critical life safety systems as "excessive" on financial grounds. A risk analysis should consider holistic stakeholder objectives and applicable sensitivity studies to support such assessment.

Further information regarding risk analysis approaches and other important considerations can be found in references such as the *SFPE Engineering Guide to Performance-Based Fire Protection* [9], NFPA 550 [10], and NFPA 551 [11].

B.9 Fire Scenarios.

B.9.1 Design Fire Scenarios Representative design fire scenarios can include any or all of the following as a hazard analysis:

(1) A fire originates outside the rail vehicle's interior.
(2) A fire originates inside a vehicle's interior.
(3) The fire spreads from car to car or train to train.
(4) A fire consumes trash, luggage, wayside electrical equipment, or other possible fuels that are not part of the train.
(5) A fire occurs in a nonsystem occupancy.

(6) A fire occurs in a dual-powered vehicle (diesel/electric and electric/battery traction).
(7) A fire originates in a maintenance vehicle or work train.

Several references provide an overview of a number of methodologies for predicting design fire profiles [12], [13], and [14].

B.9.2 Train Interior Fires.

B.9.2.1 Burning Behavior and Analysis. The burning behavior of vehicle materials and the potential for fire development have been evaluated using assembly-scale and bench-scale testing, as well as numerical modelling using a range of different methodologies.

B.9.2.2 Interior Materials and Assembly Testing. Fire testing of vehicle interior materials was conducted by NIST under a comprehensive fire safety research program [15], [16], and [17], which utilized ignition scenarios that included ignition under a seat by small source that was representative of crumpled newspaper, ignition by a small gas burner on top of a seat, and ignition of a newspaper-filled trash bag fire on top of a seat. Using materials that met Federal Railway Administration (FRA) requirements current at the time of the testing in the 1990s, it was found that a significant ignition source (such as a large trash bag along with a 25 kW gas burner) was necessary to sustain flame spread.

Δ **B.9.2.3 Computational Fluid Dynamics.** Computational fluid dynamics modeling has been employed in some studies to estimate fire development. Computational analysis of fire development using material properties is complex, and the context of model parameter uncertainty and the limitations of the methodology employed should be fully understood and maintained during the evaluation of model results. The approaches that have been employed include a prescribed burning rate approach [13] [18] [19] with model parameters for material burning characteristics derived from heat release testing with a cone calorimeter [35] and more advanced pyrolysis modeling approaches [20] [21].

The ignition and potential fire development characteristics of modern transit materials have been further examined using a coupled computational fluid dynamics/pyrolysis model in conjunction with bench-scale and assembly-scale fire testing [20].

The following parameters are important to consider when conducting a computational fluid dynamics analysis of fire development:

(1) Initiating fire size and characteristics
(2) Fire characteristics of car interior materials
(3) Layout of the car interiors, including seating layouts, orientations, and dimensions
(4) Other fuel loads, such as bags and luggage carried by passengers
(5) Overall thermal transmission value of the vehicle body
(6) Openings and protectives, including windows and doors
(7) Oxygen levels
(8) Mechanical and natural ventilation interior and exterior to the vehicle
(9) Effects of onboard fire suppression systems

B.9.2.4 Full-Scale Vehicle Testing Context. A limited number of full-scale train fire tests and estimates from actual fire incidents have yielded data regarding heat release rate and growth behavior. A number of these tests and incidents are summarized in Table B.9.2.4. Interior materials, ignition source (or sources when multiple ignition events were used), and ventilation conditions are found in the associated reference for each test.

As of 2018, most, if not all, of the full-scale burn tests performed have been made using older rolling stock and interior finishes without the benefit of the most current fire property requirements. Modern trains constructed to meet current fire property requirements, such as the degree of fire hardening, have not been tested. Research has been on older model trains where the degree of fire hardening has not been quantified. Fires initiated to combust the trains have been disproportionately large, considering the ignition source typically found on a train, and have been in a conspicuous worst-case location in order to combust the train. This results in a premature growth to the combustible lining materials on the train than would ordinarily be present from ignition sources. This yields extremely large fires that overcome the fire hardening characteristics resulting in very high peak heat release rates. Consideration should also be given to ventilation conditions, different types of lining materials, especially at the ceilings, and the interconnection of train cars.

