NFPA 130

Standard for

Fixed Guideway Transit and Passenger Rail Systems

2007 Edition

This edition of NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems*, was prepared by the Technical Committee on Fixed Guideway Transit Systems and acted on by NFPA at its June Association Technical Meeting held June 4–8, 2006, in Orlando, FL. It was issued by the Standards Council on July 28, 2006, with an effective date of August 17, 2006, and supersedes all previous editions.

This edition of NFPA 130 was approved as an American National Standard on August 17, 2006.

Origin and Development of NFPA 130

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

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

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

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

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

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

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

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

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

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

Technical Committee on Fixed Guideway Transit Systems

William D. Kennedy, *Chair*
Parsons Brinckerhoff Quade & Douglas, Incorporated, NY [SE]

William R. Segar, *Nonvoting Secretary*
Bombardier Transportation, PA [M]
(Alt. to James D. Chatham)

John F. Bender, Maryland State Fire Marshal’s Office, MD [E]
Rep. International Fire Marshals Association

John Bumanis, Parsons Transportation Group, VA [SE]

David M. Casselman, Lea & Elliott, Incorporated, TX [SE]

Mark Chan, Bay Area Rapid Transit, CA [U]

James D. Chatham, Bombardier Transportation, PA [M]

Frederic B. Clarke, Benjamin Clarke Associates, Incorporated, VA [M]
Rep. Society of the Plastics Industry, Incorporated

John F. Devlin, Schirmer Engineering Corporation, MD [I]

E. Rejean Dubois, Montreal Transit Corporation (STM), Canada [U]

Angelo Duggins, Seattle Fire Department, WA [E]

Brian Y. Lattimer, Hughes Associates, Incorporated, MD [SE]

Kwok Weng Leong, Land Transport Authority, Singapore, Singapore [U]

Harold L. Levitt, Port Authority of New York & New Jersey, NJ [U]

Harold A. Locke, Locke & Locke Incorporated, Canada [SE]

Harry Edward Lupia, Washington Metropolitan Area Transit Authority, DC [U]

Donald MacLennan, Metropolitan Transportation Authority, NY [U]

James K. Mann, Jr., National Railroad Passenger Corporation, PA [U]

David Mao, U.S. Department of Transportation, DC [E]

Stephanie H. Markos, U.S. Department of Transportation, MA [RT]

Thomas G. Middlebrook, Toronto Transit Commission, Canada [U]

Bruce C. Nelson, Chicago Transit Authority, IL [U]

Richard D. Peacock, U.S. National Institute of Standards & Technology, MD [RT]

Thomas Peacock, American Public Transportation Association, DC [U]

John L. Quintanar, Los Angeles City Fire Department, CA [E]

James R. Quiter, Arup, CA [SE]

Steven W. Roman, LTK Engineering Services, PA [SE]

Richard B. Schiehl, R. B. Schiehl & Associates, CA [SE]

John J. Troy, FPC Sierra Incorporated, OH [SE]

Joseph B. Zicherman, IFT Fire Cause Analysis, CA [RT]

Alternates

Shane D. Allen, Los Angeles City Fire Department, CA [E]
(Alt. to J. L. Quintanar)

Jason D. Averill, U.S. National Institute of Standards & Technology, MD [RT]
(Alt. to R. D. Peacock)

E. Katherine Fagerlund, Senez Reed Calder Fire Engineering Incorporated, Canada [SE]
(Alt. to H. A. Locke)

Robert W. Falvey, Lea & Elliott, Incorporated, FL [SE]
(Alt. to D. M. Casselman)

Michael J. Ferreira, Hughes Associates, Incorporated, MD [SE]
(Alt. to B. Y. Lattimer)

Paul Fok, Land Transport Authority, Singapore [U]
(Alt. to K. W. Leong)

Mark J. Gentile, U.S. Department of Transportation, MA [RT]
Rep. U.S. Department of Transportation
(Alt. to S. H. Markos)

John Dennis Gentzel, Maryland State Fire Marshal's Office, MD [E]
(Alt. to J. F. Bender)

Salvatore A. Gilardi, Jr., Parsons Transportation Group, NY [SE]
(Alt. to J. Bumanis)

James P. Gourley, H.A.S. Protection, Inc. — Fire Cause Analysis, PA [RT]
(Alt. to J. B. Zicherman)

Joseph J. Grella, National Railroad Passenger Corporation, PA [U]
(Alt. to J. K. Mann, Jr.)

Martha K. Gulick, Port Authority of New York & New Jersey, NJ [U]
(Alt. to H. L. Levitt)

William T. Hathaway, Consultant, MA [SE]

(Alt. to R. B. Schiehl)

Joseph F. Krempasky, Washington Metropolitan Area Transit Authority, DC [U]
(Alt. to H. E. Lupia)

Silas K. Li, Parsons Brinckerhoff Quade & Douglas, Incorporated, NY [SE]
(Alt. to W. D. Kennedy)

Joseph A. Mucciolo, Metropolitan Transportation Authority, NY [U]
(Alt. to D. MacLennan)

John Nelsen, Seattle Fire Department, WA [E]
(Alt. to A. Duggins)

Julian Sandu, Chicago Transit Authority, IL [U]
(Alt. to B. C. Nelson)

Lee M. Sorensen, MTA Long Island Rail Road, NY [E]
(Voting Alt. to MTA LIRR Rep.)

Lurae B. Stuart, American Public Transportation Association, DC [U]
(Alt. to T. Peacock)

Christian Thibault, Montreal Transit Corporation (STM), Canada [U]
(Alt. to E. R. Dubois)

Nonvoting

Arnold Dix, Counsel at Law/Adj. Prof. Engineering, Australia [SE]

Vince Dowling, CSIRO Fire Science & Technology Laboratory, Australia [RT]

Norman H. Danziger, Boynton Beach, FL
(Member Emeritus)

Edward K. Farrelly, E. Farrelly & Associates, NJ

James D. Lake, NFPA Staff Liaison

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

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

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex G. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope.

1.1.1 This standard shall cover fire protection requirements for underground, surface, and elevated fixed guideway transit and passenger rail systems, including trainways, vehicles, and vehicle maintenance and storage areas, and for life safety from fire in fixed guideway transit and passenger rail system stations, trainways, vehicles, and outdoor vehicle maintenance and storage areas.

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

1.1.3 This standard shall not cover requirements for the following:

(1) Conventional freight systems

(2) Buses and trolley coaches

(3) Circus trains

(4) Tourist, scenic, historic, or excursion operations

(5) Any other system of transportation not included in the definition of fixed guideway transit *(see 3.3.49.1)* or passenger rail *(see 3.3.49.2)* system

(6)* Shelter stops

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

1.2 Purpose.

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

1.3 Application.

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

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

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

1.4 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 and life safety.

1.5 Units and Formulas.

1.5.1 SI Units. Metric units of measurement in this standard are in accordance with the modernized metric system known as the International System of Units (SI).

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

Chapter 2 Referenced Publications

2.1 General.

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

2.2 NFPA Publications.

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

NFPA 10, *Standard for Portable Fire Extinguishers,* 2007 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2007 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2007 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection,* 2003 edition.

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2002 edition.

NFPA 30, *Flammable and Combustible Liquids Code,* 2003 edition.

NFPA 70, *National Electrical Code®,* 2005 edition.

NFPA 72®, *National Fire Alarm Code®,* 2007 edition.

NFPA 80, *Standard for Fire Doors and Other Opening Protectives,* 2007 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids,* 2004 edition.

NFPA *101®*, *Life Safety Code®,* 2006 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 2005 edition.

NFPA 220, *Standard on Types of Building Construction,* 2006 edition.

NFPA 241, *Standard for Safeguarding Construction, Alteration, and Demolition Operations,* 2004 edition.

NFPA 251, *Standard Methods of Tests of Fire Resistance of Building Construction and Materials,* 2006 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source,* 2006 edition.

NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials,* 2006 edition.

NFPA 262, *Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces,* 2007 edition.

NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter,* 2004 edition.

NFPA 286, *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth,* 2006 edition.

2.3 Other Publications.

2.3.1 AMCA Publications.

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

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

AMCA 300, *Reverberant Room Method for Sound Testing of Fans*, 1996.

ANSI/AMCA 210, *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating*, 1999.

2.3.2 APTA Publications.

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

APTA Standard SS-PS-002–098 Rev 2.

2.3.3 ASHRAE Publications.

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

ASHRAE *Handbook — Fundamentals*, 2005.

ASHRAE 149, *Standard of Laboratory Methods of Testing Fans Used to Exhaust Smoke in Smoke Management Systems*, 2000.

2.3.4 ASTM Publications.

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

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

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

ASTM D 3574, *Test* I_2 *(Dynamic Fatigue Test by the Roller Shear at Constant Force) or Test* I_3 *(Dynamic Fatigue Test by Constant Force Pounding)*.

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

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

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

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

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

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

ASTM E 814, *Standard Test Method for Fire Tests of Through-Penetration Fire Stops*, 2002.

ASTM E 1354, *Standard Test Method for Heating and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 2002d.

ASTM E 1537, *Standard Test Method for Fire Testing of Upholstered Furniture*, 2002a.

ASTM E 1590, *Standard Test Method for Fire Testing of Mattresses*, 2002.

2.3.5 California Technical Bulletins.

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

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

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

2.3.6 CSA Publications.

Canadian Standards Association, 5060 Spectrum Way, Mississauga, L4W SN6, Canada.

CSA C22.2 No. 0.3, *Test Methods for Electrical Wires and Cables*, 2001.

2.3.7 ICEA Publications.

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

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

2.3.8 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*, 1999.

2.3.9 IEEE Publications.

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

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

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

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

IEEE 1202, *Standard for Flame Testing of Cables for Use in Cable Tray in Industrial and Commercial Occupancies*, 1991.

2.3.10 UL Publications.

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

ANSI/UL 1666, *Standard Test for Flame Propagation Heights of Electrical and Optical-Fiber Cable Installed Vertically in Shafts*, 1997.

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

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

UL 1581, *Reference Standard for Electrical Wires, Cables and Flexible Cords*, 2001.

UL 1685, *Standard Vertical Cable Tray Propagation and Smoke Release Test for Electrical and Optical Fiber Cables*, 1997.

UL 2196, *Standard for Safety for Tests for Fire Resistive Cables*, 2001.

2.3.11 U.S. Government Publications.

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

Title 14, Code of Federal Regulations, Part 25, Appendix F, Part I, vertical test.

2.3.12 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 72®, *National Fire Alarm Code®,* 2007 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source,* 2006 edition.

NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter,* 2004 edition.

NFPA 402, *Guide for Aircraft Rescue and Fire Fighting Operations,* 2002 edition.

NFPA 472, *Standard for Professional Competence of Responders to Hazardous Materials*

Incidents, 2002 edition.

NFPA 502, *Standard for Road Tunnels, Bridges, and Other Limited Access Highways,* 2004 edition.

NFPA 921, *Guide for Fire and Explosion Investigations,* 2004 edition.

Chapter 3 Definitions

3.1 General.

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

3.2.5 Shall. Indicates a mandatory requirement.

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

3.3 General Definitions.

3.3.1 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.

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

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

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

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

3.3.6 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)].

3.3.7 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,** 2002]

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

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 level(s) or area(s) 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,** 2006]

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

3.3.13 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.

3.3.14* Engineering Analysis/Fire Hazard Analysis. An analysis that evaluates all the various factors that affect the fire safety of the system or component.

3.3.15 Fire Command Center. The principal attended or unattended location where the status of the detection, alarm communications, and control systems is displayed and from which the system(s) can be manually controlled. [*72,* 2007]

3.3.16 Fire Emergency. The existence of, or threat of, fire or the development of smoke or fumes, or any combination thereof, that demands immediate action to correct or alleviate the condition or situation. [**502,** 2004]

3.3.17 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.

3.3.18 Fire Load.

3.3.18.1 *Effective Fire Load.* The portion of the total fire load under a given, specific fire scenario of a certain fuel package that would be expected to be released in a design fire incident (units: joules or Btu). This can include transit and/or passenger rail vehicle(s), luggage, fuel, and/or wayside facilities or structures, that, because of the fuel package configuration, separation, and combustion characteristics, would be expected to be released in a design fire incident.

3.3.18.2 *Total Fire Load.* The total heat energy of all combustibles available from the constituent materials of a certain fuel package (units: joules or Btu). This can include a transit and/or passenger rail vehicle(s), luggage, fuel, and/or wayside facilities or structures.

3.3.19 Fire Smoke Release Rate. Rate of smoke release for a given fire scenario expressed as a function of time (units: m^2/s or ft^2/s).

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

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

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

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

3.3.24* Heat Release Rate (HRR). The rate at which heat energy is generated by burning. [**921,** 2004]

3.3.24.1 *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 NFPA 271 or ASTM E 1354 (units: kW/m^2).

3.3.24.2 *Fire Heat Release Rate for Ventilation Calculations.* Rate of energy release for a given fire scenario expressed as a function of time (units: W or Btu/s).

3.3.25 Incident Commander. The person who is responsible for all decisions relating to the management of the incident and is in charge of the incident site. [**472,** 2002]

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

3.3.27 Noncombustible. Not capable of igniting and burning when subjected to a fire.

3.3.28 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.

3.3.29 Occupancy.

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

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

3.3.30 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.

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

3.3.32 Passenger Load.

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

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

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

3.3.33 Point of Safety. In a transportation system, an enclosed fire exit that leads to a public way or safe location outside the station, trainway, or vehicle, or to an at-grade point beyond the vehicle, any enclosing station, trainway, or vehicle, or another area that affords adequate protection to passengers.

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

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

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

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

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

3.3.39 Smoke Obscuration. The reduction of light transmission by smoke, as measured by light attenuation). [**271,** 2004]

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

3.3.41 Specific Optical Density (D_s). The optical density, as measured in ASTM E 662, over unit path length within a chamber of unit volume, produced from a specimen of unit surface area, that is irradiated by a heat flux of 2.5 W/cm² for a specified period of time.

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

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

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

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

3.3.44 Structure.

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

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

3.3.45 System. See 3.3.49.1, Fixed Guideway Transit System, or 3.3.49.2, Passenger Rail System.

3.3.46 Tenable Environment. In a transportation system, an environment that permits the self-rescue of occupants for a specific period of time.

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

3.3.48 Trainway. That portion of the guideway in which the rail vehicles operate.

3.3.49 Transportation Systems.

3.3.49.1 *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 system; buildings; maintenance facilities; stations; transit vehicle yard; and other stationary and movable apparatus, equipment, appurtenances, and structures.

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

3.3.49.2 *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; maintenance facilities; stations; passenger rail vehicle yard; and other stationary and movable apparatus, equipment, appurtenances, and structures.

3.3.50 Vehicle.

3.3.50.1 *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.

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

Chapter 4 General

4.1 Characteristics of Fire Safety.

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 provide requirements for the protection of 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 Goal.

4.2.1 The goal 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) Protect occupants not intimate with the initial fire development

(2) Maximize 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 3.3.27) are not used due to other considerations in the design and constructions 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 goals stated in Section 4.2 shall be effective in mitigating the hazard or condition for which they are being used, shall be reliable, shall be maintained to the level at which they were designed to operate, and shall remain operational.

4.4 Assumption of a Single Fire Source.

The protection methods described in this standard shall assume a single fire source.

Chapter 5 Stations

5.1 General.

5.1.1 Occupancy.

5.1.1.1 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.

5.1.1.2 Where contiguous commercial occupancies are in common with the station, or where the station is integrated into a building the occupancy of which is neither for fixed guideway transit nor for passenger rail, special considerations beyond this standard shall be necessary.

5.1.1.3 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 Construction Materials. Building construction for all new stations shall be not less than Type I– or Type II– or combinations of Type I– and Type II–approved noncombustible construction as defined in NFPA 220, as determined by an engineering analysis of potential fire exposure hazards to the structure.

5.2.2 Safeguards During Construction. During the course of construction or major modification of any structure, provisions of NFPA 241 shall apply.

5.2.3 Compartmentation and Fire Separation.

5.2.3.1 Stair and Escalator Enclosure. Stairs and escalators regularly used by passengers shall not be required to be enclosed.

5.2.3.2 Ancillary Spaces. In all stations, fire resistance ratings of separations between occupancies shall be established as required by the local building code in accordance with NFPA 251.

5.2.3.2.1 All power substations shall have a fire separation of at least 3 hours from all other occupancies.

5.2.3.2.2 Electrical control rooms, auxiliary electrical rooms, and associated battery rooms shall have a fire separation of at least 2 hours from all other occupancies.

5.2.3.2.3 Trash rooms shall have a fire separation of at least 1 hour from all other occupancies.

5.2.3.2.4 Train control rooms and associated battery rooms shall have a fire separation of at least 2 hours from all other occupancies.

5.2.3.2.5 All public areas shall have a fire separation of at least 2 hours from nonpublic areas.

5.2.3.3 Doors and Openings. Doors and other openings through the separations identified in 5.2.3.2, including 5.2.3.2.2 through 5.2.3.2.5, shall be protected by fire door assemblies having a protection rating of 1½ hours.

5.2.3.3.1 Power substations identified in 5.2.3.2.1 shall be protected by fire door assemblies having a protection rating of 3 hours.

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

5.2.3.5 Fire Separation.

5.2.3.5.1* All station public areas shall have a fire separation of at least 3 hours from all nontransit occupancies.

5.2.3.5.2 The fire separation for stations shall be permitted to be modified based on an engineering analysis of potential fire exposure hazards.

5.2.3.6 Openings.

5.2.3.6.1 All openings (e.g., private entrances) from station public areas to all nontransit occupancies shall be protected by approved fire-protective assemblies with an appropriate rating for the location in which they are installed.

5.2.3.6.2 Where a fire door is required to be open, one of the following shall apply:

(1) The door shall be of the automatic closing type.

(2) The door shall be activated by listed smoke detectors.

(3) Where a separate smoke barrier is provided, the operation shall be permitted to be by fusible links.

5.2.3.6.3 Fire doors shall be installed in accordance with NFPA 80.

5.3 Ventilation.

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

5.4 Wiring Requirements.

5.4.1 All wiring materials and installations within stations other than for traction power shall conform to requirements of NFPA 70 and, in addition, shall satisfy the requirements of 5.4.2

through 5.4.9.

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

5.4.2.1 Other materials when encased in concrete shall be acceptable.

5.4.3 All conductors shall be insulated.

5.4.3.1 Ground wire installed in a metallic raceway shall be insulated.

5.4.3.2 Other ground wires shall be permitted to be bare.

5.4.4 All insulations shall conform to Article 310 of NFPA 70 and shall be moisture- and heat-resistant type carrying temperature ratings corresponding to either of the following conditions:

(1) 75°C (167°F) for listed fire-resistive cables

(2) 90°C (194°F) for all other applications

5.4.5 Wire and cable constructions intended for use in operating train signal circuits, power circuits to emergency lights, and so forth shall be listed as being resistant to the spread of fire and shall have reduced smoke emissions.

5.4.5.1* Cable shall be permitted to be listed in accordance with any of the following methods:

(1) The cable does not spread fire to the top of the tray in the vertical-tray flame test in Section 1160 of UL 1581, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode, when tested in accordance with ASTM E 662.

(2) The cable exhibits damage (char length) that does not exceed 1500 mm (4.9 ft) when the vertical flame test, with cables in cable trays, is performed as described in CSA C22.2 No. 0.3, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode, when tested in accordance with ASTM E 662.

(3) The cable is listed as a limited smoke cable (/LS) by meeting the cable damage height, total smoke released, and peak smoke release rate criteria required when tested in the vertical tray flame test in UL 1685. The following performance criteria shall be met when testing according to UL 1685:

  (a) When testing in the UL vertical tray flame exposure:

    i. The cable damage height shall be less than 2500 mm (8.2 ft) when measured from the bottom of the cable tray.

    ii. The total smoke released shall not exceed 95 m^2 (1023 ft^2).

iii. The peak smoke release rate shall not exceed 0.25 m^2/s (2.69 ft^2/s).

