VILLE DE MONTRÉAL
RÈGLEMENT
11-018 (Codification administrative)

MISE EN GARDE : *Cette codification a été préparée uniquement pour la commodité du lecteur et n'a aucune valeur officielle. Aucune garantie n'est offerte quant à l'exactitude du texte. Pour toutes fins légales le lecteur devra consulter la version officielle du règlement et de chacun de ses amendements.*

RÈGLEMENT SUR LA CONSTRUCTION ET LA TRANSFORMATION DE BÂTIMENTS

CODIFICATION ADMINISTRATIVE AU 23 JANVIER 2020
(11-018, modifié par 15-069, 11-018-1, 11-018-2, 11-018-3)

Vu les articles 118, 118.1, 119, 120 et 120.0.1 de la Loi sur l'aménagement et l'urbanisme (RLRQ, chapitre A-19.1);

Vu les articles 4, 6, 19, 55 et 62 de la Loi sur les compétences municipales (RLRQ, chapitre C-47.1);

Vu les articles 369 et 411 de la Loi sur les cités et villes (RLRQ, chapitre C-19);

Vu les articles 47, 50, 51 et 80 de l'annexe C de la Charte de la Ville de Montréal (RLRQ, chapitre C-14.1);

À l'assemblée du 24 octobre 2011, le conseil de la Ville de Montréal décrète :

CHAPITRE I
INTERPRÉTATION

1. Dans le présent règlement, les mots ou expressions qui suivent ont la signification suivante :

« autorité compétente » : au sens du Code et du présent règlement le directeur du Service de l'urbanisme et de la mobilité. Dans le Code, une référence à la « Régie du bâtiment » ou à la « Régie » doit se comprendre comme étant une référence à l'autorité compétente lorsqu'il s'agit d'exigences pour lesquelles la Ville a compétence;

« bâtiment exempté » : bâtiment exempté de l'application du Chapitre I de la division I - Bâtiment du Code de construction du Québec par l'article 1.04 de ce même Code;

« Code » : le Code national du bâtiment – Canada 2010 (CNRC 53301F) publié par la Commission canadienne des codes du bâtiment et de prévention des incendies du Conseil national de recherches du Canada, tel qu'il a été adopté et modifié par les décrets 953-2000, 293-2008, 347-2015 et 990-2018, aussi connu sous la désignation Code de construction du Québec, (RLRQ, chapitre B-1.1, r. 2) (Chapitre I, Bâtiment, et Code national du bâtiment – Canada 2010 (modifié)). Ce Code est joint à l'annexe A du présent règlement;

« combustible solide » : toute matière solide avec laquelle on peut faire du feu;

« construction » : assemblage ordonné de matériaux dont l'utilisation exige un emplacement sur le sol ou qui est joint à quelque chose exigeant un emplacement sur le sol.

Sauf indication contraire, les termes « construction » ou « construit » utilisés au sens de l'action de construire incluent les termes « transformation » ou « transformé »;

« espace habitable » : un espace ou une pièce destiné à la préparation ou à la consommation de repas, au sommeil ou au séjour en excluant notamment une salle de bain, une salle de toilette, un espace de rangement, une penderie et une buanderie;

« logement » : suite servant ou destinée à servir de domicile à une ou plusieurs personnes et comportant des appareils sanitaires et des espaces où l'on peut préparer et consommer des repas et dormir;

« maison de chambres » : bâtiment ou partie de bâtiment défini comme tel dans la réglementation de l'arrondissement. À défaut d'être défini dans la réglementation, il s'agit d'un bâtiment ou partie de bâtiment où au moins 4 chambres sont en location et où des services peuvent être fournis aux personnes qui y ont domicile, tels les repas, l'entretien et la surveillance;

« niveau moyen du sol » : le niveau moyen du sol tel qu'il est défini à la partie 1 de la division A du Code. Au sens de cette définition, les dépressions localisées qui n'ont pas à être prises en compte dans la détermination du niveau moyen du sol incluent les dépressions, notamment les entrées pour véhicules ou pour piétons qui n'ont pas d'incidence sur l'évacuation ou sur l'accès pour la lutte contre l'incendie;

« plaine inondable » : étendue de terre occupée par un lac ou un cours d'eau en période de crue;