Testing and computational evaluation of materials and vehicle interiors has shown that it has become more difficult to initiate a fire, but that when provided with sufficient initiating energy even modern vehicles with components of appropriate fire performance can become fully engulfed. It is suggested that the specifics of the vehicle interior construction and material selections be evaluated in conjunction with the range of potential ignition scenarios.

The validity of assumptions relating to encapsulation or enclosure of combustible materials within or behind less combustible skins should be evaluated with great care.

The overall materials and ignition evaluation in the determination of the design fire peak heat release rate and the design fire growth curve should be conducted with great care such that excess in neither optimism nor pessimism results in a deficient or overly conservative design basis.

N **B.9.2.5 Vehicle Scale Model Testing.** Scale model testing is an approach in which a reduced-scale, model-size railcar is created as a replica of a full-scale railcar and used to estimate fire behavior. Reduced-scale testing of model-size railcars can be used to estimate the fire development characteristics and heat release rates of fires inside full-scale railcars. Algebraic expressions such as scaling laws can be used to extrapolate heat release rate, fire development, and material burning characteristics to full-scale performance.

Scaling laws based on the Froude number were used in reference 36 for scaling railcar fires. This approach required the modification of combustible lining types and thicknesses to limit burning characteristics. Reduced-scale testing was performed using model railcars that were as small as $\frac{1}{10}$ the size of a full-scale railcar. However, the Froude-based scaling laws did not capture all of the compartment fire dynamics, requiring an additional test to be developed to predict full-scale behavior with reduced-scale results.

Table B.9.2.4 Summary of Measured and Estimated Heat Release Rates and Associated Context

Description	Peak Heat Release Rate (MW)	Time to Peak Heat Release Rate (min)	Materials and Ignition Context
EUREKA Intercity EUREKA Intercity (test 1992) [22]	12	25	German IC train with steel body with legacy interior materials. Ignition by 6.2 kg of accelerant. Tunnel air velocity 0.5 m/sec.
EUREKA Intercity Express (test 1992) [22]	19	80	German ICE train with steel body, with modern materials at the time of test. First ignition by 6.2 kg of accelerant, fire development ceases after 18 minutes. Second ignition source of 170 wood sticks and 12.3 kg of accelerant is added. Heat release rate below 10 MW for approximately 65–70 minutes. Tunnel air velocity 0.5 m/sec.
EUREKA Metro (test 1992) [22]	35	5	Aluminum body subway train. Seat materials of “latest” design at time of test, other interior materials of “former” design. Tunnel air velocity 0.5 m/sec.
Baku Metro (actual fire 1995) [23]	100 (Est)	30–45	Fire cause reported to be related to an electrical failure. Train approximately 30 years old, with 90% of interior materials estimated to be combustible.
METRO Commuter (test 2009–2012) [24]	76.7	12.7	X1 train dating to 1970s with original combustible interior lining and an additional fire load of 351 kg of luggage. Ignition by igniting 1L of petrol with burning fiberboard. Ventilation was applied throughout the test using a mobile ventilation unit with a volumetric flowrate of 60.3 m^3/sec.
METRO Commuter ‘Refurbished’ (test 2009–2012) [24]	77.4	118	“Refurbished X1” train to be similar to a modern C20 carriage for Stockholm metro. Original combustible interior surfaces were covered incombustible covering. Seats replaced with ones consistent with C20 carriages. First ignition was achieved by igniting 1L of petrol with burning fiberboard. After approximately 110 minutes, fire development had largely stopped. 10L of diesel was applied to 5 pieces of luggage that were then placed into the train car, with rapid ignition and fire development resulting from this second major introduced ignition source. Ventilation was applied throughout the test using a mobile ventilation unit with a volumetric flowrate of 60.3 m^3/sec.
Carleton Subway Car (test 2011) [25]	52.5	9	Legacy Korean subway car with interior materials dating to before modern fire safety guidelines. Tunnel exhaust fan system initially set to 66 m^3/sec and ramped up to 132 m^3/sec after 6 minutes. For ignition, a sand propane burner with an HRR of 75 kW for the first 3 minutes and 150 kW for the following 8 minutes was placed in the corner of the car.
Carleton Railway Car (test 2011) [25]	32	18	Legacy Korean railway car. Tunnel exhaust fan system initially set to 66 m^3/sec and ramped up to 132 m^3/sec after 3 minutes. For ignition, a sand propane burner with an HRR of 75 kW for the first 3 minutes and 150 kW for the following 8 minutes was placed in the corner of the car.
British Rail Sprinter (test) [26]	16	NA	Test details not published.
British Rail Sprinter (test) [26]	7	NA	Test details not published.
Australian Passenger Rail (test 2005) [27]	13	2.3	Carriage materials consist of a stainless steel shell with interior materials selected from salvaged and spare parts stock; it was not determined if the legacy interior materials were tested to any flammability standards. Ignition source was 1 kg of crumpled newspaper (approximately 170 kW) on the floor in a corner behind the end seat shell, ignited using a gas flame.