(b) Alternatively, when testing in the IEEE 1202 flame exposure:

i. The cable damage height shall be less than 1500 mm (4.9 ft) when measured from the lower edge of the burner face.

ii. The total smoke released shall not exceed 150 m^2 (1615 ft^2).

iii. The peak smoke release rate shall not exceed 0.40 m^2/s (4.3 ft^2/s).

(4) The cable is listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor, by being capable of passing the requirements of ANSI/UL 1666, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode, when tested in accordance with ASTM E 662.

(5) The cable is listed as having adequate fire-resistant and low-smoke-producing characteristics, by having a flame travel distance that does not exceed 1500 mm (4.9 ft), generating a maximum peak optical density of smoke of 0.5 and a maximum average optical density of smoke of 0.15 when tested in accordance with NFPA 262.

5.4.6 All conductors, except radio antennas, shall be enclosed in their entirety in armor sheaths, conduits, or enclosed raceways, boxes, and cabinets except in ancillary areas or other nonpublic areas.

5.4.6.1* Conductors in conduits or raceways shall be permitted to be embedded in concrete or run in concrete electrical duct banks, but they shall not be installed exposed or surface-mounted in air plenums unless cables are listed fire-resistive cables in accordance with 5.4.10.

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

5.4.8 Conductors for emergency lighting and communications shall be protected from physical damage by system vehicles or other normal system operations and from fires in the system by any of the following:

(1) Suitable embedment or encasement

(2) Routing of such conductors external to the interior underground portions of the transit system facilities

(3) Diversity in system routing (such as separate redundant or multiple circuits, or circuits with a physically diverse network topology) so that a single fire or emergency event in the station will not lead to a failure of the system

(4) Be a listed fire-resistive cable system with a minimum 1-hour rating in accordance with 5.4.10

5.4.9 Power Supply for Emergency Ventilation Fans. See Chapter 7.

5.4.10 Fire-resistive cables, where permitted, shall be listed and have a minimum 1-hour fire-resistive rating in accordance with UL 2196 and shall be installed per the listing requirements.

5.4.11 Emergency Power. Enclosed stations shall be provided with Class I, Type 60 emergency power in accordance with Article 700 of NFPA 70, and NFPA 110.

5.4.11.1 The emergency power system shall have a capacity and rating sufficient to supply all equipment required to be connected by 5.4.11.3.

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

5.4.11.3 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

5.5* Means of Egress.

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

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

5.5.1.2 Stairs and escalators permitted by 5.2.3.1 to be unenclosed shall be permitted to be counted as contributing to the means of egress capacity in stations as detailed in 5.5.2 and 5.5.6.

5.5.1.3 Alternate Egress. At least two means of egress remote from each other shall be provided from each station platform.

5.5.1.3.1 Means of egress from separate platforms shall be permitted to converge.

5.5.1.3.2 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.

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

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

5.5.2 Escalators. *(See also Section C.2.)*

5.5.2.1 Escalators shall be permitted as a means of egress in stations provided the following criteria are met:

(1)* The escalators are 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 remotely or manually. *(See Section C.2.)*

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

5.5.2.3 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 steps shall be heated to prevent the accumulation of ice and snow.

5.5.2.4 Stopped escalators shall be permitted to be started in the direction of egress provided that the escalators can be restarted in a fully loaded condition and that passengers are given warning.

5.5.3 Fare Collection Gates or Turnstiles. The design features of 5.5.3.1 and 5.5.3.2 shall be provided to facilitate the exit of passengers in the event of an emergency.

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

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

5.5.4 Platform Screen and Edge Doors. Horizontal sliding platform screen or platform edge doors shall be permitted to separate the platform from the trainway in stations provided that the following criteria are met:

(1) The doors permit emergency egress from the train to the platform regardless of the stopping position of the train.

(2) The doors provide egress when a force not exceeding 220 N (49 lb) is applied from the train side of the doors.

(3) The doors are designed to withstand positive and negative pressures caused by passing trains.

5.5.5 Occupant Load.

5.5.5.1* 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.

5.5.5.2 The train load shall consider only one train at any one track.

5.5.5.2.1 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.

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

5.5.5.4 At multiplatform stations, the maximum occupant load for each platform shall be considered separately for the purpose of sizing the means of egress from that platform.

5.5.5.4.1* At multilevel stations, simultaneous loads shall be considered for all egress routes passing through each level of that station.

5.5.5.5 Where an area within a station is intended for use by other than passengers or employees, the occupant load for that area shall be determined in accordance with the provisions of NFPA *101* as appropriate for the class of occupancy.

5.5.5.5.1 The additional occupant load shall be included in determining the required egress from that area.

5.5.5.5.2 The additional occupant load shall be permitted to be omitted from the station occupant load when the area has independent means of egress of sufficient number and capacity.

5.5.5.6* Calculation of Platform Occupant Load. The platform occupant load for each platform in a station shall be the maximum peak period loads calculated according to 5.5.5.6.1 through 5.5.5.6.4.

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

5.5.5.6.2 The entraining load for each platform shall be the sum of the entraining loads for each track serving that platform.

5.5.5.6.2.1* The entraining load for each track shall be based on the entraining load per train headway factored to account for service disruptions and system reaction time.

5.5.5.6.3 The train load for each platform shall be the sum of the train loads for each track serving that platform.

5.5.5.6.3.1 The maximum train load for each track shall be based on the train load per train headway factored to account for service disruptions and system reaction time.

5.5.5.6.4 The maximum train load at each track shall be the maximum passenger capacity for the largest capacity train operating on that track during the peak period.

5.5.6* Number and Capacity of Means of Egress.

5.5.6.1 Platform Evacuation Time. There shall be sufficient egress capacity to evacuate the platform occupant load as defined in 5.5.5.6 from the station platform in 4 minutes or less.

5.5.6.1.1 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 (300 ft).

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

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

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

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

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

5.5.6.3 Capacity of Means of Egress Components. The capacity of the means of egress shall be computed in persons per millimeter per minute (p/mm-min) [persons per inch per minute (pim)], and passenger travel speeds in meters per minute (m/min) [feet per minute (fpm)] in accordance with 5.5.6.3.1 through 5.5.6.3.3.

5.5.6.3.1 Platforms, Corridors, and Ramps.

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

5.5.6.3.1.2* In computing the means of egress capacity available on platforms, corridors, and ramps, 300 mm (1 ft) shall be deducted at each sidewall and 460 mm (1 ft 6 in.) at open platform edges.

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

5.5.6.3.1.4 The maximum means of egress travel speed along platforms, corridors, and ramps shall be computed at 37.8 m/min (124 fpm).

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

5.5.6.3.2 Stairs and Escalators.

5.5.6.3.2.1 Stairs in the means of egress shall be a minimum of 1100 mm (43 in.) wide.

5.5.6.3.2.2* Escalators shall be permitted to be used as a means of egress.

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

(1) Capacity — 0.0555 p/mm-min (1.41 pim)

(2)* Travel speed — 14.63 m/min (48 fpm) (indicates vertical component of travel speed)

5.5.6.3.2.4* Escalators shall not account for more than half of the means of egress capacity at any one level.

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

(1) The escalators are capable of being remotely brought to stop after a warning announcement from a location having visual surveillance of the full escalator.

(2) A portion of the means of egress capacity from each station level is comprised of stairs.

(3) For enclosed stations, at least one enclosed exit stair or exit passageway shall provide continuous access from the platforms to the public way.

5.5.6.3.2.6* In calculating the egress capacity of escalators, one escalator at each level shall be considered as being out of service.

5.5.6.3.2.7 The escalator chosen shall be the one having the most adverse effect upon egress capacity.

5.5.6.3.3 Doors and Gates.

5.5.6.3.3.1 Doors and gates in the means of egress shall have a minimum clear width of 915 mm (36 in.).

5.5.6.3.3.2 The maximum means of egress capacity for doors and gates shall be computed at 0.0893 p/mm-min (2.27 pim) clear width dimension.

5.5.6.3.3.3 Emergency exit gates shall be in accordance with NFPA *101*.

5.5.6.3.3.4* Gate-type exits shall be provided for at least 50 percent of the required emergency exit capacity unless fare collection equipment provides unobstructed exiting under all conditions.

5.5.6.3.4 Fare Collection Equipment.

5.5.6.3.4.1 Gate-type fare collection equipment shall meet the following criteria:

(1) They shall provide a minimum of 450 mm (18 in.) clear width at and below a height of 960 mm (38 in.) and 710 mm (28 in.) clear width above a height of 950 mm (38 in.) when deactivated.

(2) Consoles shall not exceed 1000 mm (39 in.) in height.

(3) They shall have a capacity of 50 people per minute (ppm) for egress calculations.

5.5.6.3.4.2 Turnstile-type fare collection equipment shall meet the following criteria:

(1) They shall provide a minimum of 450 mm (18 in.) clear width.

(2) They shall have a maximum height of 900 mm (35 in.) at the turnstile bar.

(3) They shall free-wheel in the direction of egress when deactivated.

(4) They shall have a capacity of 25 people per minute (ppm) for egress calculations.

5.5.6.3.4.3 Electronically operated fare collection equipment in the required means of egress shall be designed to release, permitting unimpeded travel in the direction of egress upon 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

5.6 Emergency Lighting.

5.6.1 Stations shall be provided with a system of emergency lighting in accordance with NFPA *101*, except as otherwise noted in this standard.

5.6.2 Emergency lighting for stairs and escalators shall be designed to emphasize illumination on the top and bottom steps and landings.

5.6.2.1 All newel- and comb-lighting on escalator steps shall be on emergency power circuits.

5.7 Fire Protection.

5.7.1 Protective Signaling Systems.

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

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

5.7.1.2.1 The location shall be approved by the authority having jurisdiction.

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

5.7.1.3 When activated, all fire alarm, smoke detection, valve switches, and waterflow indicator signals shall be transmitted simultaneously to the local station and to the central supervising station.

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

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

5.7.2 Emergency Communication.

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

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

5.7.2.2.1 These notification devices shall be placed in approved locations at each facility.

5.7.2.3 Emergency alarm reporting devices shall be located on passenger platforms and throughout the stations such that the travel distance from any point in the public area shall not exceed 100 m (328 ft) or 90 m (295 ft) unless otherwise approved by the authority having jurisdiction.

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

5.7.3 Automatic Sprinkler Systems.

5.7.3.1 An automatic sprinkler protection system shall be provided in areas of stations used for concessions, in storage areas, in trash rooms, and in the steel truss area of all escalators and other similar areas with combustible loadings, except trainways.

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

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

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

5.7.3.4 Other approved fire suppression systems shall be permitted to be substituted for automatic sprinkler systems in the areas listed in 5.7.3.1 with the approval of the authority having jurisdiction.

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

5.7.4 Standpipe and Hose Systems.

5.7.4.1 Class I or Class III standpipes shall be installed in enclosed stations in accordance with NFPA 14 except as modified herein.

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

(1) The system is cross-connected or fed from two locations.

(2) Isolation valves are installed not more than 245 m (800 ft) apart.

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

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

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

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

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

5.7.6* Fire Command Center.

5.7.6.1 Underground stations shall be provided with a fire command center in accordance with *NFPA 72*.

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

5.8 Storage Tanks and Service Stations.

5.8.1 Aboveground storage tanks above subsurface stations shall meet the requirements of 6.6.4.

5.8.2 Underground storage tanks above subsurface station structures shall meet the requirements of 6.6.5.

5.8.3 Service stations above subsurface station structures shall meet the requirements of 6.6.6.

5.8.4 Existing storage tanks in or under buildings shall meet the requirements of 6.6.7.

5.9 Seating Furniture.

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

(1) The peak rate of heat release for the single seating furniture item shall not exceed 80 kW.

(2) The total energy released by the single seating furniture item during the first 10 minutes of the test shall not exceed 25 MJ.

5.10 Interior Finish.

5.10.1 Interior Wall and Ceiling Finish.

5.10.1.1 Interior wall and ceiling finish materials in stations shall comply with one of the following:

(1) Interior wall and ceiling finish materials shall be noncombustible materials.

(2) Interior wall and ceiling finish materials, other than textile wall coverings or foam plastic insulation, shall exhibit a flame spread index not exceeding 25 and a smoke developed index not exceeding 450, when tested by NFPA 255 or by ASTM E 84.

5.10.1.2 Interior wall and ceiling finish materials, when tested in accordance with NFPA 286, shall comply with the following:

(1) Flames shall not spread to the ceiling during the 40 kW exposure.

(2) During the 160 kW exposure, the following criteria shall be met:

(a) Flame shall not spread to the outer extremities of the sample on the 2440 mm × 3660 mm (96 in. × 144 in.) wall.

(b) The peak heat release rate shall not exceed 800 kW.

(c) Flashover shall not occur.

(3) The total smoke released throughout the test shall not exceed 1000 m^2.

5.10.2 Interior Floor Finish. Interior floor finish materials in stations shall be noncombustible or shall exhibit a critical radiant flux not less than 0.8 W/cm^2 when tested in accordance with ASTM E 648.

5.11 Rubbish Containers.

Rubbish containers shall be manufactured of noncombustible materials.

5.12* Combustible Furnishings and Contents.

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.

Chapter 6 Trainways

6.1 Safeguards During Construction.

During the course of construction or major modification of any trainway, provisions of NFPA 241 shall apply, except as modified in this chapter.

6.2 Egress for Passengers.

6.2.1 General.

6.2.1.1 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.

6.2.1.2 System egress points shall be illuminated.

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

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

6.2.1.5 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.

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

6.2.1.7 Crosswalks shall be provided at track level to ensure walkway continuity.

6.2.1.8 Crosswalks shall have uniform walking surface at the top of the rail.

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

6.2.1.10 A guard shall not be required on the trackside of raised walkways in trainways.

6.2.1.11* The means of egress within the trainway shall be provided with an unobstructed clear width of 610 mm (24 in.) along the walking surface measured at the following points:

(1) 610 mm (24 in.) at the walking surface

(2) 760 mm (30 in.) at 1420 mm (56 in.) above the walking surface

(3) 610 mm (24 in.) at 2050 mm (80 in.) above the walking surface

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

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

6.2.2 Means of Egress Underground.

6.2.2.1 General. The provisions for means of egress shall comply with Chapter 7 of NFPA *101* except as herein modified.

6.2.2.2* Number and Location of Means of Egress Routes. Within underground or enclosed trainways, the maximum distance between exits shall not exceed 762 m (2500 ft).

6.2.2.3 Cross-Passageways.

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

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

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

(2) Cross-passageways shall not be further than 244 m (800 ft) from the station, tunnel

portal, or ventilation inlet.

(3) Cross-passages shall be provided with a minimum clear width of 1120 mm (44 in.) and ceiling height of 2100 mm (7 ft).

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

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

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

(7) An approved method shall be provided for evacuating passengers in the uncontaminated trainway.

(8) An approved method for protecting passengers from oncoming traffic shall be provided.

(9) An approved method for evacuating the passengers to a nearby station or other emergency exit shall be provided.

6.2.2.4 Doors.

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

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

(1) Open fully when a force not exceeding 220 N (50 lb) is applied to the latch side of the door

(2) Be adequate to withstand positive and negative pressures caused by passing trains and tunnel ventilation system

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

6.2.2.5 Exit Hatches.

6.2.2.5.1 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 (29 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.

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

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

6.2.3 Surface and Elevated Emergency Access.

6.2.3.1 Surface.

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

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

6.2.3.1.3 Access gates shall be placed as close as practical to the portals to permit easy access to tunnels.

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

6.2.3.2 Elevated.

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

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

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

6.2.3.2.4 Adjacent to each blue light station, information shall be provided that identifies the route and location of the access.

6.2.3.2.5 The graphics shall be legible from the ground level outside the trackway.

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

6.2.4.1 General. Combustible components not covered in 6.3.1 through 6.3.3.2.8 shall comply with 6.2.4.

6.2.4.2 Engineering Analysis.

6.2.4.2.1 An engineering analysis shall be conducted on nonstructural combustible components that includes, as a minimum, an examination of peak heat release rate for combustible elements, total heat released, ignition temperatures, radiant heating view factors, and behavior of the component during internal or external fire scenarios to determine that, if a fire propagates beyond involving the component of fire origin, a level of fire safety is provided within an enclosed trainway commensurate with this standard.

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

6.2.5 Emergency Lighting.

6.2.5.1 The requirements of 6.2.5.2 through 6.2.5.5.2 shall apply to all underground or enclosed trainways that are greater than 30.5 m (100 ft) in length or 2 car lengths, whichever is greater.

6.2.5.2 Emergency lighting systems shall be installed and maintained in accordance with NFPA 70.

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

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

6.2.5.5* The illumination levels of underground, enclosed or elevated trainway walkways and walking surfaces (i.e., trackway and bench wall walkway) shall not be less than 2.7 lx (0.25 ft-candles) at the walking surface.

6.2.5.5.1 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.

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

6.2.6 Warning Signs.

6.2.6.1 Warning signs shall be posted on entrances to the trainway (e.g., station platforms and portals), on fences or barriers adjacent to the trainway, and at such other places where nontransit authority employees might trespass.

6.2.6.2 The warning signs shall clearly state the hazard (e.g., DANGER HIGH VOLTAGE — 750 VOLTS) with letter sizes and colors in conformance with NFPA 70 and Occupational Safety and Health Administration (OSHA) requirements.

6.2.7 Blue Light Station.

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

(1) At the ends of station platforms

(2) At cross-passageways *(see 6.2.2.3)*

(3) At emergency access points

(4) At traction power substations

(5) In underground trainways as required by the authority having jurisdiction

6.2.7.2 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.

6.2.8* Directional Signs.

6.2.8.1 Underground or 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.

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

6.2.8.3 Signs shall be readily visible by passengers for emergency evacuation.

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

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

6.3 Construction Materials.

6.3.1 General.

6.3.1.1 Underground (Subways).

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

6.3.1.1.2 Lining.

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

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

6.3.1.1.3 Walking Surfaces.

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

6.3.1.1.3.2 Walking surfaces shall have a slip-resistant design.

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

6.3.1.1.5 Rail Ties.

6.3.1.1.5.1 Noncombustible rail ties shall be used in underground locations except at switch or crossover locations, where fire-retardant, treated wood ties are used.

6.3.1.1.5.2 Wood ties and tie blocks that are encased in concrete such that only the top surface is exposed shall be permitted in underground track sections.

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

6.3.1.1.7 Ancillary Areas.

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

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

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

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

6.3.2 Ventilation. Emergency ventilation shall be provided in enclosed trainways in accordance with Chapter 7.

6.3.3 Wiring Requirements. *(See Section 5.4.)*

6.3.3.1* General.

6.3.3.1.1 Traction power shall include the wayside pothead, the cable between the pothead and the contact (third) rail or overhead wire, the contact rail supports, and special warning and identification devices.

6.3.3.1.2 Life safety and fire protection criteria for the subsystem installed in the trainway shall conform to the requirements for underground trainways that are listed in 6.4.2.

6.3.3.1.3 All wiring materials and installations other than those for traction power shall conform to the requirements of NFPA 70.

6.3.3.2 Underground (Subways).

6.3.3.2.1 All wiring materials and installations within trainways, other than for traction power, shall conform to the requirements of NFPA 70 and, in addition, shall satisfy the requirements of 6.3.3.2.2 through 6.3.3.2.9.