« surface utile » : surface des espaces habitables mesurée entre les faces des murs dont la hauteur est conforme aux hauteurs minimales du tableau 9.5.3.1 de la division B du Code excluant la surface occupée par les armoires de cuisine, l'aire de plancher destinée à être occupée par une cuisinière, un réfrigérateur, un congélateur, un lave-linge et un sèche-linge, les commodes incorporées et les penderies;

« toit végétalisé » : partie d'un système de recouvrement de toit qui est conçue pour permettre la croissance de la végétation;

« toit végétalisé de type 1 » : toit végétalisé dont le substrat de croissance a une épaisseur d'au plus 150 mm;

« toit végétalisé de type 2 » : toit végétalisé dont le substrat de croissance a une épaisseur supérieure à 150 mm;

« zone de faible courant » : partie d'une plaine inondable, au-delà de la limite de la zone de grand courant, qui peut être inondée lors d'une crue de récurrence de cent ans, dont les limites sont établies dans la réglementation de l'arrondissement;

« zone de grand courant » : partie d'une plaine inondable qui peut être inondée lors d'une crue de récurrence de vingt ans, dont les limites sont établies dans la réglementation de l'arrondissement.

11-018, a. 1; 11-018-3, a. 1.

2. Les mots utilisés dans le présent règlement qui sont définis par le Code ont, à moins que le contexte n'impose un sens différent, le même sens que celui prévu par le Code.

11-018, a. 2.

CHAPITRE II
APPLICATION DU CODE ET EXIGENCES PARTICULIÈRES

SECTION I
GÉNÉRALITÉS

3. À moins d'indication contraire, le présent règlement s'applique à tous les bâtiments et toutes les constructions, tant ceux auxquels le Code s'applique en vertu de la Loi sur le bâtiment (RLRQ, chapitre B-1.1) que ceux qui sont exemptés de l'application du chapitre I de la division I - Bâtiment du Code de construction du Québec par l'article 1.04 du Code.

11-018, a. 3; 11-018-3, a. 2.

4. Sous réserve de l'article 4.2 et à l'exception de la partie 11 de la division B, le Code s'applique à un bâtiment exempté.

Toute modification et toute nouvelle édition du Code s'appliquent à l'égard d'un bâtiment exempté à compter de la date qui est établie par résolution du conseil de la Ville.

11-018, a. 4; 11-018-3, a. 3.

4.1. Sous réserve de l'article 13, la construction ou la transformation d'un bâtiment doit être réalisée en conformité aux dispositions du présent règlement et aux solutions acceptables pertinentes de la division B du Code.

11-018-3, a. 4.

4.2. Les exigences de la norme NFPA-130 – édition 2017, « *Standard for Fixed Guideway Transit and Passenger Rail Systems* » jointe à l'annexe B du présent règlement remplacent les exigences du Code pour tous les travaux de construction et de transformation des stations de métro.

11-018-3, a. 4.

SECTION II
EXIGENCES NORMATIVES PARTICULIÈRES S'APPLIQUANT À TOUS LES BÂTIMENTS

SOUS-SECTION I
DISPOSITIONS DIVERSES

5. Les articles de la présente section s'appliquent à tous les bâtiments.

11-018, a. 5; 11-018-3, a. 5.

6. Tout mur mitoyen doit être construit comme un mur coupe-feu.

Tout mur coupe-feu doit être construit en béton ou en maçonnerie liée par du mortier.

11-018, a. 6.

7. Un mur construit à la limite de propriété ne bordant pas une voie publique, à l'exception de celui d'un garage ou d'un bâtiment secondaire visé par les paragraphes 4 et 5 de l'article 9.10.14.5. de la division B du Code, doit être recouvert d'un parement de béton ou de maçonnerie liée par du mortier, d'au moins 90 mm d'épaisseur, et avoir au moins la moitié du degré de résistance au feu requis pour un mur coupe-feu exigé selon l'usage principal prévu.

11-018, a. 7; 11-018-3, a. 6.

8. Tout bâtiment dont le toit est de revêtement métallique ou à surface lisse et est incliné vers la voie publique ou vers un espace destiné à la circulation de piétons ou de véhicules doit se trouver en retrait de cette voie ou de cet espace à une distance au moins égale au tiers de la hauteur comprise entre le sol et la partie inférieure du toit ou être muni d'un dispositif pour empêcher la chute de neige ou de glace sur la voie publique ou sur l'espace précité.

11-018, a. 8; 11-018-3, a. 7.