As a result, different scaling laws have been developed to reduce the compartment fire opening factor and the heat release rate per unit area of a burning surface [37]. This approach has been shown through computational modeling to scale fire behavior and heat release rate results with models down to one-fifth the size of full-scale railcars. The scaling laws from reference 37 have also been shown to be better than the Froude number scaling applied in reference 36. However, additional experimental validation of the scaling laws developed in reference 37 is needed.

Scale model testing and scaling laws provide an approximation of fire development behavior that might occur at full-scale. As a result, the uncertainty of the results from the scale model approach, as well as the limitations of the methodology employed, should be fully understood and documented along with the results. This includes validating the scaling laws, which might require full-scale fire test data.

B.9.3 Train Exterior Fires. In accordance with Chapter 8, floor and roof assemblies are required to provide minimum fire exposure durations to protect the passenger compartment from exterior fire development for the period of occupant evacuation.

Testing and computational evaluation relative to exterior ignition scenarios for rolling stock have not been widely reported in the literature. An exterior fire event for a train vehicle would typically correlate with a local equipment failure, or an ignition source related to the propulsion, third rail power, or braking systems.

The potential fire development for an exterior fire will depend upon factors including, but not limited to, the exterior equipment, traction power configuration, exterior train materials, ignition source, and ventilation conditions. The train car ventilation might draw smoke and hot gases into the vehicle. There is an assumption that if this system exists, it will automatically stop when exposed to excessive heat from an external source.

B.9.4 Non-Vehicle Fire in Station Public Area. In public areas of stations that are of noncombustible construction and that have interior finishes in accordance with the requirements of Chapter 5, the ignition and potential contribution to combustion of station materials is likely to be negligible.

Accumulation of significant transient fuel load within the public areas of a station would not be expected to occur with regular housekeeping and maintenance of the stations. It is anticipated that a potential trash fire in the public areas would be limited by the size of an individual trash receptacle, which might present the more likely ignition location, or by the size of some other transient combustible material such as luggage left in the station by its owner, which might be the less likely cause of ignition. However, the carried-on fuel load can be significant, particularly in stations serving major transportation hubs, such as airports.

Examples of the measured peak heat release rates for representative trash and other transient combustibles that could be present on a station public area are summarized in references [28] through [33]. The peak heat release rate might be of short duration compared to a vehicle fire. The fire load and burning duration should be considered along with the peak heat release rate in the evaluation of potential fire hazard of trash and other transient fuels.

Where a fire hazard analysis indicates that public area fire scenarios present a life safety hazard, they should be identified and evaluated in terms of impact to passenger evacuation routes and tenability requirements. Public area design fire scenarios should be established and approved for the level of safety of the overall system.

B.9.5 Retail and Other Occupancy Fires. Stations might include incidental occupancies, such as retail shops, kiosks, and stands. Where stations are integrated with nonsystem occupancies, the nonsystem occupancy fire hazards, protective measures, and potential impact on occupants should be evaluated considering the full station environment as a unified space and system response. *(See Chapter 5.)*

Δ **B.10 References.** The following references are cited in this annex:

(1) Associated Engineers: A Joint Venture of Parsons, Brinckerhoff, Quade, and Douglas, Inc.; DeLeuw, Cather, and Company; and Kaiser Engineers, *Subway Environmental Design Handbook: Volume I, Principles and Applications*, Second Edition, NTIS PB254788, 1976.