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

6.3.3.2.2.1 Other materials, where encased in concrete or suitably protected, shall be acceptable.

6.3.3.2.3 All conductors shall be insulated.

6.3.3.2.3.1 Ground wire installed in a metallic raceway shall be insulated.

6.3.3.2.3.2 Other ground wires shall be permitted to be bare.

6.3.3.2.4 All insulations shall conform to Article 310 of NFPA 70 and shall be moisture- and heat-resistant types carrying temperature ratings corresponding to either of the following conditions:

(1) 75°C (167°F) for listed fire-resistive cables

(2) 90°C (194°F) for all other applications

6.3.3.2.5 All wire and cable constructions intended for use in trainways, other than traction power cables, shall be listed as being resistant to the spread of fire and shall have reduced smoke emissions in accordance with 6.3.3.2.5.1.

6.3.3.2.5.1* Cable shall be permitted to be listed by any of the following methods:

(1) The cable does not spread fire to the top of the tray in the vertical-tray flame test in UL 1581, Section 1160, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode when tested in accordance with ASTM E 662.

(2) The cable exhibits damage (char length) that does not exceed 1500 mm (4.9 ft) when the vertical flame test, with cables in cable trays, is performed as described in CSA C22.2 No. 0.3, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode when tested in accordance with ASTM E 662.

(3) The cable is listed as a limited smoke cable (/LS) by meeting the cable damage height, total smoke released, and peak smoke release rate criteria required when tested in the vertical tray flame test in UL 1685. The following performance criteria shall be met when testing by UL 1685.

    (a) When testing in the UL vertical tray flame exposure, the following requirements shall be met:

        i. The cable damage height shall be less than 2500 mm (8.2 ft) when measured from the bottom of the cable tray.

        ii. The total smoke released shall not exceed 95 m^2 (1023 ft^2).

        iii. The peak smoke release rate shall not exceed 0.25 m^2/s (4.3 ft^2/s).

    (b) Alternatively, when testing in the IEEE 1202 flame exposure, the following requirements shall be met:

        i. The cable damage height shall be less than 1500 mm (4.9 ft) when measured from the lower edge of the burner face.

ii. The total smoke released shall not exceed 150 m^2 (1615 ft^2).

iii. The peak smoke release rate shall not exceed 0.40 m^2/s (4.5 ft^2/s).

(4) The cable is listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor, by being capable of passing the requirements of ANSI/UL 1666, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode when tested in accordance with ASTM E 662.

(5) The cable is listed as having adequate fire-resistant and low smoke-producing characteristics, by having a flame travel a distance that does not exceed 1500 mm (4.9 ft), generating a maximum peak optical density of smoke of 0.5 and a maximum average optical density of smoke of 0.15 when tested in accordance with NFPA 262.

6.3.3.2.6* All conductors, except radio antennas, shall be enclosed in their entirety in armor sheaths, conduits, or enclosed raceways, boxes, and cabinets except in ancillary areas.

6.3.3.2.6.1* Conductors in conduits or raceways shall be permitted to be embedded in concrete or run in concrete electrical duct banks, but shall not be installed, exposed, or surface-mounted in air plenums unless cables are listed fire-resistive cables in accordance with 5.4.10.

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

6.3.3.2.8 Conductors for emergency lighting and communications shall be protected from physical damage by transit or passenger rail vehicles or other normal operations and from fires in the system by one of the following:

(1) Suitable embedment or encasement

(2) Routing of such conductors external to the interior underground portions of the transit system facilities

(3) Diversity in system routing (such as separate redundant or multiple circuits or integrated loop systems) so that a single fire or emergency event in the trainway will not lead to a failure of the system

(4) Use of a listed fire-resistive cable system with a minimum 1-hour rating in accordance with 6.3.3.2.10.

6.3.3.2.9 Power Supply for Emergency Ventilation. See Chapter 7.

6.3.3.2.10 Fire-resistive cables used for emergency lighting and communication shall be listed and have a minimum 1-hour fire-resistive rating in accordance with UL 2196 and shall be installed per the listing requirements.

6.4 Traction Power.

6.4.1 Application.

6.4.1.1* Section 6.4 shall apply to life safety and fire protection criteria for the traction power subsystem installed in the underground trainway.

6.4.1.2 Section 6.4 shall apply to traction power, 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.

6.4.2 Traction Power Contact Rail Protection.

6.4.2.1 To provide safety isolation from the contact rail, the requirements of 6.4.2.2 through 6.4.2.6 shall apply.

6.4.2.2 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.

6.4.2.3 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.

6.4.2.4 Coverboards, where used, shall be capable of supporting a vertical load of 1100 N (247 lb) at any point with no visible permanent deflection.

6.4.2.5 Coverboard or Protective Material.

6.4.2.5.1 Coverboard or protective material shall have a flame spread rating index of not more than 25 and a smoke developed index not exceeding 450 when tested in accordance with NFPA 255 (ASTM E 84).

6.4.2.5.2 Materials that comply with the requirements of 6.4.2.5.3 when tested in accordance with NFPA 286 shall be permitted to be used in all areas where flame spread index and smoke developed index when tested by NFPA 255 or by ASTM E 84 is required.

6.4.2.5.3 Test Criteria. The following test criteria shall apply:

(1) Flames shall not spread to the ceiling during the 40 kW exposure.

(2) During the 160 kW exposure, the following criteria shall be met:

   (a) Flame shall not spread to the outer extremities of the sample on the 2440 mm × 3660 mm (96 in. × 144 in.) wall.

   (b) Flashover shall not occur.

(3) The peak heat release rate throughout the test shall not exceed 800 kW.

(4) The total smoke released throughout the test shall not exceed 1000 m^2.

6.4.2.6 Insulating material for the cable connecting power to the rail shall meet the requirements of IEEE 383, Section 2.5.

6.4.3 Traction Power Overhead Contact System Protection.

6.4.3.1 To provide isolation from the overhead contact system, the requirements of 6.4.3.2 and 6.4.3.3 shall apply.

6.4.3.2 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.

6.4.3.3 Insulating material for the cable connecting power to the overhead contact system shall meet the requirements of IEEE 383, Section 2.5.

6.5 Protection.

6.5.1 Automatic Fire Detection.

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

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

6.5.2 Standpipe and Hose Systems.

6.5.2.1 An approved fire standpipe system shall be provided in underground fixed guideway transit or passenger rail system trainways where physical factors prevent or impede access to the water supply or fire apparatus, where required by the authority having jurisdiction.

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

(1) The system is cross-connected or fed from two locations.

(2) Isolation valves are installed not more than 245 m (800 ft) apart.

6.5.2.2 Standpipes shall be permitted to be of the dry type with the approval of the authority having jurisdiction.

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

6.5.2.3.1 Acceptable water supplies shall include the following:

(1) Municipal or privately owned waterworks systems that have adequate pressure and flow rate and a level of integrity acceptable to the authority having jurisdiction

(2) Automatic or manually controlled fire pumps that are connected to an approved water source

(3) Pressure-type or gravity-type storage tanks that are installed in accordance with NFPA 22.

6.5.2.4 Identification numbers and letters conforming to the sectional identification numbers and letters of the fixed guideway transit or passenger trainway system shall be provided at each surface fire department connection and at each hose valve on the standpipe lines.

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

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

6.5.2.5 An approved water supply shall be provided for standpipe systems.

6.5.2.6 A fire department access road shall extend to within 30 m (100 ft) of the fire department connection.

6.5.3 Standpipe Installations in Tunnels Under Construction.

6.5.3.1 A standpipe system shall be installed in tunnels under construction in accordance with NFPA 241.

6.5.3.1.1 A standpipe system shall be installed in tunnels under construction before the tunnel has exceeded a length of 61 m (200 ft) beyond any access shaft or portal and shall be extended as tunnel work progresses.

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6.5.3.2 Reducers or adapters shall be provided and attached for connection of the contractor's hose.

6.5.3.3 Reducers or adapters shall be readily removable through the use of a fire fighter's hose spanner wrench.

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6.5.3.4 Risers shall be identified with signs as outlined in 6.5.2.4.

6.5.3.5 Risers shall be readily accessible for fire department use.

6.5.3.6 Risers shall be protected from accidental damage.

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

6.6 Flammable and Combustible Liquids Intrusion.

6.6.1 General. Prevention of accidental intrusion of flammable and combustible liquids due to spills shall be provided in accordance with 6.6.2 through 6.6.7.

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

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

(1) It is at a higher elevation than the surrounding grade level.

(2) It is separated from the roadway by a concrete curb at least 150 mm (6 in.) in height.

6.6.4 Aboveground Atmospheric Storage Tanks. Aboveground atmospheric storage tanks storing, handling, or processing Class I flammable liquid or Class II or Class III combustible liquids and related piping shall not be located directly over a subsurface structure or within 6 m (20 ft) measured horizontally from the outside wall of such subsurface structure unless provided with an approved leak detection system.

6.6.4.1 Where the top of the subsurface trainway or station is more than 15 m (49.2 ft) below the surface of the earth, an engineering analysis to determine the need of rate requirement in 6.6.4 shall be permitted to be conducted.

6.6.5 Underground Storage Tanks. Underground storage tanks for Class I flammable or Class II or Class III combustible liquids and related piping shall not be permitted directly over a subsurface structure or within 6 m (20 ft) measured horizontally from the outside wall of such subsurface structure. *(See 6.6.7 for tanks in or under existing buildings.)*

6.6.5.1 Where the top of the subsurface trainway or station is more than 15 m (49.2 ft) below the surface of the earth, an engineering analysis to determine the need for the requirement in 6.6.5 shall be permitted to be conducted.

6.6.5.2 For underground storage tanks and related piping for Class I flammable or Class II or Class III combustible liquids located in the area between 6 m (20 ft) and 30 m (98.4 ft) (measured horizontally) from the outside wall of the subsurface structure and within that same area, such tanks and related piping within 600 mm (24 in.) (measured vertically) below the lowest point of subsurface structure excavation shall be constructed and installed according to one of the following methods:

(1) For tanks of double-wall construction, the following shall apply:

    (a) Tanks shall be equipped with an approved automatic leak detection and monitoring system.

    (b) Tanks shall be provided with an approved corrosion protection system.

    (c) Installation, maintenance, and inspection shall conform to the requirements specified by the authority having jurisdiction.

(2) For tanks installed in a cast-in-place reinforced concrete vault large enough to hold and retain the entire contents of the tank, the following shall apply:

    (a) The storage tank shall be completely encompassed by not less than 600 mm (24 in.) of well-tamped, noncorrosive inert material within the vault.

    (b) An approved method for the monitoring of, or testing for, product and enclosure leakage shall be incorporated into the enclosure design.

    (c) The vault lid shall be designed and constructed to withstand anticipated surface loadings and shall be not less than 150 mm (6 in.) of reinforced concrete.

(d) Vault, tank, and piping shall be protected from corrosion.

6.6.5.3 All tanks, vaults, and appurtenances used to store Class I flammable and Class II and Class III combustible liquids shall be compatible with the materials stored and shall conform to the provisions of NFPA 30.

6.6.6 Service Stations.

6.6.6.1 Service stations dispensing Class I flammable liquids and Class II and Class III combustible liquids, and located in the area within 30 m (98.4 ft) (measured horizontally) from the outside wall of the underground structure, shall be required to comply with 6.6.6.2 through 6.6.6.5.

6.6.6.2 The surface around pump islands shall be graded or drained in a manner to divert spills away from the tunnel vent gratings or tunnel entrances or exits.

6.6.6.3 Continuous drains across driveways, ramps, or curbs of at least 150 mm (6 in.) in height shall separate service station properties from adjacent tunnel vent gratings or tunnel entrances or exits.

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

6.6.6.5 Dispensing pumps for Class I flammable liquids and Class II and Class III combustible liquids shall not be located less than 6 m (20 ft) from the face of such pump to the nearest side of a tunnel vent grating or subway entrance or exit.

6.6.7 Existing Storage Tanks in or Under Buildings.

6.6.7.1 Existing storage tanks for Class I flammable liquids and Class II and Class III combustible liquids located in or under buildings, and located directly above a subsurface transit structure or within 6 m (20 ft) (measured horizontally) from the outside wall of the subsurface transit structure, shall be removed and relocated outside the prohibited area.

6.6.7.1.1 Where the top of the subsurface trainway or station is more than 15 m (49.2 ft) below the surface of the earth, an engineering analysis to determine the need for the requirement of 6.6.7.1 shall be permitted to be conducted.

6.6.7.2 Where it is not possible to remove and relocate tanks for Class I flammable and Class II combustible liquids due to limited space, such underground tanks shall be abandoned in accordance with the provisions of Annex C of NFPA 30.

6.6.7.3 Where it is not possible to remove and relocate tanks for Class III combustible liquids located in buildings, such tanks shall be provided with leak detection and a secondary containment system of adequate capacity to contain the contents of the tank.

6.6.7.4 Tanks shall be abandoned in accordance with the provisions of Annex C of NFPA 30.

6.6.7.5 Where it is not possible to remove and relocate tanks for Class III combustible liquids located under a building, such tanks shall be UL-listed double wall or installed in a cast-in-place reinforced concrete vault and shall be provided with an approved leak detection system.

6.6.7.6 Tanks shall be abandoned in accordance with the provisions of Annex C of NFPA 30.

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 or trainway as required by Section 5.3 and 6.3.2.

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

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

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

(1) In an enclosed system station

(2) In a system underground or enclosed trainway that is greater in length than 300 m (984 ft)

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

(1) In an open system station

(2) Where the length of an underground trainway is less than or equal to 60 m (197 ft)

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

(1) Where the length of the underground or enclosed trainway is less than or equal to 300 m (984 ft) and greater than 60 m (197 ft)

(2) In an enclosed station where engineering analysis indicates that a nonmechanical emergency ventilation system supports the tenability criteria of the project

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

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

7.1.4 Where required by 7.1.2, the mechanical emergency ventilation system shall make provisions for the protection of passengers, employees, and emergency personnel from fire and smoke during a fire emergency and shall be designed to maintain the required airflow rates for a minimum of 1 hour but not less than the anticipated evacuation time.

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 airflow rates sufficient to prevent backlayering of smoke in the path of egress within enclosed trainways

(3) Be capable of reaching full operational mode within 180 seconds

(4) Accommodate the maximum number of trains that could be between ventilation shafts during an emergency

7.2.2 The design shall encompass the following:

(1) The heat release rate produced by the combustible load of a vehicle and any combustible materials that could contribute to the fire load at the incident site

(2) The fire growth rate

(3) Station and trainway geometries

(4) A system of fans, shafts, and devices for directing airflow in stations and trainways

(5) A program of predetermined emergency response procedures capable of initiating prompt response from the central supervising station in the event of a fire emergency

(6) A ventilation system reliability analysis that, as a minimum, considers the following subsystems:

(a) Electrical

(b) Mechanical

(c) Supervisory control

7.2.3 The system reliability analysis in 7.2.2(6) shall consider as a minimum the following events:

(1) Fire in trainway or station

(2) Local incident within the electrical utility that interrupts power to the emergency

ventilation system

(3) Derailment

7.2.4* 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.

7.3 Emergency Ventilation Fans.

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

7.3.1.1 Individual emergency ventilation fan motors shall be designed to achieve their full operating speed in no more than 30 seconds from a stopped position when started across the line and in no more than 60 seconds for variable-speed motors.

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

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

7.3.2 Emergency ventilation fans, their motors, and all related components exposed to the exhaust airflow shall be designed to operate in an ambient atmosphere of 250°C (482°F) for a minimum of 1 hour.

7.3.2.1 A design analysis shall be permitted to be used to reduce this temperature; however, it shall not be less than 150°C (302°F).

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

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

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

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

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

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

NFPA 91.

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

7.4 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 that are subject to exposure to the fire anticipated in the design of the emergency ventilation system and are critical to its effective functioning in the event of that emergency shall be constructed of noncombustible, fire-resistant materials and shall be designed to operate in an ambient atmosphere of 250°C (482°F) for a minimum of 1 hour.

7.4.2.1 A design analysis shall be permitted to be used to reduce this temperature; however, it shall not be less than 150°C (302°F).

7.4.2.2 Finishes applied to noncombustible devices are not required to meet the provisions of 7.4.2.

7.4.3 Devices shall be designed to operate throughout the maximum anticipated temperature range.

7.5 Shafts.

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

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

7.5.3 Adjacent structures and property uses also shall be considered.

7.6 Emergency Ventilation System Control/Operation.

7.6.1 Operation of the emergency ventilation system components shall be initiated from the central supervising station.

7.6.1.1 The central supervising station shall receive verification of proper response by emergency ventilation fan(s) and interrelated device(s).

7.6.1.2 Local controls shall be permitted to override the central supervising station in all modes in the event the central supervising station becomes inoperative or where the operation of the emergency ventilation system components is specifically redirected to another site.

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

7.7 Power and Wiring.

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

7.7.1.1 Alternatively, the design of the power for the emergency ventilation system shall be permitted to be based upon the results of the electrical reliability analysis as per 7.2.2(6) as approved by the AHJ.

7.7.2 All wiring materials and installations shall conform to the requirements of NFPA 70 and, in addition, shall satisfy the requirements of 7.7.3 through 7.7.8.

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

7.7.4 All conductors shall be insulated.

7.7.4.1 Ground wire installed in a metallic raceway shall be insulated.

7.7.4.2 Other ground wires shall be permitted to be bare.

7.7.4.3 All thicknesses of jackets shall conform to NFPA 70.

7.7.5 All insulations shall conform to Article 310 of NFPA 70 and shall be moisture- and heat-resistant types carrying temperature ratings corresponding to either of the following conditions:

(1) 75°C (167°F) for listed fire-resistive cables

(2) 90°C (194°F) for all other applications

7.7.6 Wire and cable constructions intended for use in control circuits and power circuits to related emergency devices shall be listed as being resistant to the spread of fire and shall have reduced smoke emissions.

7.7.6.1* Cable shall be permitted to be listed by any of the following methods:

(1) The cable does not spread fire to the top of the tray in the vertical-tray flame test in Section 1160 of UL 1581, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode when tested in accordance with ASTM E 662.

(2) The cable exhibits damage (char length) that does not exceed 1500 mm (4.9 ft) when the vertical flame test, with cables in cable trays, is performed as described in CSA C22.2 No. 0.3, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode when tested in accordance with ASTM E 662.

(3) The cable is listed as a limited smoke cable (/LS) by meeting the cable damage height,

total smoke released, and peak smoke release rate criteria required when tested in the vertical tray flame test in UL 1685. The following performance criteria shall be met when the cable is tested according to UL 1685:

(a) When testing in the UL vertical tray flame exposure:

i. The cable damage height shall be less than 2500 mm (8.2 ft) when measured from the bottom of the cable tray.

ii. The total smoke released shall not exceed 95 m^2 (1023.6 ft^2).

iii. The peak smoke release rate shall not exceed 0.25 m^2/s (2.7 ft^2/s).

(b) Alternatively, when the cable is tested in the IEEE 1202 flame exposure:

i. The cable damage height shall be less than 1500 mm (4.9 ft) when measured from the lower edge of the burner face.

ii. The total smoke released shall not exceed 150 m^2 (1615 ft^2).

iii. The peak smoke release rate shall not exceed 0.40 m^2/s (4.3 ft^2/s).

(4) The cable is listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor, by being capable of passing the requirements of the ANSI/UL 1666, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode when tested in accordance with ASTM E 662.

(5) The cable is listed as having adequate fire-resistant and low smoke-producing characteristics, by having a flame travel distance that does not exceed 1500 m (4.9 ft), generating a maximum peak optical density of smoke of 0.5 and a maximum average optical density of smoke of 0.15 when tested in accordance with NFPA 262.

7.7.7* All conductors for emergency ventilation fans and related emergency devices routed through the station and/or trainway shall be protected from physical damage by transit or passenger rail vehicles or other normal operations and from fires in the system by one of the following:

(1) Suitable embedment or encasement

(2) Routing of such conductors external to the interior underground portions of the transit system facilities

(3) Diversity in system routing (such as separate redundant or multiple circuits, circuits or with a physically diverse network topology) so that a single fire or emergency event in the station will not lead to a failure of the system

(4) Use of a listed fire-resistive cable system with a minimum 1-hour rating in accordance with 7.7.10

7.7.7.1 Except in ancillary areas or other nonpublic areas, encased conductors shall be enclosed in their entirety in armor sheaths, conduits, or enclosed raceway boxes and cabinets.