9. Sauf pour des bâtiments visés par la partie 10 de la division B du Code, un bâtiment comportant plusieurs suites qui sont destinées à être occupées par des établissements industriels à risques faibles doit être considéré comme ayant un usage principal du groupe F, division 2, établissement industriel à risques moyens.

11-018, a. 9.

9.1. Le paragraphe 4 de l'article 9.10.9.14. de la division B du Code relatif à la possibilité de remplacer les séparations coupe-feu par des barrières étanches à la fumée, pour les bâtiments d'au plus 3 logements et d'au plus 2 étages, ne s'applique pas.

11-018-3, a. 8.

10. Sous réserve des deuxième et troisième alinéas, une voie de circulation couverte pour automobiles qui donne accès aux garages de stationnement d'une habitation est considérée comme faisant partie des garages et de l'aire de plancher des garages.

Sous réserve du troisième alinéa, une voie de circulation couverte pour automobiles, qui donne accès aux garages de stationnement d'une habitation, n'est pas considérée comme faisant partie ni des garages, ni de l'aire de plancher des garages, lorsque toutes les conditions suivantes sont réunies :

1° les garages sont fermés et isolés de la voie de circulation;

2° le toit et les murs de la voie de circulation sont construits en béton;

3° les murs extérieurs de la voie comportent des ouvertures dont la surface totale à l'air libre est d'au moins 25 % de la surface totale de la face intérieure de ses murs de pourtour, et ces ouvertures sont réparties sur au moins 3 murs extérieurs de façon à assurer une ventilation transversale;

4° la voie de circulation est utilisée uniquement pour permettre l'accès aux garages.

Une voie de circulation couverte pour automobiles qui donne accès aux garages de stationnement desservant une habitation n'est pas considérée comme faisant partie ni des garages ni de l'aire de plancher des garages si les murs extérieurs de la voie comportent des ouvertures à l'air libre, dont la surface totale est d'au moins 50 % de la surface totale de la face intérieure de ses murs de pourtour, et si ces ouvertures sont réparties sur au moins 3 murs extérieurs de façon à assurer une ventilation transversale.

11-018, a. 10; 11-018-3, a. 9.

11. Une rue, une voie privée ou une cour permettant l'accès au matériel de lutte contre les incendies d'un bâtiment régi par la partie 9 de la division B du Code, doit être conforme aux exigences des paragraphes 2, 3 et 4 de l'article 3.2.5.5. et du paragraphe 1 de l'article 3.2.5.6. de la division B du Code.

11-018, a. 11; 11-018-3, a. 10.

11.1. Sauf dans le cas d'une issue horizontale conforme aux articles 3.4.1.6. et 3.4.6.10. de la division B du Code, tout parcours d'une issue exigée d'un bâtiment doit être situé entièrement sur la propriété qu'il dessert.

11-018-3, a. 11.

12. L'installation, à l'intérieur d'un bâtiment, de tout appareil ou foyer permettant l'utilisation d'un combustible solide est interdite sauf si l'appareil ou le foyer a fait l'objet d'une reconnaissance par un organisme identifié à l'annexe B du Règlement concernant les appareils et les foyers permettant l'utilisation d'un combustible solide (15-069), dans le cadre d'un processus de certification, à l'effet qu'il a un taux d'émission égal ou inférieur à 2.5 g/h de particules fines dans l'atmosphère.

Le présent article ne s'applique pas à un appareil utilisé pour la cuisson des aliments, à des fins commerciales, installé dans un immeuble où l'usage commercial est autorisé.

Aux fins du présent article, l'installation inclut le remplacement.

11-018, a. 12; 15-069, a. 12.

13. S'il est démontré à l'autorité compétente que les conditions d'aménagement et d'occupation d'un bâtiment et les exigences stipulées au Code ne peuvent être raisonnablement appliquées, celle-ci peut appliquer des mesures différentes ou des solutions de rechange à ces conditions si elle est d'avis que ces mesures ou solutions fournissent un degré de sécurité et de salubrité suffisant.

Les mesures différentes et les solutions de rechange proposées doivent être approuvées par l’autorité compétente.

11-018, a. 13; 11-018-3, a. 12.

SOUS-SECTION II
LOGEMENTS ET MAISONS DE CHAMBRES

14. La surface vitrée minimale assurant l’éclairage naturel des pièces d’un logement doit être de :

1° 10 % de la surface desservie des pièces suivantes : salon, salle à manger, salle de séjour et espace de sommeil combiné avec un autre espace;

2° 5 % de la surface desservie des chambres et autres pièces aménagées non mentionnées ci-dessus;

3° 8 % de la surface desservie d'une chambre d'une maison de chambres.