(2) *ASHRAE Handbook — HVAC Applications*, Chapter 15, "Enclosed Vehicle Facilities," 2015.

(3) Purser, D. A. and McAllister, J. L., "Assessment of Hazards to Occupants from Smoke, Toxic Gases, and Heat," *SFPE Handbook of Fire Protection Engineering*, Fifth Edition, Volume III, Chapter 63, Springer, 2016.

(4) ISO/DIS 13571, *Life-threatening components of fire — Guidelines for the estimation of time to compromised tenability in fires*, International Standards Organization, 2012.

(5) "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.

(6) Kuligowski, E. D., "Compilation of Data on the Sublethal Effects of Fire Effluent," Technical Note 1644, National Institute of Standards and Technology, 2009.

(7) NFPA 1710, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments*, 2020 edition.

(8) NFPA 1720, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments*, 2020 edition.

(9) *SFPE Engineering Guide to Performance-Based Fire Protection*, Second Edition, 2007.

(10) NFPA 550, *Guide to the Fire Safety Concepts Tree*, 2017 edition.

(11) NFPA 551, *Guide for the Evaluation of Fire Risk Assessments*, 2019 edition.

(12) Li, S., Louie, A., and Fuster, E., "The Impacts of Train Fire Profiles on Station Ventilation System Design," presented at the 15th International Symposium on Aerodynamics, Ventilation & Fire in Tunnels, Barcelona, Spain, 18–20 September 2013.

(13) Chiam, Boon Hui, "Numerical Simulation of a Metro Train Fire," Fire Engineering Research Report 05/1, Department of Civil Engineering, University of Canterbury, Christchurch, New Zealand, June 2005.