7.7.7.2 Conductors in conduits or raceways shall be permitted to be embedded in concrete or to run in concrete electrical duct banks.

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

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

7.7.10 Where fire-resistive cables are permitted, they shall be listed and have a minimum 1-hour fire-resistive rating in accordance with UL 2196 and shall be installed per the listing requirements.

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 Sections 8.3 through 8.10 or the engineering analysis requirements of Section 8.11.

8.3 Equipment Arrangement.

8.3.1 Heat-producing equipment or 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 operating on voltage of greater than 300 V shall be located external to and isolated from passenger and crew compartments to prevent electrical failures from extending into these areas.

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

8.3.3 Where it is not possible to locate high-energy equipment external to the passenger and crew compartments, the equipment shall be isolated from these compartments to prevent a hazard from extending into these areas.

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

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

8.4 Flammability and Smoke Emission.

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

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

Category	Function of Material	Test Method	Perforr Crite
Cushioning	All individual flexible cushioning materials used in seat cushions, mattresses, mattress pads, armrest, crash pads, and grab rail padding [a-e]	ASTM D 3675	$I_s \leq 25$
		ASTM E 662	D_s (1.5) ≤ D_s (4.0) ≤
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 seconds Burn length
		ASTM E 662	D_s (4.0) ≤
Other vehicle components	Seat and mattress frames, wall and ceiling lining and panels, seat and toilet shrouds, toilet seats, trays and other tables, partitions, shelves, opaque windscreens, combustible signage, end caps, roof housings, articulation bellows, exterior shells, nonmetallic skirts, and component boxes and covers[a, b, i, j, k]	ASTM E 162	$I_s \leq 35$
		ASTM E 662	D_s (1.5) ≤ D_s (4.0) ≤
	Thermal and acoustical insulation[a, b]	ASTM E 162	$I_s \leq 25$
		ASTM E 662	D_s (4.0) ≤
	HVAC ducting [a, b]	ASTM E 162	$I_s \leq 25$
		ASTM E 662	D_s (4.0) ≤
	Floor covering[k, l]	ASTM E 648	CRF ≥ 5 k
		ASTM E 662	D_s (1.5) ≤ D_s (4.0) ≤
	Light diffusers, windows and transparent plastic windscreens[b,i, m]	ASTM E 162	$I_s \leq 100$
		ASTM E 662	D_s (1.5) ≤ D_s (4.0) ≤

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

Category	Function of Material	Test Method	Perforr Crite
Elastomers[a, i, j,]	Window gaskets, door nosings, intercar diaphragms, seat cushion suspension diaphragms, and roof mats	ASTM C 1166	Flame prop: ≤ 101.6 mı
		ASTM E 662	D_s (1.5) ≤ D_s (4.0) ≤
Wire and cable	All	See 8.5.7.1.2 through 8.5.7.1.4.	See 8.5.7.1. 8.5.7.1.4.
Structural components[m]	Flooring,[n] other[o]	ASTM E 119	Pass

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

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

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

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

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

8.4.1.3.2 The requirements of 8.4.1.5, 8.4.1.6, 8.4.1.7, and 8.4.1.8 shall be met.

8.4.1.4 Testing shall be performed without upholstery.

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

8.4.1.6 The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by washing, if appropriate.

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

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

8.4.1.9 Combustible operational and safety signage shall not be required to meet flame spread or smoke emission requirements if the combustible mass of a single sign does not exceed 500 g (1.1 lb) and the aggregate area of combustible signage does not exceed one square foot 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) that will not contribute materially to fire growth in end use configuration are exempt from flammability and smoke emission performance requirements, provided that the surface area of any individual small part is less than 100 cm^2 (16 $in.^2$) in end use configuration and an appropriate fire hazard analysis is conducted that addresses the location and quantity of the materials used and the vulnerability of the materials to ignition and contribution to flame spread.

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

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

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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. *(See Section 8.5.)*

8.4.1.14* See Section 8.5.

8.4.1.15* Portions of the vehicle body that separate the major ignition source, energy sources, or sources of fuel load from vehicle interiors shall have fire resistance as determined by a fire hazard analysis, acceptable to the authority having jurisdiction, that addresses the location and quantity of the materials used, as well as vulnerability of the materials to ignition, flame spread, and smoke generation. These portions 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 8.6. In those cases, the use of the NFPA 251 (ASTM E 119) test procedure shall not be required.

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

8.5 Fire Resistance.

8.5.1 Test Details. Fire resistance testing on assemblies shall be conducted in general accordance with NFPA 251 and ASTM E 119.

8.5.1.1* 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 exposure duration.

8.5.1.2 The fire resistance test exposure duration shall be at least equal to the time required to evacuate passengers from a vehicle.

8.5.1.2.1 The nominal test period shall be 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 all the vehicle's occupants.

8.5.1.2.1.1 The nominal test period shall be not less than 15 minutes.

8.5.1.2.1.2 The fire resistance period required shall be consistent with the safe evacuation of a full load of passengers from the vehicle under conditions approved by the authority having jurisdiction.

8.5.1.2.2 The fire exposure duration shall be at least 15 minutes.

8.5.1.3 The fire exposure shall be conducted with the furnace at a positive pressure relative to the unexposed side of the test assembly as specified in ASTM E 814.

8.5.1.4 During the entire fire exposure, 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.

8.5.1.4.1 Unexposed side thermocouples shall be installed in accordance with NFPA 251 and ASTM E 119.

8.5.1.5 During the entire fire exposure, the assembly shall not permit the passage of flame or gases hot enough to ignite cotton waste on the unexposed surface of the assembly.

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

8.5.1.6.1 Penetrations shall be installed in the test assembly in accordance with Section 7 of

ASTM E 814.

8.5.1.6.2 In the case where 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.

8.5.1.6.3 No temperatures shall be required to be measured.

8.5.2 Floor Assembly. All vehicle floor assemblies shall require fire resistance testing as described in 8.5.1.

8.5.2.1 The size of the exposed portion of the floor assembly shall be at least 3.1 m (10 ft) long by the normal width of the vehicle floor.

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

8.5.2.3 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, other relevant design loads, and a safety factor.

8.5.3 Roof Assembly.

8.5.3.1 Vehicles that contain propulsion equipment or equipment that operates at voltages higher than 600 V on the roof shall require roof assembly fire resistance testing as described in 8.5.1.

8.5.3.2 Vehicles that travel through tunnels and contain 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.

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

8.5.5 Equipment Lockers.

8.5.5.1 Portions of the vehicle separating electric equipment and related wiring from the passenger and crew areas shall be lined with an arc-resistant lining.

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

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

8.6 Electrical Fire Safety.

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

8.6.2 Clearance and Creepage.

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

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

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

8.6.2.3 Creepage Distance.

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

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

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

8.6.3 Propulsion Motors.

8.6.3.1 Rotary motors shall be rated and tested in accordance with IEEE 11.

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

8.6.5 Motor Control.

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

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

8.6.5.3 Metal enclosures that surround arcing devices shall be lined with insulating material approved by the authority having jurisdiction, unless otherwise permitted in 8.6.5.5.

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

8.6.5.5 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.

8.6.6 Propulsion and Braking System Resistors.

8.6.6.1 Self-ventilated propulsion and braking resistors shall be mounted with air space between resistor elements and combustible materials.

8.6.6.2 Heat-resisting barriers of at least 6 mm (¼ in.) noncombustible insulating material, or sheet metal not less than 1.0 mm (0.04 in.) thickness, shall be installed extending horizontally beyond resistor supports to ensure protection from overheated resistors.

8.6.6.3 Forced ventilated resistors shall be mounted in ducts, enclosures, or compartments of noncombustible material.

8.6.6.3.1 Forced ventilated resistors shall be mounted with air space between the resistor enclosure and combustible materials.

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

8.6.6.5 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

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

8.6.6.7 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.

8.6.6.8 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.

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

8.6.6.10 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.

8.6.7 Current Collectors.

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

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

8.6.7.3 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.

8.6.8 Wiring.

8.6.8.1 Electrical Insulation.

8.6.8.1.1 All wires and cables shall be listed as being resistant to the spread of fire and shall have reduced smoke emissions.

8.6.8.1.2* Cable shall be permitted to be listed by any of the following methods:

(1) The cable does not spread fire to the top of the tray in the vertical-tray flame test in Section 1160 of UL 1581, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode when tested in accordance with ASTM E 662.

(2) The cable exhibits damage (char length) that does not exceed 1500 mm (4.9 ft) when the vertical flame test, with cables in cable trays, is performed as described in CSA C22.2 No. 0.3, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode when tested in accordance with ASTM E 662.

(3) The cable is listed as a limited smoke cable (/LS) by meeting the cable damage height, total smoke released, and peak smoke release rate criteria required when tested in the vertical tray flame test in UL 1685. The following performance criteria shall be met when cable is tested by UL 1685:

  (a) When the test is done in the UL vertical tray flame exposure:

    i. The cable damage height shall be less than 2500 mm (8.2 ft) when measured from the bottom of the cable tray.

    ii. The total smoke released shall not exceed 95 m^2 (1023 ft^2).

    iii. The peak smoke release rate shall not exceed 0.25 m^2/s (2.7 ft^2/s).

  (b) Alternatively, when the test is done in the IEEE 1202 flame exposure:

    i. The cable damage height shall be less than 1500 mm (4.9 ft), measured from the lower edge of the burner face.

    ii. The total smoke released shall not exceed 150 m^2 (1615 ft^2).

    iii. The peak smoke release rate shall not exceed 0.40 m^2/s (4.3 ft^2/s).

(4) The cable is listed as having fire-resistant characteristics capable of preventing the carrying of fire from floor to floor by being capable of passing the requirements of

ANSI/UL 1666, and the cable exhibits a specific optical density of smoke at 4 minutes into the test that does not exceed 200 in the flaming mode and 75 in the nonflaming mode when tested in accordance with ASTM E 662.

(5) The cable is listed as having adequate fire-resistant and low smoke-producing characteristics by having a flame travel distance that does not exceed 1500 mm (4.9 ft), generating a maximum peak optical density of smoke of 0.5 and a maximum average optical density of smoke of 0.15 when tested in accordance with NFPA 262.

8.6.8.1.3 Wires and cables for control and other low voltage (i.e, less than 100 V ac and 150 V dc) functions shall comply with 8.6.8.1.2 and either of the following:

(1) The physical, mechanical, and electrical property requirements of ICEA S-19/NEMA WC3

(2) UL 44 for thermosetting insulation and UL 83 for thermoplastic insulation

8.6.8.1.4 Wires and cables used for fire alarm systems and smoke alarms shall comply with 8.6.8.1.2 and one of the following:

(1) Be capable of having 15-minute circuit integrity when tested in accordance with IEC 60331-11

(2) Demonstrate that, if circuit integrity is tested during the vertical flame test, a current continues operating for at least 5 minutes during the test

(3) Have fire alarm circuit integrity cable in accordance with NFPA 70

8.6.8.2 Minimum Wire Size. In no case shall wire smaller than the following sizes be used:

(1) 14 AWG (cross-section 1.8 mm^2) for wire pulled through conduits or wireways or installed exposed between enclosures

(2) 22 AWG (cross-section 0.35 mm^2) for wire used on electronic units, cards, and card racks

(3) 18 AWG (cross-section 0.90 mm^2) for all other wire, including wire laid in (rather than pulled through) wireways

8.6.8.3 Cable and Wire Sizes.

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

8.6.8.3.2 Conductors shall be no smaller than the minimum sizes specified in 8.6.8.2.

8.6.8.3.3 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.

8.6.8.4 Wiring Methods.

8.6.8.4.1 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

8.6.8.4.2 Firestops shall be provided in raceways.

8.6.8.4.3 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.

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

8.6.8.4.5 Conduits, electrical metallic tubing, nonmetallic ducts or tubing, and all wires with their outer casings shall be extended into devices and cases where practicable.

8.6.8.4.6 Conduits, electrical metallic tubing, nonmetallic ducts or tubing, and all wires with their outer casings shall be rigidly secured in place by means of cleats, straps, or bushings to prevent vibration or movement and to give environmental protection.

8.6.8.4.7 Conduits, electrical metallic tubing, nonmetallic ducts or tubing, and all wires with their outer casings shall be run continuously into junction boxes or enclosing cases and be securely fastened to these devices.

8.6.8.4.8 Splices outside of junction boxes shall be approved by the authority having jurisdiction.

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

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

8.6.9 Overload Protection.

8.6.9.1 Propulsion Line Breaker.

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

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

8.6.9.2 Main Fuse Protection.

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

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

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

8.6.9.3 Auxiliary Circuits.

8.6.9.3.1 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.

8.6.9.3.2 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.

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

8.6.10 Battery Installation. Battery installations and circuitry shall include the following:

(1) Minimal use of organic materials, particularly those having hygroscopic properties

(2) Fire-retardant treatment for necessary organic materials used

(3) Battery-charging systems designed for protection against overcharging

(4) Use of smoke and heat detectors, if appropriate

(5) Use of an emergency battery cutoff switch, if appropriate

(6) Isolation of battery compartment from car interior using noncombustible materials, if appropriate

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 as practicable.

8.8.1.1 Alternate means of emergency egress, including roof hatches as necessary for the type of vehicle, shall be approved by the authority having jurisdiction.

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 level of illumination determined necessary by the authority having jurisdiction or with 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 600 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 600 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 8.8.5.1 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 without special tools from the interior and exterior of the vehicle.

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 Standard SS-PS-002-098 Rev 2.

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 Standard SS-PS-002-098 Rev 2.

8.9 Protective Devices.

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

8.9.2 Communications.

8.9.2.1 Each vehicle, except as required in 8.9.2.2, shall be equipped with a communication system consisting of the following:

(1) A PA system whereby the train, crew personnel, and, at the option of the authority,

the central supervising station can make announcements to the passengers

(2) A radio system whereby the train operator can communicate with the central supervising station

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

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

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

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

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

8.9.3 Portable Fire Extinguishers.

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

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

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

8.9.4 Lightning Protection.

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

8.9.4.2 Lightning arresters on vehicles shall have a grounding connection of not less than 6 AWG or cross-section of 13.5 mm^2 and be run in as straight a line as possible to the ground.

8.9.4.2.1 Lightning arresters shall be properly protected against mechanical injury.

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

8.9.5 Heater Protection.

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

(1) Ventilation airflow, if appropriate

(2) Failure of temperature controls or occurrence of overtemperature conditions, as

appropriate

(3) Short circuits and overloads in supply wiring

8.9.5.2 Heater-forced air distribution ducts and plenums 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 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 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 Performance-Based Option.

8.11.1 General. The requirements of this section shall apply to fixed guideway and passenger rail vehicles designed to meet the performance-based 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 applying Section 8.11, performance-based design activities shall be carried out by an individual or entity having qualifications acceptable to the authority having jurisdiction.

8.11.1.2 In applying Section 8.11, the design, engineering analysis, and documentation shall be approved by the authority having jurisdiction.

8.11.2* Basis for Engineering Analysis.

8.11.2.1 To use this performance-based 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 their 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.

Chapter 9 Emergency Procedures

9.1 General.

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

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 central supervising station.

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

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

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

9.3 Emergencies.

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

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

(2) Collision or derailment involving the following:

  (a) Rail vehicles on the guideway

  (b) Rail vehicles with privately owned vehicles

  (c) Intrusion into the right-of-way from adjacent roads or properties

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

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

(5) Passenger panic

(6) Disabled, stalled, or stopped trains due to adverse personnel/passenger emergency conditions

(7) Tunnel flooding from internal or external sources

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

(9) Structural collapse or imminent collapse of the authority property or adjacent property that threatens safe operations of the system

(10) Hazardous materials accidentally or intentionally released into the system

(11) Serious vandalism or criminal acts, including terrorism

(12) First aid or medical care for passengers on trains and in stations

(13) Extreme weather conditions, such as heavy snows, high or low temperatures, sleet, or ice

(14) Earthquake

(15) Any other emergency as determined by the authority having jurisdiction

9.4* Emergency Procedures.

An emergency procedure shall be developed to address specifically the various types of emergencies that might be experienced on the system and shall include, but not be limited to, the following:

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

(2) Policy, purpose, scope, and definitions

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

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

(5) Purpose and operations of the central supervising station and alternate location(s), as applicable

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

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

(8) Fire and smoke emergency information and procedures to be provided, including the following:

  (a) Location of fire in station or support facility

  (b) Location of train in tunnel and fire location on train

  (c) Fire detection systems/zones in stations

  (d) Fire protection systems and devices and their location/point of initiating operation

  (e) Exit/entrance locations 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 ventilation system preplanned mode of fan operation (exhaust or supply)

  (k) Preplanned passenger evacuation direction as coordinated with fan mode operation

  (l) Fire and emergency incidents on adjoining properties

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

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

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

9.5* Participating Agencies.

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

(1) Ambulance service

(2) Building department

(3) Fire department

(4) Medical service

(5) Police department

(6) Public works (i.e., bridges, streets, sewers)

(7) Sanitation department

(8) Utility companies (i.e., gas, electricity, telephone, steam)

(9) Water department (i.e., water supply)

(10) Local transportation companies

(11) Red Cross, Salvation Army, and similar agencies

9.6 Operations Control Center (OCC).

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

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

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

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

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

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

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

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

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

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

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

9.7 Liaison.

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

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

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

9.8 Command Post.

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

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

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

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

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

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

9.9* Auxiliary Command Post.

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

9.10 Training, Exercises, Drills, and Critiques.

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

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

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

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

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

9.11 Records.

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

9.12 Removing and Restoring Traction Power.

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

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

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

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

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

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

Chapter 10 Communications

10.1* General.

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

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

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

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

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

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

10.3 Radio Communication.

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

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

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

10.4 Telephone.

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

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

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

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

10.4.5 Telephone locations shall be automatically identified in the OCC or other location approved by the authority having jurisdiction.

10.5 Portable Telephones and Lines.

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

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

10.6 Public Address (PA) System.

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

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

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

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

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

10.7 Portable Powered Speakers (Audiohailers).

During emergency operations, portable powered speakers shall be made available by the authority where other forms of communication are not available.

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

A.1.3.3 The nature of facilities retrofit 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.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

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

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

A.3.3.10 Concourse. A concourse is distinct from a platform since it can be more open and passenger speeds can be different from those prescribed for a platform, platform stair, or escalator.

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A.3.3.14 Engineering Analysis/Fire Hazard Analysis. A written report of the analysis is submitted to the authority having jurisdiction indicating recommended fire protection method(s) that will provide a level of fire safety commensurate with this standard.

A.3.3.24 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 kilowatts (kW) or Btu/s. [**921:** A.3.3.87]

A.5.2.3.5.1 Because of the difference in the potential level of hazard between various stations (i.e., open stations as compared to enclosed stations), alternative methods to fire separation could be considered.

A.5.4.5.1 Testing of electrical and optical fiber cables for specific optical density of smoke in accordance with ASTM E 662 should be conducted with test specimens prepared in accordance with the section specific to cables.

A.5.4.6.1 Cables in the air plenum might be exposed to air at elevated temperature accompanying fire emergency conditions.

A.5.5 Annex C provides additional information and sample calculations relating to means of egress.

A.5.5.1 Where codes other than NFPA *101* are in effect, reference to NFPA *101* can be replaced by reference to relevant requirements in the locally applicable building code.

A.5.5.1.4 The determination of common path of travel from ends of platforms should consider the configuration (e.g., width and enclosure) of the platform versus the anticipated exposure to a train on fire at the platform. Where the platform is sufficiently wide to allow passengers to move away from the radiation effects of the train fire, it is reasonable to consider the egress from that platform as not creating a common path of travel.