Aucune surface vitrée n’est exigée pour une salle de toilette, une salle de bains, une cuisine, un coin cuisine, une buanderie, une salle de jeu en sous-sol, un sous-sol non aménagé, un hall, un corridor, une chaufferie, un espace technique, un espace de rangement et tout autre pièce ou espace analogue à ceux-ci.

11-018, a. 14; 11-018-3, a. 13.

14.1. Malgré l’article 14, l’éclairage naturel en second-jour d’une pièce d’un logement est permis quand les conditions suivantes sont réunies en plus des exigences mentionnées aux sous-paragraphes a et b du paragraphe 4 de l’article 9.7.2.3. de la division B du Code :

1° l’aire éclairée en second-jour et l’aire comportant la surface vitrée assurant l’éclairage naturel forment des pièces combinées au sens du Code;

2° l’ouverture entre les deux aires doit être libre de tout obstacle;

3° la surface vitrée assurant l’éclairage naturel est d’au moins 10 % de la surface totale des pièces combinées.

11-018-3, a. 14.

14.2. Aucune saillie pouvant intercepter la lumière, tel un balcon, une corniche ou autre construction, située à moins de 1,5 m au-dessus d’une fenêtre exigée ne doit projeter sur plus de 2 m, sauf si le minimum exigible de surface vitrée est augmenté selon le tableau 14.2.

TABLEAU 14.2			
Pourcentage de fenestration avec saillie pouvant intercepter la lumière			
Projection de la saillie	**% fenestration exigé selon l'article 14**		
	5	**8**	**10**
2 m et moins	**5**	**8**	**10**
Plus de 2 m - 2,5 m	**6**	**9**	**11**
Plus de 2,5 m - 3 m	**7**	**10**	**12**
Plus de 3 m - 3,5 m	**8**	**11**	**13**
Plus de 3,5 m - 4 m	**9**	**12**	**14**
plus de 4 m	**10**	**13**	**15**

11-018-3, a. 14.

14.3. Toute surface vitrée exigée doit donner sur un dégagement libre conforme aux conditions suivantes :

1° avoir au moins 1,5 m de profondeur sur une largeur égale à la largeur de surface vitrée sans être inférieure à 1,5 m;

2° être à ciel ouvert à partir du haut de la surface vitrée;

3° être adjacent à la surface vitrée ou séparé de celle-ci par un espace libre, un balcon, une galerie ou un escalier ajouré.

Ce dégagement ne doit pas empiéter hors des limites latérales ou arrière du terrain, mais il peut empiéter sur la voie publique.

Les corniches et les avant-toits peuvent empiéter sur le dégagement sur une profondeur maximale de 600 mm.

11-018-3, a. 14.

14.4. Pour chaque pièce d'un logement dont toutes les pièces sont situées sous le niveau du sol ou d'une maison de chambre dont une partie de la hauteur libre est sous le niveau du sol, le niveau du sol devant chaque fenêtre exigée doit être à au moins 1 m au-dessous du plafond de cette pièce. Le niveau du sol est déterminé sans tenir compte des dépressions localisées telles que les sauts-de-loup.

11-018-3, a. 14.

14.5. Lors de l'aménagement d'un nouveau logement, l'appui des fenêtres exigées à l'article 9.9.10.1. de la division B du Code, prévu pour servir de sortie de secours à une chambre, doit se trouver à au plus 1,5 m du plancher.

11-018-3, a. 14.

15. Tout bâtiment dans lequel des logements partagent une entrée commune doit comporter un dispositif de déverrouillage de la porte de l'entrée principale pouvant être actionné à partir de chaque logement et, lorsque le bâtiment comporte plus de 8 logements partageant une entrée commune, un dispositif d'intercommunication phonique reliant chaque logement à l'entrée principale.

Toute maison de chambres de plus de 8 chambres doit comporter un dispositif de déverrouillage de la porte de l'entrée principale pouvant être actionné à partir de chaque chambre.

11-018, a. 15.

16. Les dimensions des portes coulissantes dans un logement doivent être conformes au tableau 9.5.5.1. de la division B du Code.

11-018, a. 16; 11-018-3, a. 15.