(14) Kennedy, W. D., Ray, R. E., and Guinan, J. W., "A Short History of Train Fire Heat Release Calculations," presented at the 1998 ASHRAE Annual Meeting, Toronto, Ontario, Canada, June 1998.
(15) Peacock, R. D. and Braun, E. *Fire Safety of Passenger Trains — Phase I: Material Evaluation (Cone Calorimeter).* NISTIR 6132, National Institute of Standards and Technology, Gaithersburg, MD, March 1999.
(16) Peacock, R. D., Reneke, P. A., Averill, J. D., Bukowski, R. W., and Klote, J. H. *Fire Safety of Passenger Trains —Phase II: Application of Fire Hazard Analysis Techniques.* NISTIR 6525, December 2002.
(17) Peacock, R. D., Averill, J. D., Madrzykowski, D., Stroup, D. W., Reneke, P. A., and Bukowski, R. W. *Fire Safety of Passenger Trains — Phase III: Evaluation of Fire Hazard Analysis Using Full-Scale Passenger Rail Tests.* NISTIR 6563, National Institute of Standards and Technology, Gaithersburg, MD, April 2004.
(18) Milford, A., Senez, P., Calder, K., and Coles, A., "Computational Analysis of Ignition Source Characteristics on Fire Development in Rapid Transit Vehicles," Proceedings of the 3rd International Conference on Fire in Vehicles, 131–142, Berlin, Germany, 1–2 October 2014.
(19) Milford, A., Calder, K., Senez, P., and Coles, A., "Computational Study of Tunnel Ventilation Effects on Fire Development in Rapid Transit Vehicles," Proceedings of the 6th International Symposium on Tunnel Safety and Security, 381–390, Marseille, France, 12–14 March 2014.
(20) Coles, A., Wolski, A., and Lautenberger, C., "Predicting Design Fires in Rail Vehicles," 13th International Symposium on Aerodynamics and Ventilation of Vehicle Tunnels (ISAVV 13), New Brunswick, New Jersey, 13–15 May 2009.
(21) Lautenberger, C., Wong, W. C., Coles, A., Dembsey, N., and Fernandez-Pello, A. C., "Comprehensive Data Set for Validation of Fire Growth Models: Experiments and Modeling," Interflam 2010, Nottingham, UK, July 2010.
(22) *Fire in Transport Tunnels — Report on Full-Scale Tests,* EUREKA-Project EU 499: FIRETUN, Editor Studiengesellschaft Stahlanwendung e.V, November 1995.
(23) Poon, L. and Lau, R., "Fire Risk in Metro Tunnels and Stations," *International Journal of Performability Engineering,* Vol. 3, No. 3, 355-368, July 2007.
(24) Ingason, H., Kumm, M., Nilsson, D., Lonnermark, A., Claesson, A., Li, Y. Z., and Palm, A., *The Metro Project: Final Report, Studies in Sustainable Technology,* Malardalen University, 2012.
(25) Hadjisophocleous, G., Lee, D. H., and Park, W. H., "Full-scale Experiments for Heat Release Rate Measurements of Railcar Fires," Proceedings of the 5th International Symposium on Tunnel Safety and Security, New York, 14–16 March 2012.
(26) Ingason, H., "Design Fires in Tunnels," Second International Symposium on Safe and Reliable Tunnels: Innovative European Achievements, Lausanne, 2006.
(27) White, N., Dowling, V., and Barnett, J., "Full-scale Fire Experiment on a Typical Passenger Train," Eight International Symposium on Fire Safety Science, 1157–1168, Beijing, China, 2005.
(28) Bowman, I. and Tooley, D., "Towards a Risk-Informed Approach for Specifying Design Fire Size in Transit Tunnels," Proceedings of the 7th International Symposium on Tunnel Safety and Security, 193–204, Montreal, Canada, 16–18 March 2016.
(29) Kumm, M., "Carried Fire Load in Mass Transport Systems," Malardalen University, Studies in Sustainable Technology, 2010.
(30) Sardqvist S., "Initial Fires — RHR, Smoke Production and CO Generation from Single Items and Room Fire Tests," Institute of Technology — Department of Fire Safety Engineering, Lund University, Sweden, April 1993.
(31) Babrauskas, V., "Heat Release Rates," *SFPE Handbook of Fire Protection Engineering,* 5th Edition, Volume I, Chapter 26, Springer, 2016.
(32) Stroup, D. W. and Madrzykowski, D., "Heat Release Rate Tests of Plastic Trash Containers," Test FR 4018, National Institute of Standards and Technology, 2003.
(33) Lee, B. T., "Heat Release Rate Characteristics of Some Combustible Fuel Sources in Nuclear Power Plants," NBSIR 85-3195, US Department of Commerce, July 1985.
(34) NFPA 92, *Standard for Smoke Control Systems,* 2018 edition.
(35) ASTM E1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter,* 2017.
(36) Y. Z., Li, H., Ingason, and A., Lönnermark, "Fire development in different scales of metro carriages," Fire Safety Science — Proceedings of the Eleventh International Symposium, pp. 302–315, 2014.
(37) Yang, F., Hodges, J., Rippe, C., Kraft, S., and Lattimer, B., "Predicting Fully-Developed Railcar Fire Heat Release Rate," Report DOT/FRA-ORD-20/32, US Department of Transportation, Federal Railroad Administration, August 2020.
(38) NFPA 72, *National Fire Alarm and Signaling Code,* 2022 edition.

Annex C Egress Calculations for Stations

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

Δ **C.1 Occupant Load.** Station platform dimensions are a function of the length of the trains served and the trainload. Thus, the length of a platform at an outlying station might be equal to those in central business district transit stations where the train loads are significantly bigger. 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.

Δ **C.1.1 Ridership.** Projected ridership figures serve as the basis for determining the transit system design. Per this standard, ridership must consider peak ridership figures for new transit systems and existing operating systems, as well as events near stations at civic centers, sports complexes, and convention centers that establish occupant loads not included in normal passenger loads. These ridership figures serve as the basis for calculating train and entraining loads, which, in turn, are the basis for deriving the station occupant load.

The methodology used to determine passenger ridership figures can vary by transit system.

As noted in A.5.3.2.1, it is also recommended that surveys be conducted at regular intervals to verify projections applied during the design of the system. Where surveys indicate that ridership exceeds the design projections, adjustments to either train headways or station configuration should be considered.

As suggested in A.5.3.2.1, where peak-hour ridership is used to derive occupant loads, a surge factor is often applied as a distribution curve correction to account for peak flows within the peak hour.