A.5.5.1.5 Transit stations are unique in that many are constructed beneath and enveloped by adjacent buildings. The use of horizontal exits for up to 100 percent of the required capacity provided that not more than 50 percent is into a single building addresses conditions in stations that differ from those in NFPA *101*, which envisions a single building subdivision.

A.5.5.2.1(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.5.5.5.1 In that the peak ridership data is used to determine occupant load (and, consequently, required egress capacity), the basis for that 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.5.5.5.3 Consideration of control of the access to platforms might be necessary so that the station occupant load does not exceed the station egress capacity.

A.5.5.5.4.1 At multilevel stations, it can be reasonable to consider only entraining (or entraining plus detraining) loads for nonincident levels for determining required egress capacity at points where egress routes converge. Nonincident platform loads that do not adversely impact the egress route need not be considered.

A.5.5.5.6 The determination of maximum occupant load at a platform often requires comparison of calculations based on different peak periods. For example, to determine the maximum peak period platform occupant load for stations serving predominantly commuter ridership, the calculations described in 5.5.5.6.1 through 5.5.5.6.4 can be computed based on both the a.m. and the p.m. peak ridership for each platform and then compared to determine the maximum platform occupant load.

A.5.5.5.6.2.1 It is important that the load/headway capture the potential buildup of passengers that might occur before an emergency event is recognized as requiring evacuation. The determination of the appropriate accumulation factor should reflect system-specific characteristics such as the following:

(1) The type of system (e.g., automated/driverless vs. manually driven)

(2) The amount and type of surveillance

(3) The distance between stations and train headways

For systems with longer headways, a factor of two headways might be adequate to approximate accumulation and response time. For systems with very short headways, a fixed time (e.g., 5 minutes to 10 minutes) might be more appropriate to approximate the potential passenger buildup.

Consideration should also be given to whether the entraining and train loads should be subject to the same accumulation factor.

A.5.5.6 The means of egress capacity factors and travel speeds are consistent with observed pedestrian movement within congested areas of passenger stations as represented by level of service E/F in *Pedestrian Planning and Design* by J. J. Fruin.

A.5.5.6.1.2 Where automated spreadsheet calculations or computer-based software programs are used, the means of egress analysis should include documentation detailing all input parameters and algorithm(s).

A.5.5.6.2.3 See A.5.5.6.1.2.

A.5.5.6.3.1.2 The 2003 and previous editions of NFPA 130 required that exit corridors and ramps be a minimum of 1727 mm (5 ft 8 in.) wide. There is/was no technical basis for the previous minimum. The intent of 5.5.6.3.1.1 is to make NFPA 130 consistent with NFPA *101* relative to the minimum 1120 mm (44 in.) corridor width in the means of egress. NFPA 130 addresses means of egress conditions unique to transit/passenger rail facilities such as open platform edges. In NFPA *101*, means of egress facilities are based upon a function of the persons served (units of width/person served). NFPA 130 introduces a unit of time in determining the required egress width. This is necessary to demonstrate compliance with the performance requirements related to platform evacuation time and reaching a point of safety.

Assuming a 1120 m (44 in.) wide side platform per 5.5.6.3.1.2, the effective platform width for egress is:

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

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

$$\begin{aligned}&(355 \text{ mm})(0.819 \text{ p/ mm-min}) = 29 \text{ persons/ min}\\&[(14 \text{ in.})(2.08\text{pim})] = 29\end{aligned}$$

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

$$\begin{aligned}&(1120 \text{ mm})(0.0819 \text{ p/ mm-min}) = 91 \text{ persons}\\&[(44 \text{ in.})(2.08 \text{ pim})] = 91 \text{ person/ min}\end{aligned}$$

It must be recognized that while strict interpretation of this section indicates a station could be designed using a 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 impact the platform width such as the travel distance to the point(s) of egress, maximum 4-minute platform evacuation time, and 6-minute point of safety time.

A.5.5.6.3.1.5 See A.5.5.6.3.1.2 for clarification.

A.5.5.6.3.2.2 Stairs positioned in proximity to, but not necessarily adjacent to, escalators can be beneficial in affording additional egress capacity. Stairs are typically not placed out of service for repairs, and are not subject to single directional flow.

A.5.5.6.3.2.3(2) The vertical component of travel speed is calculated based on the vertical change in elevation between each station level. See Figure A.5.5.6.3.2.3(2). See also *Application Guidelines for the Egress Element of the Fire Protection Standard for Fixed Guideway Transit Systems*, and the example calculations in Annex C.

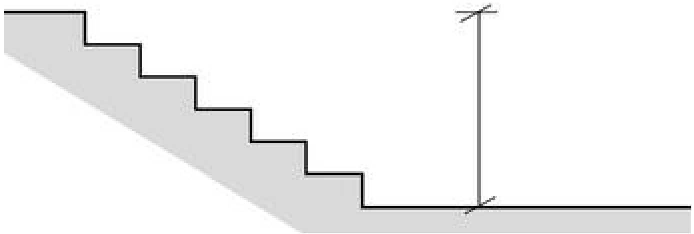

FIGURE A.5.5.6.3.2.3(2) Distance Measure for Walk Time Computation. *(Source: M. B. Schachenmayr, Parsons Brinckerhoff Quade & Douglas, Inc.)*

A.5.5.6.3.2.4 See A.5.5.6.3.1.2 for clarification.

A.5.5.6.3.2.6 Where multiple escalators are provided in the means of egress, the means of egress calculations should consider the potential of more than one escalator on any one level being out of service for repair and impassible.

A.5.5.6.3.3.4 "Unobstructed exiting under all conditions" implies that the fare barrier equipment is the type that does not require collection of a proof of payment to operate, and drops away to create an unimpeded egress path in a fail-safe manner when pressure is applied. Turnstile-type gates are not considered "unobstructed exiting."

A.5.7.1.2 Discrete zone indications are desirable for unmanned stations.

A.5.7.1.4 Separate zones on the annunciator panel to monitor main control valves on standpipe systems should be established.

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A.5.7.6 Where an underground station is part of another building or building complex, consideration should be given to creating a combined fire command center.

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A.5.12 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.6.2.1.11 Maintaining a clear space above the walking surface is important to ensure that projections do not encroach into the means of egress. The envelope created by the boundary limits defined by this paragraph is intended to gradually change from point to point.

A.6.2.2.2 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 twice the prescribed exit travel distance to the alternate exit. Since two means of egress are required at any one point in a tunnel, the exits cannot be more than twice the travel distance, or 762 m (2500 ft) apart.

A.6.2.2.5.3 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.6.2.4 The fire hazard analysis should determine that the fire does not propagate beyond the area of fire origin, and that a level of fire safety is provided within the trainway 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.6.2.5.5 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.

A.6.2.5.5.2 Point illumination can be utilized to accentuate critical elements within the trainway such as walkway change of elevation, steps, and access points.

A.6.2.7.1 The placement of blue light stations at the ends of station platforms should be governed by actual need. For instance, an at-grade system that has stations in dedicated streets and overhead power supply would not need blue light stations at the ends of platforms.

A.6.2.8 Directional signs are provided to assist emergency evacuation of passengers. The signs should be of reflective or illuminated materials and readily visible by passengers within the trainway. Inclusion of distance to the station or portal is discouraged since that might influence passenger evacuation route, which could contradict the emergency evacuation strategy.

A.6.3.3.1 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.6.3.3.2.5.1 Testing of electrical and optical fiber cables for specific optical density of smoke in accordance with ASTM E 662 should be conducted with test specimens prepared in accordance with the section specific to cables.

A.6.3.3.2.6 The trainway, although used for ventilation, should not be considered as an air plenum for purposes of mounting electrical appurtenances.

A.6.3.3.2.6.1 Cables in the air plenum might be exposed to air at elevated temperature accompanying fire emergency conditions.

A.6.4.1.1 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.7.1.1 Separate ventilation systems for tunnels and underground stations can be provided, but are not required. Annex B provides information on types of mechanical systems for normal ventilation of fixed guideway transit systems and information for determining a tenable environment.

A.7.2.4 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 reversing capability and rapidness of executing a reversal in an emergency are key to the effective extraction of non-incident trains. The best protection to passengers is to allow no more than one train in a ventilation zone. Failing that, there must 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.

A.7.7.6.1 Testing of electrical and optical fiber cables for specific optical density of smoke in accordance with ASTM E 662 should be conducted with test specimens prepared in accordance with the section specific to cables.

A.7.7.7 The trainway, although used for ventilation, should not be considered as an air plenum for purposes of mounting electrical appurtenances.

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 this section 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.

A.8.4.1.1 Annex E contains additional guidance describing the overall process that could be used to conduct a performance-based hazard analysis, using the test procedures included in Annex D.

A.8.4.1.3 The test methods in ASTM E 1537 (for upholstered furniture, 19 kW exposure) and ASTM E 1590 (for mattresses, 18 kW 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 those normally present in rail transportation vehicles. Thus, the applicability of the test methods to rail transportation vehicles has not been validated, and they probably are not sufficiently representative of the situation and might require some modifications for better applicability. The use of alternative ignition sources (by varying the location, the gas flow intensity, or the exposure time) for ASTM E 1537 or ASTM E 1590 might be a means of addressing some very high challenge fire scenarios potentially present in rail transportation vehicles. Examples of more powerful ignition sources that could be used include a 50 kW gas burner [Hirschler, 1997], shown to be relevant to detention mattresses or the oil burner used for aircraft seat cushions [FAR 25.853(c)], but the measurements should involve the same fire properties as in ASTM E 1537 or ASTM E 1590. If the ignition source used for a test method is inadequate, the result can be misleading; it has been shown that upholstered furniture and mattresses that are totally consumed when using the appropriate ignition source appear to perform well when using the ignition sources in ASTM E 1537 and ASTM E 1590, respectively.

A.8.4.1.10 If the surface area of any individual small part is less than 100 cm^2 (16 $in.^2$) in end use configuration, materials used to fabricate such a part should be permitted to be tested in accordance with NFPA 271 (ASTM E 1354) as an alternative to both the ASTM E 162 flammability test procedure or the appropriate flammability test procedure otherwise specified in Table 8.4.1 and the ASTM E 662 smoke generation test procedure. Testing should be at 50 kW/m^2 (4.4 $Btu/s \cdot ft^2$) applied heat flux with a retainer frame. Materials tested in accordance with NFPA 271 (ASTM E 1354) should meet the following performance criteria: Materials tested should meet the performance criteria of 180 sec average heat release rate of q''_{180} < 100 kW/m^2 (8.8 $Btu/s \cdot ft^2$) and test average smoke extinction area (F_f) < 500 m^2/kg (2441.2 ft^2/lb).

Testing for heat release and smoke obscuration by using NFPA 271 or ASTM E 1354 is required only as an alternate approach to testing by the test methods for flammability and smoke obscuration in Table 8.4.1.

A.8.4.1.14 Only one specimen need be tested. A proportional reduction can be made in the dimensions of the specimen, provided the specimen represents a true test of the ability of the structural flooring assembly to perform as a barrier against undervehicle fires.

A.8.4.1.15 ASTM E 2061 and APTA RP PS-005-01 both describe and discuss passenger-carrying vehicle fire scenarios. See also Annex E.

A.8.5.1.1 ASTM E 162 might not be suitable for materials that exhibit flaming running or dripping because the test apparatus is not designed to accommodate this kind of burning behavior. A fire hazard analysis seeking to demonstrate the acceptability of such materials as permitted in 8.4.2 should include not only the contribution to the generation of heat and smoke at the original ignition site but also any contribution resulting from burning material that melts and/or flows away from that site. The fire hazard analysis should address as well the risk of spread to, and ignition of, other car components from either of these potential ignition sources.

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.8.6.8.1.2 Testing of electrical and optical fiber cables for specific optical density of smoke in accordance with ASTM E 662 should be conducted with test specimens prepared in accordance with the section specific to cables.

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 bileaf side doors, one on each side, emergency exit windows usually are not provided.

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, U.S. Department of Transportation, determined that the level of illumination required by NFPA *101* might not be necessary due to the more limited size (85 ft long and 10 ft wide) and configuration of rail passenger cars (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 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 rail passengers cars, the Volpe Center research resulted in the recommendation for a uniform height of 25 in. above the floor height to perform the aisle measurements.

Accordingly, the FRA issued a passenger equipment regulation on May 12, 1999, which specified the Volpe recommended minimum for egress door floor locations, minimum average along the center aisle, and a minimum at any point along the aisle.

Moreover, the American Public Transportation Association (APTA) developed APTA SS-E-013-99, which addresses passenger rail vehicle emergency lighting. The APTA standard requires minimum emergency lighting levels for intercity passenger and commuter rail vehicles that are identical to FRA requirements and contains additional guidance in performing the illumination measurements. 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 one hour. The minimum period of time for the vehicle emergency lighting system power supply is consistent with NFPA *101*, APTA standards, and FRA regulation.

A.8.8.4 Until the 2003 edition, NFPA 130 did not address means of emergency egress from rail vehicles. 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.

Before the 2003 edition, NFPA 130 did not address marking of the location of means of emergency egress and instructions for the operation of egress (access) facilities for fixed guideway transit and passenger rail vehicles from the interior.

A.8.8.5 The United States Federal Aviation Administration (FAA) requires the installation of independently powered floor proximity path marking to delineate the path to emergency exits. The American Public Transportation Association (APTA) has also issued a standard that requires this same concept of marking to be installed in intercity and commuter rail cars.

The Federal Railroad Administration (FRA) issued a rule in 1998 that required marking and instructions for the operation of emergency exit windows and doors used for emergency egress. Although the FRA requires that the marking be conspicuous and legible, specific objective performance criteria were not included.

APTA has issued a standard that contains extensive provisions for the marking of and instructions for emergency egress facilities that are operated from the inside of 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 an 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. The HPPL material has been certified by the FAA for use as floor proximity path marking on certain aircraft.

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A.8.11.2 Section 4.3 includes specific objectives necessary to achieve desired goals.

A.9.2.4 The following standards might be applicable for training qualification and competency assessment: NFPA 1006, NFPA 472, and NFPA 1670.

A.9.4 Tunnels more than 610 m (2000 ft) in length should be equipped with emergency tunnel evacuation carts (ETECs) at locations to be determined by the authority having jurisdiction.

ETECs should be capable of carrying a capacity of at least four stretchers and a total weight capacity of at least 453.5 kg (1000 lb). ETECs should be constructed of corrosion-resistant materials, be equipped with a "deadman" brake, and safely operate on the rail tracks in the tunnel.

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

A.9.6.9 Fan units serving train control and communications rooms should be protected by fire detection, protection, and extinguishing equipment so that there will be early detection and extinguishment of any fire involving these units.

A.9.8.1 The command post should be located at a site that is convenient for responding personnel, easily identifiable, and suitable for supervising, coordinating, and communicating with participating agencies.

A.9.8.5 Signs should be designed to be visible during day or 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 their 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.

Annex B Ventilation

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

B.1 General.

The purpose of this annex is to provide guidelines for the potential compatibility of the emergency ventilation system with the system employed with normal ventilation of trainways and stations. This annex does not present all factors to be considered in the normal ventilation criteria. For normal ventilation, refer to the *Subway Environmental Design Handbook* (SEDH) and the ASHRAE Handbook series (*Fundamentals, Applications, Systems and Equipment*).

Current technology is capable of analyzing and evaluating all unique conditions of each property to provide proper ventilation for normal operating conditions and for pre-identified emergency conditions. The same ventilating devices might or might not serve both normal operating conditions and pre-identified emergency requirements. The goals of the subway ventilation system, in addition to addressing fire and smoke emergencies, are to assist in the containment and purging of hazardous gases and aerosols such as those that could result from a chemical/biological release.

B.2 Tenable Environments.

B.2.1 Environmental Conditions. Some factors that should be considered in maintaining a tenable environment for periods of short duration are defined in B.2.1.1 through B.2.1.5.

B.2.1.1 Heat Effects. Exposure to heat can lead to life threat in three basic ways:

(1) Hyperthermia

(2) Body surface burns

(3) Respiratory tract burns

For use in the modeling of life threat due to heat exposure in fires, it is necessary to consider only two criteria—the threshold of burning of the skin and the exposure at which hyperthermia is sufficient to cause mental deterioration and thereby threaten survival.

Note that thermal burns to the respiratory tract from inhalation of air containing less than 10 percent by volume of water vapor do not occur in the absence of burns to the skin or the face; thus, tenability limits with regard to skin burns normally are lower than for burns to the respiratory tract. However, thermal burns to the respiratory tract can occur upon inhalation of air above 60°C (140°F) that is saturated with water vapor.

The tenability limit for exposure of skin to radiant heat is approximately 2.5 kW · m^{-2}. Below this incident heat flux level, exposure can be tolerated for 30 minutes or longer without significantly affecting the time available for escape. Above this threshold value, the time to burning of skin due to radiant heat decreases rapidly according to Equation B.2.1.1a.

$$t_{Irad} = 4q^{-1.35} \qquad \textbf{(B.2.1.1a)}$$

where:

t = time in minutes

q = radiant heat flux in kW/m^2

As with toxic gases, an exposed occupant can be considered to accumulate a dose of radiant heat over a period of time. The fraction equivalent dose (FED) of radiant heat accumulated per minute is the reciprocal of t_{Irad}.

Radiant heat tends to be directional, producing localized heating of particular areas of skin even though the air temperature in contact with other parts of the body might be relatively low. Skin temperature depends on the balance between the rate of heat applied to the skin surface and the removal of heat subcutaneously by the blood. Thus, there is a threshold radiant flux below which significant heating of the skin is prevented but above which rapid heating occurs.

Based on the preceding information, it is estimated that the uncertainty associated with the use of Equation B.2.1.1a is ±25 percent. Moreover, an irradiance of 2.5 $kW \cdot m^{-2}$ would correspond to a source surface temperature of approximately 200°C, which is most likely to be exceeded near the fire, where conditions are changing rapidly.

Calculation of the time to incapacitation under conditions of exposure to convected heat from air containing less than 10 percent by volume of water vapor can be made using either Equation B.2.1.1.b or Equation B.2.1.1c.

As with toxic gases, an exposed occupant can be considered to accumulate a dose of convected heat over a period of time. The fraction equivalent dose (FED) of convected heat accumulated per minute is the reciprocal of t_{Iconv}.

Convected heat accumulated per minute depends on the extent to which an exposed occupant is clothed and the nature of the clothing. For fully clothed subjects, Equation B.2.1.1b is suggested:

$$t_{Iconv} = \left(4.1\times10^{8}\right)\, T^{-3.61} \qquad \textbf{(B.2.1.1b)}$$

where:

t_{Iconv} = time in minutes
T = temperature in °C

For unclothed or lightly clothed subjects, it might be more appropriate to use Equation B.2.1.1c:

$$t_{Iconv} = \left(5\times10^{7}\right)\, T^{-3.4} \qquad \textbf{(B.2.1.1c)}$$

where:

t_{Iconv} = time in minutes
T = temperature in °C

Equations B.2.1.1b and B.2.1.1c are empirical fits to human data. It is estimated that the uncertainty is ±25 percent.

Thermal tolerance data for unprotected human skin suggest a limit of about 120°C (248°F) for convected heat, above which there is, within minutes, onset of considerable pain along with the production of burns. Depending on the length of exposure, convective heat below this temperature can also cause hyperthermia.

The body of an exposed occupant can be regarded as acquiring a "dose" of heat over a period of time. A short exposure to a high radiant heat flux or temperature generally is less tolerable than a longer exposure to a lower temperature or heat flux. A methodology based on additive FEDs similar to that used with toxic gases can be applied. Providing that the temperature in the fire is stable or increasing, the total fractional effective dose of heat acquired during an exposure can be calculated using Equation B.2.1.1d:

$$FED = \sum_{t_1}^{t_2} \left(\frac{1}{t_{Irad}} + \frac{1}{t_{Iconv}} \right) \Delta t \quad \textbf{(B.2.1.1d)}$$

Note 1: In areas within an occupancy where the radiant flux to the skin is under 2.5 kW · m-2, the first term in Equation B.2.1.1d is to be set at zero.

Note 2: The uncertainty associated with the use of this last equation would be dependent on the uncertainties with the use of the three earlier equations.

The time at which the FED accumulated sum exceeds an incapacitating threshold value of 0.3 represents the time available for escape for the chosen radiant and convective heat exposures.

As an example, consider the following:

(1) Evacuees lightly clothed

(2) Zero radiant heat flux

(3) Time to FED reduced by 25 percent to allow for uncertainty in Equations B.2.1.1b and B.2.1.1c.

(4) Exposure temperature constant

(5) FED not to exceed 0.3

Equations B.2.1.1c and B.2.1.1d can be manipulated to provide:

$$t_{exp} = (1.125 \times 10^7) T^{-3.4}$$

where:

t_{exp} = time of exposure in minutes to reach a FED of 0.3

This gives the values in Table B.2.1.1.

Table B.2.1.1 Maximum Exposure Time

Exposure Temperature		
°C	°F	Without Incapacitation (minutes)
80	176	3.8
75	167	4.7
70	158	6.0
65	149	7.7
60	140	10.1
55	131	13.6
50	122	18.8
45	113	26.9
40	104	40.2

B.2.1.2 Air Carbon Monoxide Content. Air carbon monoxide (CO) content is as follows:

(1) Maximum of 2000 ppm for a few seconds

(2) Averaging 1150 ppm or less for the first 6 minutes of the exposure

(3) Averaging 450 ppm or less for the first 15 minutes of the exposure

(4) Averaging 225 ppm or less for the first 30 minutes of the exposure

(5) Averaging 50 ppm or less for the remainder of the exposure

These values should be adjusted for altitudes above 1000 m (3000 ft).

B.2.1.3 Smoke Obscuration Levels. Smoke obscuration levels should be continuously maintained below the point at which a sign internally illuminated at 80 lx (7.5 ft-candles) is discernible at 30 m (100 ft) and doors and walls are discernible at 10 m (33 ft).

B.2.1.4 Air Velocities. Air velocities in the enclosed trainway should be greater than or equal to 0.75 m/s (150 fpm) and less than or equal to 11.0 m/s (2200 fpm).

B.2.1.5 Noise Levels. Noise levels should be a maximum of 115 dBa for a few seconds and a maximum of 92 dBa for the remainder of the exposure.

B.2.2 Geometric Considerations. Some factors that should be considered in establishing a tenable environment in stations are as follows:

(1) The evacuation path requires a height clear of smoke of at least 2.0 m (6.56 ft). The current precision of modeling methods is within 25 percent. Therefore, in modeling methods, a height of at least 2.5 m (8.2 ft) should be maintained above any point along the surface of the evacuation pathway.

(2) The application of tenability criteria at the perimeter of a fire is impractical. The zone of tenability should be defined to apply outside a boundary away from the perimeter of the fire. This distance will be dependent on the fire heat release rate and could be as much as 30 m (100 ft).

B.2.3 Time Considerations. The project should develop a time-of-tenability criterion for stations with the approval of the authority having jurisdiction. Some factors that should be considered in establishing this criterion are as follows:

(1) The time for fire to ignite and become established

(2) The time for fire to be noticed and reported

(3) The time for the entity receiving the fire report to confirm existence of fire and initiate response

(4) The time for all people who can self-rescue to evacuate to a point of safety

(5) The time for emergency personnel to arrive at the station platform

(6) The time for emergency personnel to search for, locate, and evacuate all those who cannot self-rescue

(7) The time for fire fighters to begin to suppress the fire

If a project does not establish a time-of-tenability criterion, the system should be designed to maintain the tenable conditions indefinitely.

B.3 Configurations.

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

Enclosed stations and trainways might be configured with the following characteristics:

(1) High or low ceilings

(2) Open or doored entrances

(3) Open or screened platform edges

(4) End-of-station or midtunnel fan shafts

(5) End-of-station or midtunnel vent shafts

(6) Single, double, or varying combinations of tracks in tunnels

(7) Intersecting tunnels

(8) Multilevel stations

(9) Multilevel tunnels

(10) Varying depths below the surface

(11) Varying grades and curvatures of tracks and tunnels

(12) Varying blockage ratios of vehicles to tunnel cross section

(13) Varying surface ambient conditions

(14) Varying exit points to surface or points of safety

B.4 Draft Control.

B.4.1 For patron comfort in stations, the air velocities induced by train motion should be evaluated carefully by designers. Infrequent exposure to higher velocities can be tolerated briefly but are to be avoided wherever possible. *[Refer to the Subway Environmental Design Handbook (SEDH); the ASHRAE Handbook — Fundamentals; and the Beaufort Scale.]*

B.4.2 Draft control can be achieved by the placement of shafts along the tunnel length between stations. Shafts can be arranged with the fan shafts at the ends of stations, with vent shafts midtunnel if required or with vent shafts at the ends of stations and fan shafts midtunnel. End-of-station shaft configurations should be related to the station geometries in the consideration of patron comfort in the station relative to train piston draft effects.

B.5 Temperature Control.

B.5.1 Temperature control for patron comfort in the station can be achieved by circulating ambient air in moderate climates or by providing heating and/or cooling in more extreme regions. Preferred temperature goals should be defined in the criteria developed for the design of an individual property relative to the local climate and the length of station occupancy, such as train headways specific to the property during which the patron would be exposed to the station temperatures.

B.5.2 Temperature control and ventilation for ancillary areas housing special equipment should reflect the optimum operating conditions for the specific equipment to ensure the availability of critical equipment and should also give consideration for intermittent occupancy by maintenance personnel. These systems should be separate from the emergency ventilation system for stations and tunnels and should be considered in the design of the emergency ventilation system.

B.6 Under-Platform Ventilation System.

B.6.1 An under-platform ventilation system should be considered for the extraction of heat from traction and braking devices. Intakes should be provided below the platform level and should be situated relative to the heat-producing devices on a train berthed in a station.

B.6.2 Ceiling ventilation, by powered or gravity design, to aid in the removal of smoke and/or heat should be considered.

B.7 Platform Screen and Edge Doors.

B.7.1 The inclusion of platform edge screens is a design option that is effective for comfort control in stations as well as for smoke control in tunnels. When used, the screens should meet both fire resistivity and structural strengths relative to the train and ventilation system drafts and the operational efficiency requirements.

B.7.2 In a tunnel-to-station evacuation scenario, access to the platform level from the trainway should be considered.

B.8 Nonfire Tunnel Ventilation.

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

Annex C Emergency Egress

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

C.1 Station Occupant Load.

The station platform dimensions are a function of the length of trains served and the train load. Thus the length of a platform at an outlying station might be equal to those of central business district transit stations where the train loads are significantly higher. Consequently, the platform and station occupant loads are a function of the train load and the simultaneous entraining load. This concept differs from that of NFPA *101*, *Life Safety Code*, where the occupant load is determined by dividing the floor area by an occupant load factor assigned to that use. Applying the *Life Safety Code* approach to determine the station platform occupant load is inappropriate.

C.1.1 Calculating Occupant Load. Projected ridership figures serve as the basis for determining transit system design. Per this standard, the methodology used to determine ridership figures must also include peak ridership figures for new transit systems and existing operating systems. Events at stations such as civic centers, sports complexes, and convention centers that establish occupant loads not included in normal passenger loads must also be included. These ridership figures serve as the basis for calculating train and entraining loads and the station occupant load. The methodology used for determining passenger ridership figures can vary by transit system. The use of statistical methods for determining *calculated train loads* and *calculated entraining loads* will provide a more accurate indication of the required means of egress facilities within a station.

C.1.2 Calculating Evacuation Time. The total evacuation time is the sum of the walking travel time for the longest exit route plus the waiting times at the various circulation elements. The tunnel can be considered as an auxiliary exit from the station under certain fire scenarios.

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

(1) For the platform exits, by subtracting the walking travel time on the platform from the platform exits flow time

(2) For each of the remaining circulation elements, by subtracting the maximum of all previous element flow times

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

T = total walking travel time for the longest exit route

T_p = walking travel time on the platform

T_X = walking travel time for the Xth segment of the exit route

F_p = platform exits flow time

F_{fb} = fare barrier flow time

F_c = concourse exits flow time

F_N = flow time for any additional circulation element

$W_p = F_p - T_p$ = waiting time at platform exits

$W_{fb} = F_{fb} - T_{fb}$ = waiting time at fare barriers

$W_c = F_c$ - max (F_p or F_{fb}) = waiting time at concourse exits

$W_N = F_N$ - max (F_c, F_{fb}, or F_p) = waiting time at any additional circulation element

Note that the waiting time at any circulation element cannot be less than zero.

C.1.3 Center-Platform Station Sample Calculation. The sample center-platform station is an elevated station with the platform above the concourse, which is at grade *(see Figure C.1.3)*. The platform is 183 m (600 ft) long to accommodate the train length. The vertical distance from the platform to the concourse is 9 m (30 ft).

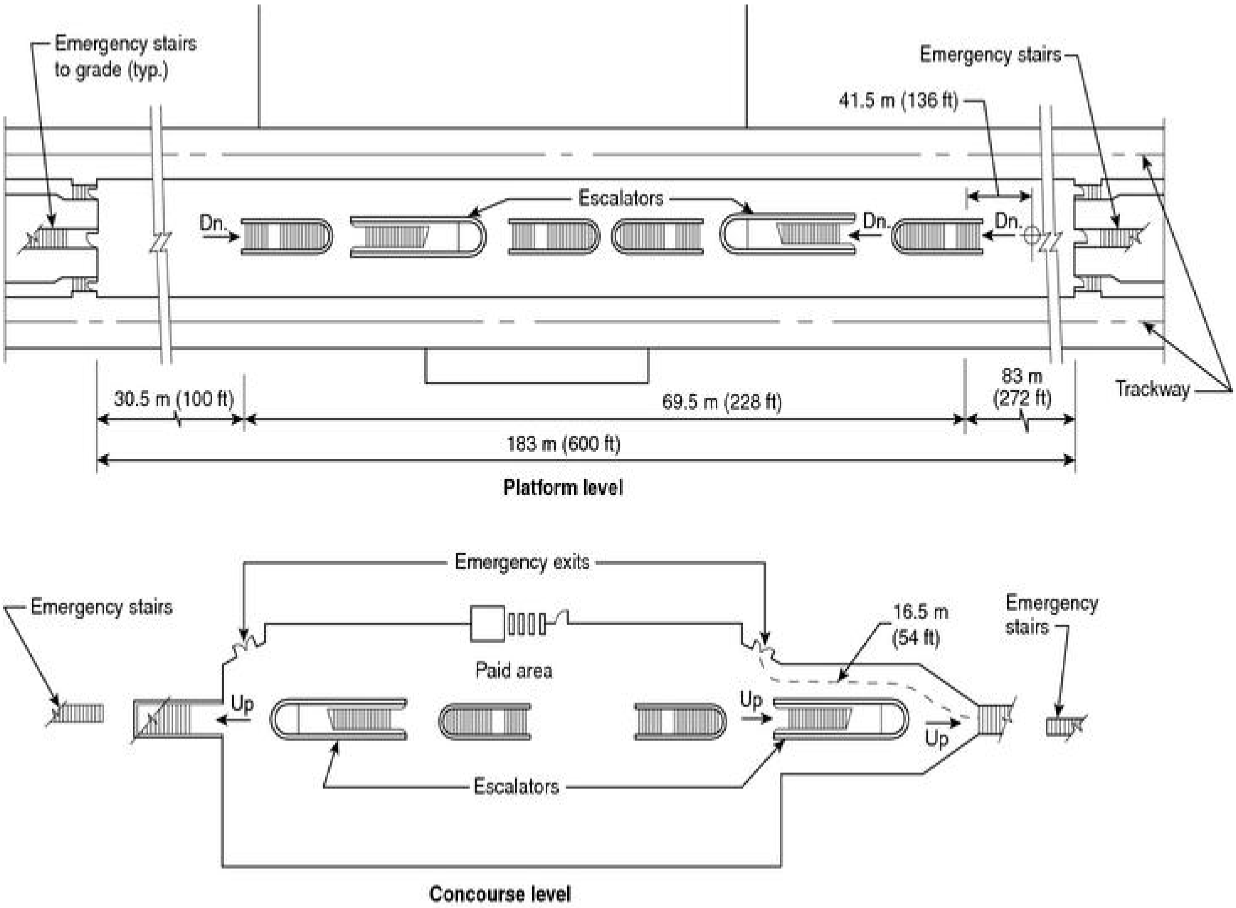

FIGURE C.1.3 Center-Platform Station.

The sample station has one paid area separated from the outside by a fare array containing four electronic fare gates and one 1220 mm (48 in.) handicapped/service gate. In addition, two 1829 mm (72 in.) wide emergency exits are provided. Six open wells communicate between the platform and the concourse. Each well contains one stair or one escalator. Station ancillary spaces are located at the concourse level.

Elevators (not shown in Figure C.1.3) are provided for use by handicapped persons or service personnel. Open emergency stairs are provided at each end of the platform and discharge directly to grade through grille doors with panic hardware.

Escalators are nominal 1220 mm (48 in.) wide. Stairs regularly used by patrons are 1829 mm

(72 in.) wide; emergency stairs are 1220 mm (48 in.) wide. Gates to emergency stairs are 1220 mm (48 in.) wide.

The station occupant load is 2314 persons.

Table C.1.3 lists the data for the exiting analysis of the sample center-platform station.

Table C.1.3 NFPA 130 Exiting Analysis of Sample Center-Platform Station

Egress Element	mm	in.	p/mm-min	pim
Platform to concourse (downward)				
Stairs (4)	7315	288	0.0555	1.41
Escalators (2*)	1219	48	0.0555	1.41
Emergency stairs (2)	2438	96	0.0555	1.41
Escalator test: 8.67% (Not > 50%)				
Throughfare barriers				
Fare gates (4) (capacity = 50 per gate)				
Service gates (1)	1219	48	0.0819	2.08
Emergency exit doors (2)	3658	144	0.0819	2.08
Fare barriers to safe area (fare barriers discharge to outside)				
Stairs	0	0	0.0555	1.41
Escalators	0	0	0.0555	1.41
Emergency stairs	0	0	0.0555	1.41
Escalator test: 0.00% (Not > 50%)				
Walking Time for Longest Exit Route	**m**	**ft**	**m/min**	**fpm**
Platform to safe area				
On platform, T_1	41.4	136	37.7	124
Platform to concourse, T_2	9.1	30	14.6	48
On concourse, T_3	16.4	54	37.7	124
Concourse to grade, T_4	0	0	14.6	48
On grade to safe area, T_5	3.05	10	37.8	124
Total walking time, $T = T_1 + T_2 + T_3 + T_4 + T_5$				

*One escalator discounted.

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

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

$$F_p = \frac{2314}{609}$$

$$F_p = 3.80 \text{ minutes}$$

In Test No. 1, the time to clear the platform is found to be 3.80 minutes. This meets the requirement of 5.5.6.1.

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

W_p (waiting time at platform exits) = F_p - T_1

W_p = 3.80 - 1.09 = 2.71 minutes

Concourse occupant load = Platform occupant load - (F_p × emergency stair capacity)

Concourse occupant load = 2314 - 513

Concourse occupant load = 1801 persons

W_{fb} (waiting time at fare barriers) = F_f - F_p

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

$$F_{fb} = \frac{1801}{600} = 3.0$$

W_c = F_{fb} - F_p

W_c = 3.0 – 3.80 = 0.000 minutes

W_c (waiting time at concourse exits) = [F_c - max(F_{fb} or F_p)]

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

$$F_c = \frac{1801}{0} = 0.000 \text{ minutes}$$

W_c = F_c - max(F_{fb} or F_p)

W_c = 0.000 - 3.80 = 0.000 minutes

Total exit time = T + W_p + W_f + W_c

Total exit time = 2.14 + 2.71 + 0.000 + 0.000

Total exit time = 4.85 minutes

In Test No. 2, the time to reach a point outside any enclosing structure is found to be 4.85 minutes. This meets the requirement of 5.5.6.2.

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

C.1.4 Side-Platform Station Sample Calculation. The sample side-platform station is a subway station with a concourse above the platform level but below grade. *(See Figure*

C.1.4.) The platform is 183 m (600 ft) long to accommodate the train length. The vertical distance from grade to concourse is 8 m (26 ft). The concourse is 5.5 m (18 ft) above the platform.

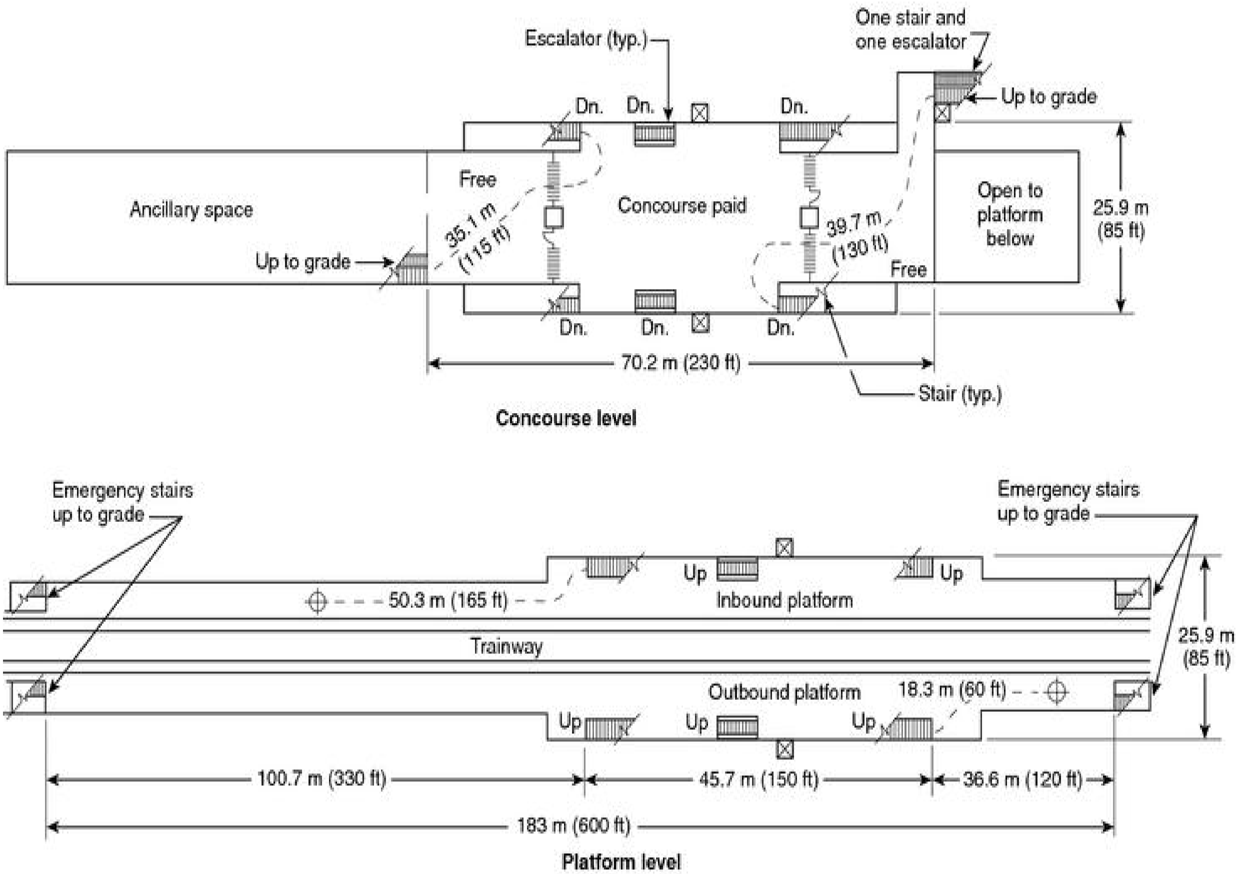

FIGURE C.1.4 Side-Platform Station.