N **C.1.2 Train Operations.** After ridership, assumptions regarding train operations have the largest impact on the calculated occupant load in a transit system station. The assumed train headway acts as an accumulation factor — i.e., where ridership is based on peak-hour demand, the train headway represents a fixed interval of that peak hour, with longer headways resulting in higher accumulation values. For example, for the same ridership, applying a train service headway of 20 trains per hour (with 3-minute headways) versus 30 trains per hour (with 2-minute headways) will increase the calculated platform occupant load by 50 percent.

Calculations should also consider the potential impact of delayed train arrivals on entraining and detraining loads. This is often accounted for by including a doubled headway interval in the peak direction in the occupant load calculations.

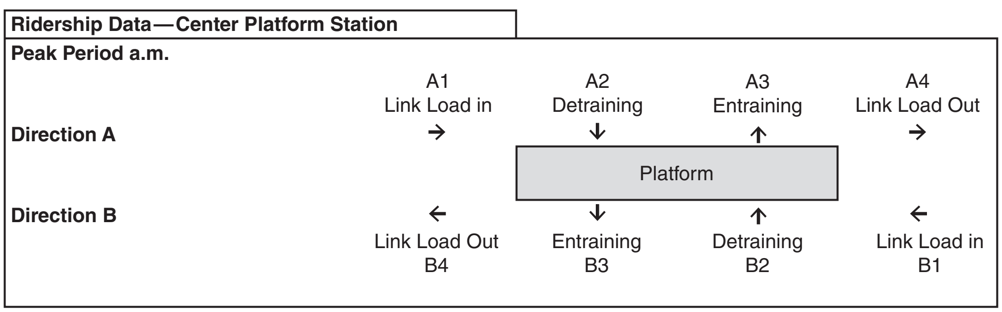
For link loads (i.e., the number of passengers on board an incoming train), the maximum trainload acts as a capping factor where the calculated trainload, which is based on ridership and headway, exceeds the actual capacity of the train. Care should be taken to use a realistic maximum trainload that considers the number of seats as well as standing capacity based on achievable pedestrian density (where standing is permitted).

N **C.1.3 Sample Occupant Load Calculations.** The methodology described herein is intended only as an example of how to determine platform and station occupant loads for typical station configurations *[see Figure C.1.3(a) and Figure C.1.3(b)]*. Variables like those described in C.1.1 and C.1.2 above should be carefully considered for each system application, keeping in mind that small changes to those factors can have a significant effect on the calculation results.

Δ **C.2 Egress Capacity and Evacuation Time.** The total evacuation time is the sum of the walking travel time for the longest egress route plus the waiting times at the various circulation elements. The trainway can be considered an auxiliary egress 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 means of egress, by subtracting the walking travel time on the platform from the platform egress flow time
(2) For each of the remaining circulation elements, by subtracting the maximum of all the previous element flow times



Occupant Load Calculations:		a.m.		p.m.*	
Headway:	(x)				
Surge Factor:	(y)	Platform A	Platform B	Platform A	Platform B
Link Load per Headway × Surge	(a)	A1/(x) × (y)	B1/(x) × (y)	B4/(x) × (y)	A4/(x) × (y)
Entraining per Headway × Surge	(b)	A3/(x) × (y)	B3/(x) × (y)	B2/(x) × (y)	A2/(x) × (y)
Platform Load: per Headway	(c)	A (a + b)	B (a + b)	B (a + b)	A (a + b)
Platform Load: Missed Headway	(d)	2 × A(c)	2 × B(c)	2 × B(c)	2 × A(c)

***Note:** The sample calculation assumes that a.m. peak period ridership is reversed for the p.m. peak period — i.e., that inbound passengers during the a.m. will become outbound passengers in the p.m. This assumption is for the purposes of example only. Calculations applied in system design should be based on ridership projections that evaluate the a.m. and p.m. peak periods separately.

Center Platform Station		
Platform Occupant Load and Simultaneous Occupanat Load	MAX [(Ac + Bd), (Ad + Bc)]	MAX [(Ac + Bd), (Ad + Bc)]

N **FIGURE C.1.3(a) Center Platform Occupant Load Calculation Method.**