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

The concourse is divided into two free areas and one paid area separated by fare arrays. Each fare array contains 12 fare gates of the turnstile type and one swinging service gate, 1220 mm (48 in.) wide, equipped with panic hardware for use by handicapped persons and service personnel.

Three open wells, containing two stairs and one escalator, communicate between each platform and the concourse.

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

Enclosed emergency stairs, discharging directly to grade, are provided at both ends of each platform. Escalators are nominal 1220 mm (48 in.) wide. Stairs regularly used by patrons are 1829 mm (72 in.) wide. Emergency stairs are 1220 mm (48 in.) wide. Doors to emergency stairs are 1220 mm (48 in.) wide.

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

Table C.1.4 lists the data for the existing analysis of the sample side-platform station.

Table C.1.4 Exiting Analysis of Sample Side-Platform Station

Egress Element	mm	in.	p/mm-min	pim	
Inbound platform to concourse (upward)					
Stairs (2)	3658	144	0.0516	1.31	
Escalators (1*)	1219	48	0.0516	1.31	
Emergency stairs (2)	2438	96	0.0516	1.31	____
Throughfare barriers					
Turnstiles (12) (capacity = 25 p/min)					
Service gate (1)	1219	48	0.0819	2.08	____
Fare barriers to safe area					
Stairs (1)	1829	72	0.0516	1.31	
Escalator* (0)	0	0	0.0516	1.31	____
Walking Time for Longest Exit Route	**m**	**ft**	**m/min**	**fpm**	
Inbound platform					
On platform, T_1	50.3	165	37.7	124	
Platform to concourse, T_2	5.5	18	12.1	40	
On concourse, T_3	35.1	115	37.7	124	
Concourse to grade, T_4	7.9	26	12.1	40	
On grade to safe area, T_5	3.05	10	37.7	124	____
Total walking time, $T = T_1 + T_2 + T_3 + T_4 + T_5$					
Element	**mm**	**in.**	**p/mm-min**	**pim**	
Outbound platform to concourse (upward)					
Stairs (2)	3658	144	0.0516	1.31	
Escalators (1*)	1219	48	0.0516	1.31	
Emergency stairs (2)	2438	96	0.0516	1.31	____
Throughfare barriers					
Turnstiles (12) (capacity = 25 p/min)					
Service gate (1)	1219	48	0.0819	2.08	____
Fare barriers to safe area					
Stairs	1829	72	0.0516	1.31	
Escalator	1219	48	0.0516	1.31	____
Walking Time for Longest Exit Route	**m**	**ft**	**m/min**	**fpm**	
Outbound platform					
On platform, T_1	18.2	60	37.7	124	

Table C.1.4 Exiting Analysis of Sample Side-Platform Station

Egress Element	mm	in.	p/mm-min	pim
Platform to concourse, T_2	5.5	18	12.1	40
On concourse, T_3	39.6	130	37.7	124
Concourse to grade, T_4	7.9	26	12.1	40
On grade to safe area, T_5	3.05	10	37.7	124
Total walking time, $T = T_1 + T_2 + T_3 + T_4 + T_5$				

*Worst case: escalator-out-of-service test (5.5.6.3.2.6).

The sample calculation shown is one of several that needs to be done to properly analyze this type of station. The sample calculation shows the effect of discounting one of the escalators from concourse to grade. The egress capacity from platform to concourse meets the criteria of 5.5.6.1 in Test No. 1, where the time to clear the platform is found to be 3.66 minutes for the inbound platform and 0.61 minute for the outbound platform.

However, in Test No. 2, the total exit time (i.e., the maximum exit time for the two paths examined) is found to be 7.83 minutes. This does not meet the criteria of 5.5.6.2; therefore, additional egress capacity is needed from concourse to grade.

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

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

Inbound platform:

$$F_{p-i}\,(\text{time to clear platform}) = \frac{\text{Platform occupant load}}{\text{Platform egress capacity}}$$

$$F_{p-i} = \frac{1372}{375}$$

$$F_{p-i} = 3.66 \text{ minutes}$$

Outbound platform:

$$F_{p-o}\,(\text{time to clear platform}) = \frac{\text{Platform occupant load}}{\text{Platform egress capacity}}$$

$$F_{p-o} = \frac{228}{375}$$

$$F_{p-o} = 0.61 \text{ minutes}$$

F_p for inbound and outbound occupant loads satisfies the criterion of 4 minutes.

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

Inbound platform:

$W_{p\text{-}i}$ (waiting time at platform egress elements) = $F_{p\text{-}i}$ - $T_{1\text{-}in.}$

$W_{p\text{-}i}$ = 3.66 - 1.34 = 2.32 minutes

Concourse occupant load = Platform occupant load - $F_{p\text{-}i}$ × emergency stair capacity)

Concourse occupant load = Platform occupant load - $F_{p\text{-}i}$ × emergency stair capacity)

Concourse occupant load = 1372 - 458

Total concourse occupant load = 914 persons

Outbound platform:

$W_{p\text{-}o}$ (waiting time at platform egress elements) = $F_{p\text{-}o}$ - $T_{1\text{-}out}$

$W_{p\text{-}o}$ = 0.61 - 0.49 = 0.12 minute

Concourse occupant load = Platform occupant load - ($F_{p\text{-}o}$ × emergency stair capacity)

Concourse occupant load = 228 - 77

Concourse occupant load = 151 persons

Total concourse occupant load = Concourse load (inbound) + Concourse load (outbound)

Total concourse occupant load = 914 + 151 = 1065 persons

Inbound platform:

W_{fb} (waiting time at fare barriers) = F_{fb}-$F_{p\text{-}i}$

$$F_{fb} = \frac{\text{Concourse occupant load}}{\text{Fare barrier egress capacity}}$$

$$F_{fb} = \frac{533}{399}$$

F_{fb} = 1.34 minutes

$W_{fb} = F_{fb} - F_{p\text{-}i}$

W_{fb} = 1.34 - 3.66 = 0.00 minutes

W_c (waiting time at concourse egress elements) = F_c - max(F_{fb} or $F_{p\text{-}i}$)

$$F_c\,(\text{concourse flow time}) = \frac{\text{Concourse occupant load}}{\text{Concourse egress capacity}}$$

$$F_c = \frac{533}{94}$$

F_c = 5.68 minutes

$W_c = F_c$ - max(F_{fb} or $F_{p\text{-}i}$)

W_c = 5.68 - 3.66 = 2.02 minutes

Outbound platform:

W_{fb} (waiting time at fare barriers) = F_{fb} - $F_{p\text{-}o}$

$$F_{fb} = \frac{\text{Concourse occupant load}}{\text{Fare barrier egress capacity}}$$

$$F_{fb} = \frac{533}{399}$$

F_{fb} = 1.34 minutes

W_{fb} = F_{fb} - $F_{p\text{-}o}$

W_{fb} = 1.34 - 0.61 = 0.73

W_c (waiting time at concourse egress elements) = F_c - max(F_{fb} or $F_{p\text{-}o}$)

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

$$F_c = \frac{533}{156}$$

F_c = 3.42 minutes

W_c = F_c - max(F_{fb} or $F_{p\text{-}o}$)

W_c = 3.42 - 1.34 = 2.08 minutes

Total egress time = T + W_p + W_{fg} + W_c

Inbound platform:

Total = 3.49 + 2.32 + 0.00 + 2.02

Total = 7.83 minutes

Outbound platform:

Total = 2.76 + 0.12 + 0.73 + 2.08

Total = 5.69 minutes

C.1.5 Multilevel-Platform Stations. The procedures for calculating exiting times for multilevel platform stations are similar to the sample calculations in C.1.3 and C.1.4. The changes in the exiting calculations are for multilevel-platform stations primarily a function of the concurrent occupancy load determinations for the two platform levels.

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

(1) Calculate the occupancy load for each platform level as in the appropriate examples in C.1.3 and C.1.4 for the same assumed time(s) of day.

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

(3) The upper-level occupant load is increased by the people evacuating from the lower level through the normal egress routes in accordance with C.1.5(2).

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

The remainder of the exiting calculations essentially are unchanged from the other sample calculations in C.1.3 and C.1.4.

C.2 Escalators.

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

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

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

(1) Direction of travel

(2) Operating speed (if more than one)

(3) Out-of-service status

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

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

Annex D Rail Vehicle Fires

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

D.1 Introduction.

This annex provides additional information on the hazards associated with burning vehicles and the impact of a burning vehicle on the evacuation of passengers and crew to a point of safety. Emergency evacuation from a train containing a fire could include exiting a car containing the fire to an adjacent car, exiting the train into the operating environment (station, tunnel, etc.) where the train is located, and moving through the operating environment to the point of safety. Chapter 8 on vehicles contains minimum prescriptive requirements that are intended to provide sufficient time for passengers and crew to safely evacuate from a train containing a fire. Chapters 5 through 7 provide requirements on design of the operating environment to ensure that passengers can safely egress to a point of safety. A fire involving a train will have an impact on the conditions in the operating environment, and this type of fire is often used to design emergency systems in operating environments. This annex provides guidance for designing and evaluating train fire performance.

D.2 Initial Fire Development Inside Vehicles.

The development of fires inside trains is dependent on the fire performance of interior finish materials, the size and location of the initiating fire, the size of the enclosure where the fire is located, and the ventilation into the enclosure.

D.2.1 Material fire performance is most often considered in the evaluation of fire performance of the vehicle. Material fire performance is measured in terms of ignitibility, heat release rate, and smoke and toxic gas production. Flame spread and fire development is dependent on the material's ignitibility and heat release rate as well as the severity of the initiating fire and surrounding environment.

D.2.1.1 The ignitibility, heat release rate, and smoke and toxic gas production can be measured in the ASTM E 1354 cone calorimeter. It is recommended that all combustible materials on a train be tested in the cone calorimeter. At a minimum, tests should be conducted at a heat flux of 50 kW/m^2 in duplicate. For a more detailed evaluation of the material performance, cone calorimeter tests should be performed at three different heat fluxes where the material ignites (e.g., 25, 50, and 75 kW/m^2). The cone calorimeter can also be used to measure the critical heat flux of the material, which is the lowest heat flux at which the material will ignite. The critical heat flux can be used to determine the ignition temperature of the material. Analysis to predict flame spread along materials will require the more detailed set of cone calorimeter data along with the critical heat flux of the material.

D.2.1.2 In Chapter 8, the minimum fire performance of many interior finish materials is required to be measured using the ASTM E 162 flame spread test. Though this downward flame spread test will screen out many poorly performing materials, the test does not provide a measure of wind-aided flame spread (i.e., upward flame spread or flame spread along a ceiling). Wind-aided flame spread is the fastest type of flame spread and is the type of flame spread that will cause the maximum surface area of material to become involved in the fire. The amount of upward flame spread is affected by the size of the initiating fire and the material fire performance. Some materials might not exhibit any flame spread when exposed to a small fire (e.g., a newspaper fire), but when exposed to something slightly larger (e.g., burning bag of trash with paper and plastic) will readily spread flame.

D.2.1.3 Smoke and toxic gas production can have an impact on the environment through which passengers will need to evacuate. Some materials will naturally produce more smoke and toxic gases. Some fire-retardant additives can cause more smoke and toxic gases to be produced compared with untreated materials. The amount of smoke and toxic gas produced will be a function of the amount of material burning. Therefore, limiting fire propagation on materials will also help limit the amount of smoke and toxic gas production.

D.2.2 The size and location of the initiating fire will have a significant impact on whether materials become ignited and spread flame. Materials exposed to higher levels of heat (heat fluxes) will ignite more readily, release more heat, and usually will result in more flame spread. Research has shown that increasing the physical size and the heat release rate of the fire will increase the heat flux produced by the initiating fires. Increasing the heat release rate of the fire will also increase the flame height, which will expose larger areas of material to the high heat fluxes in the flaming region. The location of the initiating fire will also affect the heat fluxes produced by the fire. For the same size fire, higher heat fluxes are produced when the fire is located in a corner instead of against a flat wall.

D.2.3 The gas temperature inside of the enclosure containing a fire can have a significant impact on the growth rate of the fire. Elevated gas temperatures will pre-heat unignited material and will potentially accelerate flame spread across the material. Gas temperatures in an enclosure can be affected by the size of the enclosure, the ventilation into the enclosure, and the heat release rate of the fire. The gas temperature will increase when the enclosure size is decreased and the heat release rate is increased.

D.3 Fire Development Outside Vehicles.

Outside of vehicles, flames can spread along continuous pieces of combustible materials or ignite adjacent materials if exposed to sufficient heat. Underneath vehicles, combustible items that are adequately spaced will prevent the spread of fire. If the car is moving, flames can be longer, making safe separation distances longer. It might also be possible for flames from fires underneath vehicles to extend out to the sides and ends of the vehicle. These undercar fires can ignite and initiate flame spread along combustible materials on the sides and ends of the vehicle. Combustible materials on the sides and ends of the vehicle might also be vulnerable to other types of fires that could occur on the exterior of the vehicle.

D.3.1 An increasing amount of the exterior car body is being manufactured of fiber-reinforced resin composite materials. End caps have been made of composite materials for years, and other car body components are being constructed of composite materials to make vehicles lighter in weight. Though these materials meet the ASTM E 162 requirement in Chapter 8, these materials can ignite and flames can spread up the height of the vehicle. With large surface areas of combustible materials, there is the potential for exterior fires to become quite large.

D.3.2 Initiating fires on the exterior of the vehicle could range from a small trash fire to a car fire. Though the trash fire might be small, it could be possible for it to ignite combustible components on the exterior and for flames to spread up the car. Some trains are in close proximity with automobiles. Automobile fires can become quite large (~5 MW) and could include fuel spills. If such fires were close to a train, it would be likely that the fire would ignite nearby combustible exterior components on the train.

D.3.3 Connections between cars can be particularly vulnerable to exterior fires. Some cars are connected by articulating bellows, which are constructed of relatively thin, flexible, combustible materials. The fire resistance in these areas should be carefully designed to ensure that exterior fires do not extend into the vehicle before passengers have been safely evacuated.

D.3.4 Spread of fire from one vehicle to an adjacent vehicle can cause the total heat release rate of the train fire to significantly increase. This could occur if the fire on the outside of one vehicle radiates enough heat to ignite the nearby adjacent vehicle. Vehicle-to-vehicle spread could also occur if a fire inside a vehicle has reached flashover and flames extending outside of the vehicle through windows or doors are able to ignite the nearby vehicle.

D.4 Vehicle Fire Heat Release Rate History.

The heat release rate history of a vehicle fire should include the heat release rate during all stages of the fire. Fires inside of vehicles that are allowed to grow sufficiently large can reach flashover, where all of the items inside of the vehicle ignite. The largest heat release rates are expected after flashover occurs (i.e., postflashover). The heat release rate during postflashover is particularly important since many tunnel and station smoke control system designs are based on the maximum expected heat release rate. The heat release rate of the vehicle fire will also affect the heat that passengers could be exposed to during evacuation. The magnitude of the heat release rate during postflashover will be a function of the amount of air drawn into the vehicle, the material fire properties, and the potential heat release rate of the burning fuels inside of the vehicle.

D.4.1 The fire properties of a material will determine the impact of the material on the postflashover fire conditions. The postflashover fire is a balance of heat gains and heat losses. As a result, the ratio between the material heat of combustion and heat of gasification is particularly important. The heat of combustion is the amount of energy produced per gram of material burned (heat gain), while the heat of gasification is the energy required to convert solid material into gas (heat loss). If this ratio is high (heat of combustion several times greater than the heat of gasification), then the material will contribute more heat to the fire compared with the amount it takes to produce the gas. This scenario will result in a more intense fire. As the ratio becomes closer to 1, the fire will burn with less intensity. Depending on the conditions, materials with a ratio close to 1 might not be able to self-support a postflashover fire environment.

D.4.2 The amount of air drawn into a postflashover fire will be a function of the number of ventilation openings. Initially, this could be doors or windows where passengers have evacuated from the train. Many vehicles will contain mostly polycarbonate windows. As the fire continues to burn, polycarbonate windows will thin and begin to develop holes (Strege et al.). Glass windows will crack, shatter, and fall out. Eventually, these areas will be completely open to allow air in and smoke to exhaust from the vehicle fire.

D.4.2.1 The impact of additional ventilation openings is dependent on the heat losses and gains to the vehicle fire. Additional openings will allow more energy to be lost from the vehicle fire through radiation and convection. However, the additional air into the vehicle fire allows more heat to be released inside of the vehicle. If the fuels inside of the vehicle can produce this heat release rate, then the fire will burn at that higher heat release rate. It is also possible that when the windows fail, the energy losses might outweigh the heat that can be produced by the materials, and the fire will begin to diminish in size. This is also what happens when the fire begins to go into the decay stage; the fire inside of the vehicle can no longer produce sufficient heat to outweigh the heat losses.

D.4.3 The heat release rate of the train fire will also affect the amount of heat the passengers are exposed to during the evacuation. Larger heat release rate fires will produce longer flames that could extend out of the vehicle openings. If the vehicle is inside a tunnel, these flames could impinge on the ceiling and extend down away from the burning vehicle. Radiation from these flames to nearby evacuating passengers could be significant.

D.5 Volume of Smoke Produced by Burning Vehicles.

D.5.1 The volume of smoke produced by a fire is dependent on the entrainment into the smoke plume. The entrainment into the smoke plume varies depending on the geometry. For example, a free-burning circular pool fire will produce a different volume of smoke compared with the same heat release rate fire burning in a line. Natural or ventilation-induced air currents can have an impact on entrainment.

D.5.2 Volume of smoke from fires inside of vehicles will be exhausted out of the vehicle through open doors or window openings. As a result, the volume of smoke produced by a vehicle fire will be the smoke volume produced by a series of window plumes. The volume of smoke produced will be dependent on how high the gases are allowed to rise before they impinge on the ceiling or reach the upper smoke layer interface.

D.5.3 Volume of smoke from under-car fires or fires involving the outside of the vehicle can be modeled by assuming that the fire is a line fire. The volume of smoke produced will be dependent on how high the gases are allowed to rise before they impinge on the ceiling or reach the upper smoke layer interface.

Annex E Fire Hazard Analysis Process

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

E.1 Introduction.

This annex was prepared to provide expanded understanding of the process required to conduct a fire hazard analysis for fixed guideway and passenger rail vehicles. NFPA *101* [1] and other cited references provide more complete information.

E.2 Fire Hazard Analysis.

The prescriptive-based vehicle fire performance requirements in Chapter 8 of this standard are based on individual material tests. With the use of the fire hazard analysis process, it should be possible to ascertain the fire performance of vehicle materials and assemblies in the context of actual use. The result of such a fire hazard analysis should be a clear understanding of the role of materials, geometry, and other factors in the development of fire in the specific vehicles studied. By identifying when or if specific conditions are reached such that materials begin to contribute to the fire hazard, fixed guideway transit and passenger rail systems vehicle designers and authorities having jurisdiction will have a better foundation on which to base appropriate vehicle and system design and the evaluation of the fire performance of such vehicle designs. By showing the relative contribution of a particular design feature or material, it is possible to make a more realistic assessment of the necessity for specific vehicle design requirements to meet fire/life safety objectives and criteria.

The *SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings* [2] provides a framework for these assessments. Other useful references include ASTM E 2061 [3] and the APTA RP PS-005-01 recommended fire safety analysis practice for existing car equipment [4]. On May 12, 1999, the Federal Railroad Administration (FRA) issued a rule containing passenger rail equipment safety standards [5]. The FRA issued a revision of the fire safety regulation on June 25, 2002.[6] The standards contained in 49 CFR 238.103 require that materials used for passenger rail cars and locomotives meet certain fire safety performance criteria and that fire safety (e.g., hazard) analysis be conducted for all new and existing rail passenger equipment.

Scenarios are used to assess the adequacy of designs considered and ultimately selected. As such, initiating events as referenced from the ASTM rail fire assessment guide [3] are specified for study for which ensuing outcomes must be satisfactory. Although developed for the analysis of existing equipment, the APTA recommended fire safety practice provides a framework and resources for the application of fire hazard analysis in vehicles that might be applicable to new or retrofitted equipment.

Finally, it is important to note that the fire hazards relating to the vehicle-operating environment must be considered.

If the outcome predicted by assessment of the scenarios evaluated is bound by the performance criteria stated, then the objectives will have been met, and the life safety characteristics of a proposed vehicle design can be considered to be consistent with the goals of this standard. It must be assumed that if a design fails to comply with the life safety goals and objectives and associated performance criteria, it must be changed and reassessed iteratively until satisfactory performance levels are attained.

On June 25, 2002, the FRA published a Federal Register Notice that clarified several items relating to the fire tests and performance criteria, and revised certain parts of the fire safety analysis requirements [6].

Documentation of assessment parameters, such as those used with scenarios, is critical. The approval and acceptance of a fire/life safety design is dependent on the quality of the documentation used in this process.

E.3 Overview of Fire Hazard Analysis Process for Vehicles.

The information in this section is based on a research study sponsored by the FRA. Additional details of the research program are available [7].

ASTM E 2061 [3] provides resources and references for the application of fire hazard analysis techniques to rail vehicles but is not intended to provide a specific prescriptive standard or method. Part of the purpose of NFPA 130 is to provide such a specific method for the application of fire hazard analysis tools and the ASTM guide when applied to specific vehicle designs.

Traditionally, fire hazard analysis techniques involve a four-step process for the evaluation of a product or products in a specific scenario:

(1) Define the context.

(2) Define the scenario.

(3) Calculate the hazard.

(4) Evaluate the consequences [8].

For the analysis of vehicles, this process limits the evaluation to the contribution of specific materials and products without providing an overall assessment of the fire performance of the entire system.

The traditional four-step evaluation process can be extended to better reflect the minimum appropriate performance of the overall vehicle system while maintaining the evaluation of a specific design compared against the required baseline. For this systems-based analysis, the process is also conducted in four steps:

(1) Define vehicle performance objectives and design.

(2) Calculate vehicle fire performance.

(3) Evaluate specific vehicle fire scenarios.

(4) Evaluate vehicle car design suitability.

Steps 1 and 4 are largely subjective and depend on the expertise of the user. Step 2 can involve hand calculations or some use of computer modeling software. The heart of Step 2 is a sequence of procedures to calculate the development of hazardous conditions over time, to calculate the time needed by occupants to escape under those conditions, and to estimate the resulting effects on the vehicle occupants, based on tenability criteria. In addition to evaluating the hazard resulting from specific materials and components used in the vehicle design, Step 2 determines the worst-case fire that allows the overall vehicle system to meet chosen design criteria. Step 3 evaluates the specific fires that are likely to occur. Step 4 compares the results of Steps 2 and 3 and evaluates the appropriateness of the calculations performed, as well as determines whether the proposed design meets the performance objectives and design established in Step 1. The procedure in Table E.3 shows each step in objectives and design established in Step 1. The procedure in Table E.3 shows each step in the process tailored for rail vehicle design.

Table E.3 System of Vehicle Fire Hazard Analysis Steps

Step 1: Define vehicle performance objectives and design.	(a) Clearly define fire performance objectives. (b) Determine the geometry of the vehicle. (c) Include other design parameters that might have an impact on a possible fire, such as a tunnel operating environment, material controls, fire detection and suppression, or other system procedures.
Step 2: Calculate vehicle fire performance.	(a) Determine minimum acceptable performance criteria based on the vehicle design. (b) Establish standard design fires. (c) Use predictive calculation and/or model calculations, to determine the fire performance of the proposed design for a range of design fires. (d) Create a fire performance graph.
Step 3: Evaluate specific vehicle fire scenarios.	(a) Examine relevant fire incident experience with same/similar applications. (b) Identify the likely role/involvement of application contents in fire. (c) Ask which fires are most common/likely? Most challenging? (d) Quantify the burning behavior for chosen scenarios from available fire test data or appropriate small- and large-scale tests.
Step 4: Evaluate suitability of vehicle design.	(a) Estimate through expert judgment, regulatory guidance, and, when needed, complementary small- and large-scale tests the effects of unknowns not accounted for in the fire performance graphs.

	(b) Establish the sensitivity of the fire performance graph to known inputs. (c) Set appropriate design margins. (d) Determine the acceptability of the design.

E.3.1 Step 1: Define Vehicle Performance Objectives and Design. Both the proposed performance objectives and the vehicle design must be defined. Clear goals and objectives with well-defined acceptance criteria quantify the minimum acceptable performance that must be met in the final vehicle design. These will all be provided by the responsible fixed guideway transit or passenger railroad system, by the authorities having jurisdiction, and by expert engineering judgment based on the performance of the existing acceptable vehicle designs and the operating environment. For example, an objective might be to provide life safety for passengers in the event of a fire or to minimize damage to property. Performance criteria are more specific and might include limits on temperature of materials, gas temperatures, smoke concentration or obscuration levels, concentration of toxic gases, or radiant heat flux levels, to allow for sufficient time to evacuate occupants to a point of safety.

The analysis requires a detailed understanding of the geometry (e.g., configuration) of the system being considered, including construction materials, sizes, and connections for all compartments, typical furnishings, and other design parameters that might affect the fire. Such parameters might include fire detection or suppression systems, ventilation systems, and emergency exits and procedures.

E.3.2 Step 2: Calculate Vehicle Fire Performance. The second step determines the response of the vehicle system to a range of chosen design fires. This response can be expressed in the form of one or more fire performance graph(s), which present the calculated design criterion as a function of the size of the fire. In addition, the minimum acceptable performance criteria are determined by calculation or specification. For example, a fire performance graph might show the available egress time as a function of the fire size in a vehicle, and the minimum acceptable performance criterion might be the time necessary for passengers to safely evacuate the vehicle. These criteria can be specified by the fixed guideway transit or passenger railroad system, by authorities having jurisdiction, or by expert engineering judgment based on the performance of the existing acceptable designs.

Once the detailed problem has been defined, this information can be used as input to a hand calculation or computer fire model to predict conditions within each compartment of the vehicle as a function of time. For this analysis, these conditions include temperature, hot gas layer position (typically termed *interface height*), visibility, and toxic gas concentrations throughout the car. These conditions are used to calculate tenability within the car. Conditions are considered untenable when there is a threat to passenger life safety, evaluated as an elevated temperature, products of combustion exposure, or a combination of the two. The time at which conditions within the vehicle become untenable for each design fire are plotted as a function of the size of the design fire to produce a fire performance graph for each application.

The calculation of minimum necessary egress time, whether from a building or a vehicle, involves many assumptions. Several models can be used to increase the confidence in the egress time calculation. It is important to remember that the minimum necessary egress time does not include panic, scattered luggage in a postcrash vehicle, or bodily injury to occupants prior to evacuation commencement. An appropriate design margin applied to the model time should account for such limitations. Typically, a factor of 2 is used as a design margin [9].

E.3.3 Step 3: Evaluate Specific Vehicle Fire Scenarios. Step 3 evaluates possible vehicle fire scenarios in order to place the fire performance curves in context and to allow the designer to adopt reasonable design margins in the final vehicle design evaluation in Step 4. A significant amount of information relevant to scenario definition can be obtained from historical fire incident experience (e.g., see references 10 and 11 in Section E.4). Databases such as the National Fire Incident Reporting System (NFIRS) contain relevant vehicle data, normally segregated into specific categories [12].

Representative fire scenarios include the following:

(1) Ignition under a seat by a small source (crumpled newspaper)

(2) Ignition source on top of a vandalized seat (crumpled newspaper)

(3) Overheated equipment (electrical, HVAC)

The location of the train must be also considered in the analysis. For example, the fire risk to occupants is greater if the train is located between stations or within a tunnel.

More detailed information describing passenger-carrying vehicle fire scenarios are contained in the ASTM guide and the APTA recommended practice cited earlier in Section E.2. Relevant data describing specific fires appropriate for the vehicle application are defined and used as input to the same fire model used in Step 2. The results of these model calculations can be compared to the design fires used in Step 2 to define appropriate design margins for analysis.

E.3.4 Evaluate Suitability of Vehicle Design. Taking into account the results of the calculations and using engineering judgment, experience, and the requirements of the authorities having jurisdiction, an appropriate design margin is decided upon and applied to the minimum acceptable criteria. If the worst-case vehicle fire scenarios are all less hazardous than the minimum criteria multiplied by the design margin, then the vehicle design is said to be acceptable.

Finally, the results of any analysis should be challenged by the user's common sense and experience. Results that violate these should be questioned and resolved. Comparisons should be made to data from similar experiments or actual passenger train fires wherever possible. If such data are not available, it might be advisable to conduct verifying tests in situations where public safety is at risk.

The outcome of the fire hazard analysis will be a statement of whether the vehicle design under consideration constitutes a threat above acceptable limits. Further analysis can ascertain whether compartmentation, detection and suppression systems, and other intervention strategies can further minimize the fire hazard.

E.4 References.

The following references are cited in this annex.

(1) NFPA *101*, *Life Safety Code*, Quincy, MA: NFPA, 2006.

(2) *SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings*, Bethesda, MD: Society of Fire Protection Engineers, 2000.

(3) ASTM E 2061, *Guide for Fire Hazard Assessment of Rail Transportation Vehicles*. West Conshohocken, PA: ASTM International, 2003.

(4) APTA RP PS-005-01, *Recommended Practice for Fire Safety Analysis of Existing Passenger Rail Equipment*, Washington, DC: American Public Transportation Association, August 2000.

(5) Federal Railroad Administration, 49 CFR, Transportation, Parts 216, 223, 229, 231, 232, and 238, “Passenger Equipment Safety Standards: Final Rule.” *Federal Register*, Vol. 64, No. 91, May 12, 1999, 25540–25705 (Washington, DC: National Archives and Records Administration).

(6) Federal Railroad Administration, 49 CFR, Transportation, Parts 216, 223, 229, 231, 232, and 238, “Passenger Equipment Safety Standards: Final Rule.” *Federal Register*, Vol. 67, No. 102, June 25, 2002, 42892-42912 (Washington, DC: National Archives and Records Administration).

(7) Peacock, R. D., et al. *Fire Safety of Passenger Trains, Phase II, Application of Fire Hazard Analysis Techniques*. Prepared for Federal Railroad Administration (FRA), U.S. Department of Transportation (USDOT). National Institute of Standards and Technology (NIST) Interim Report, Report No. DOT/FRA/ORD 01/16, December 2001, and NISTIR 6525, December 2002.

(8) Bukowski, R. W., et al. *Fire Hazard Assessment Method*, NIST Handbook 146, Gaithersburg, MD: NIST, 1989.

(9) Fleming, J. M., “Code Official's View of Performance-Based Codes,” *Research and Practice: Bridging the Gap*, Proceedings, Fire Suppression and Detection Research Application Symposium, NFPA Research Foundation, Orlando, FL, February 12–14, 1997, pp. 234–251.

(10) Gross, D. “The Use of Fire Statistics in Assessing the Fire Risk of Products,” *Interflam 1985 Conference Workbook*, No. 26–28, March 1985, pp. 11–18.

(11) Karter, M. J., Jr. “Fire Loss in the United States During 1984,” *Fire Journal*, Vol. 79, No. 3: 67–70, 73, 75–76, September 1985.

(12) Aherns, M., *U.S. Vehicle Fire Trends and Patterns for Rail Transport Vehicle Fires: U.S. Rail Passenger or Diner Car Fires* 1986–1997. Quincy, MA: NFPA, 1999.

Annex F Creepage Distance

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

F.1

Table F.1 lists the minimum creepage distance for transit vehicles.

Table F.1 Minimum Creepage Distance for Transit Vehicles

Class		Low Energy		Ordinary (Enclosed environment with breathing)		Underfloor Expose Environment	
Application		Electronic and Protected Electronic Devices (½ amp where max.)		Control and Power Devices Mounted in Control Group Enclosures (Short circuit limits)		Power Resistors Op Disconnect Devices Mounted Outside Protective Enclosur	
Nominal Voltage	Surface	mm	in.	mm	in.	mm	in.
37.5	Horizontal	1.6	1/16	3.2	⅛	19.1	¾
	Vertical	1.6	1/16	3.2	⅛	12.7	½
74	Horizontal	3.2	⅛	6.5	¼	40	1 9/16
	Vertical	3.2	⅛	6.5	¼	25	1
230	Horizontal	8.3	⅜	15.9	⅝	76.2	3
	Vertical	8.3	⅜	15.9	⅝	50.8	2
600	Horizontal	19.1	¼	31.8	1¼	177.8	7
	Vertical	19.1	¼	31.8	1¼	127	5
750	Horizontal	See Note Below	See Note Below	40	1 9/16	See Note Below	See N Belo

Note: Where no value is given or for nonstandard values, the creepage distance shall be agreed between the su 50124-1:2001, while not as conservative as the requirements of this standard, provides a basis for discussion o

Annex G Informational References

G.1 Referenced Publications.

The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

G.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

Fire Protection Handbook, 19th edition, 2003.

NFPA *101*®, *Life Safety Code*®, 2006 edition.

NFPA 271, *Standard Method of Test for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 2004 edition.

NFPA 472, *Standard for Professional Competence of Responders to Hazardous Materials Incidents*, 2002 edition.

NFPA 1006, *Standard for Rescue Technician Professional Qualifications*, 2003 edition.

NFPA 1670, *Standard on Operations and Training for Technical Search and Rescue Incidents*, 2004 edition.

G.1.2 Other Publications.

G.1.2.1 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

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

G.1.2.2 APTA Publications. American Public Transportation Association, 1666 K Street NW, Washington, DC 20006.

APTA RP PS-005-01a, *Recommended Practice for Fire Safety Analysis of Existing Passenger Rail Equipment*, 2001.

APTA SS-E-013-99, *Standard for Emergency Lighting Design for Passenger Cars*, 1999.

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

ASHRAE Handbook Series.

ASHRAE Handbook — Fundamentals, 2005.

G.1.2.4 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P. O. Box C700, West Conshohocken, PA 19428-2959.

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

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

ASTM E 1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 2004a.

ASTM E 1537, *Standard Test Method for Fire Testing of Upholstered Furniture*, 2002a.

ASTM E 1590, *Standard Test Method for Fire Testing of Mattresses*, 2002.

ASTM E 2061, *Guide for Fire Hazard Assessment of Rail Transportation Vehicles*, 2003.

G.1.2.5 FAA Publications. U.S. Federal Aviation Administration, U.S. Government Printing Office, Washington, DC 20402.

FAR 25.853(c), *Oil Burner Test for Seat Cushions*.

G.1.2.6 FTA Publications. Federal Transit Administration, 400 7th Street SW, Washington, DC 20590.

Subway Environmental Design Handbook, 1975.

G.1.2.7 SFPE Publications. Society of Fire Protection Engineers, 7315 Wisconsin Avenue, Suite 1225 W, Bethesda, MD 20814.

SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings, 2000.

SFPE Handbook of Fire Protection Engineering, 2000.

G.1.2.8 TDC Publications. Transit Development Corporation, Inc., 1666 K St. NW, Washington, DC 20006.

Smith, Edwin E., Phase I Report, *Transit Vehicle Material Specification Using Release Rate Tests for Flammability and Smoke*, October 1976.

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

G.1.2.9 Other Publications.

Aherns, M., *U.S. Vehicle Fire Trends and Patterns for Rail Transport Vehicle Fires: U.S. Rail Passenger or Diner Car Fires 1986–1997*. Quincy, MA: NFPA, 1999.

Bukowski, R. W., et al. *Fire Hazard Assessment Method*, NIST Handbook 146, Gaithersburg, MD: NIST, 1989.

Federal Railroad Administration, 49 CFR, Transportation, Parts 216, 223, 229, 231, 232, and 238, “Passenger Equipment Safety Standards: Final Rule.” *Federal Register*, Vol. 64, No. 91, May 12, 1999, 25540–25705 (Washington, DC: National Archives and Records Administration).

Federal Railroad Administration, 49 CFR, Transportation, Part 238, “Passenger Equipment Safety Standards: Final rules,” Federal Register, Vol. 67, No. 122, June 25, 2002, 42892-42912 (Washington DC National Archives and Records Administration).

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G.2 Informational References. (Reserved)

G.3 References for Extracts in Informational Sections.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2004 edition.

Formal Interpretation

Formal Interpretation

NFPA 130

Standard for Fixed Guideway Transit and Passenger Rail Systems

2007 Edition

Reference: 3.3.46.2
F.I. No.: 130-07-1

Question: Is the committee's interpretation that a station, constructed at street level in the center divider with the platform raised approximately 1 meter above grade level, be defined as an elevated station?

Answer: No

Issue Edition: 2007
Reference: 3.3.46.2
Issue Date: September 6, 2006
Effective Date: September 26, 2006

Formal Interpretation

NFPA 130

Fixed Guideway Transit and Passenger Rail Systems

2007 Edition

Reference: 8.4.2
F.I. No.: 130-03-1

Background: I believe that the intent of 8.4.2 of NFPA 130-2007 is to allow a partial fire hazard analysis to be conducted to replace a material contained in a limited portion of the rail car by an alternate material not meeting the appropriate criteria of Table 8.4.1. I do not believe that the intent of this section was to permit the replacement of a material that meets all of the appropriate criteria of Table 8.4.1 and is widely used throughout the rail car (such as the foam contained within all seats or the material lining the entire ceiling) by an alternate material simply as a result of a partial fire hazard analysis. If such a broad replacement were possible, in view of the limits of precision of a fire hazard analysis, it would be possible that the complete fire hazard analysis would show the replacement material to be significantly less safe. A partial fire hazard analysis could appear to show that two materials have no significant differences in fire hazard simply because the differences found in the partial fire hazard analysis fall within the limits of precision of that analysis. Thus, I believe that the intent of this section was that extensive replacements will still require complete fire hazard analyses. Consequently, I am asking for a formal interpretation of the section.

In other words, is it the intent of the technical committee, for example, for the following sequence of events to be permissible?

1. to find a new seat padding material that does not meet the criteria in Table 8.4.1;
2. to compare its fire properties with those of the seat padding material used throughout the rail care (and that meets the criteria in Table 8.4.1);
3. to conduct a partial fire hazard analysis comparing the materials only (and not a fire hazard analysis on the entire rail car and not even a fire hazard analysis on the entire seat assembly), meaning that a heat release test is conducted, for example;
4. to find that the alternate material produces a contribution to fire hazard that is not much greater than that of material in use;
5. and as a result to replace the existing padding material with the new alternate padding material that does not meet the criteria in Table 8.4.1.

Question: Is it the intent of NFPA 130, 2007 edition, section 8.4.2 to permit the replacement of a material that meets all the appropriate criteria of Table 8.4.1 and is widely used throughout the rail car (such as the foam contained in all seats or the material lining the entire ceiling) by an alternate material that does not meet the appropriate criteria of Table 8.4.1, following a partial fire hazard analysis on the material itself (and not a fire hazard analysis on the entire rail car and not even a fire hazard analysis on an assembly containing the material) that shows that the alternate material produces a contribution to fire hazard only slightly greater than that of the material that meets the criteria of Table 8.4.1?

Answer: No

Issue Edition: 2003
Reference: 8.4.3
Issue Date: January 26, 2004
Effective Date: February 14, 2004

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