17. Une maison de chambres doit être pourvue de W.-C., ainsi que d'une baignoire ou d'une douche dispensant l'eau chaude et l'eau froide pour chaque groupe de 5 chambres offertes en location. Lorsque le nombre de chambres ne constitue pas un multiple de 5 et que le résultat du nombre d'appareils requis comporte une fraction supérieure à une demie, ce résultat est arrondi au nombre entier suivant. Une maison de chambres de moins de 5 chambres doit être pourvue d'au moins un W.-C. et d'une baignoire ou d'une douche. Une chambre d'une maison de chambres pourvue de l'un ou l'autre de ces appareils à usage privé n'est pas prise en compte dans le calcul du nombre de chambres aux fins de déterminer le nombre d'appareils à usage commun exigé.

Dans une maison de chambres, chaque chambre offerte en location doit comporter un lavabo dispensant l'eau chaude et l'eau froide.

Les salles de bains et salles de toilettes dans une maison de chambres doivent se retrouver dans des locaux séparés. Ces installations doivent être accessibles sans qu'il soit nécessaire de monter ou de descendre plus d'un étage à partir des chambres desservies.

Lorsqu'une chambre d'une maison de chambre est pourvue d'un ou plusieurs des appareils sanitaires suivants : W.-C., baignoire ou douche, ceux-ci doivent être installés dans un espace fermé.

11-018, a. 17; 11-018-3, a. 16.

17.1. Les exigences de la partie 9 de la division B du Code s'appliquent à tous logements à l'égard :

1° des équipements sanitaires;

2° de l'éclairage;

3° du chauffage.

11-018-3, a. 17.

17.2. À l'intérieur d'un logement, au moins un W.-C., une baignoire ou une douche, et un lavabo doivent être situés dans un ou plusieurs espaces fermés.

11-018-3, a. 17.

17.3. Une pièce ou un espace destiné à la préparation des repas doit être muni :

1° d'une armoire basse avec une surface de travail d'une superficie d'au moins 1 m², à l'exclusion de la surface occupée par l'évier;

2° d'armoires d'un volume d'au moins 1,25 m³, incluant celle exigée au paragraphe 1°.

11-018-3, a. 17.

18. Les autres exigences concernant l'aménagement des pièces prévues aux chapitres VI et VII du Règlement sur la salubrité, l'entretien et la sécurité des logements (03-096) qui sont plus sévères que celles contenues dans le présent règlement s'appliquent.

11-018, a. 18.

18.1. Le corridor à l'intérieur d'un logement doit avoir une largeur minimale de 900 mm.

11-018-3, a. 18.

SOUS-SECTION III
LOCAUX D'ENTREPOSAGE DES MATIÈRES RÉSIDUELLES

19. Les locaux d'entreposage des matières résiduelles desservant des habitations doivent, lorsqu'ils sont destinés à entreposer des matières putrescibles, être ventilés vers l'extérieur du bâtiment à l'aide d'un ventilateur extracteur d'une capacité d'au moins 3,9 L/s par m^2 de plancher. À défaut d'être munis d'une telle ventilation, ils doivent être maintenus à une température de 2°C à 7°C.

Les locaux desservant des usages principaux autres que des habitations et destinés à entreposer des matières putrescibles doivent être maintenus à une température de 2°C à 7°C.

Les locaux mentionnés aux premier et deuxième alinéas doivent également :

1° avoir une surface intérieure lisse, non-poreuse et lavable;

2° comporter un avaloir de sol.

11-018, a. 19.

19.1. Un local d'entreposage provisoire destiné aux matières résiduelles doit être aménagé dans tout bâtiment :

1° construit après le 23 janvier 2020 et occupé par plus de 11 logements;

2° dont l'usage est modifié pour un usage résidentiel après le 23 janvier 2020 et comportant plus de 11 logements;

3° faisant l'objet d'une transformation entraînant un accroissement de la hauteur de bâtiment, de l'aire de bâtiment ou de l'aire de plancher et qui comporte plus de 11 logements après les travaux;

4° comportant un établissement ayant une superficie égale ou supérieure à 100 m² où sont préparés ou consommés des aliments et qui est soit :

a) aménagé après le 23 janvier 2020;

b) réaménagé après le 23 janvier 2020 et dont la valeur des travaux est supérieure à 100 000 $.

11-018-3, a. 19.

SOUS-SECTION IV
PLAINES INONDABLES

20. Lorsque la réglementation de l'arrondissement exige des mesures d'immunisation pour une construction autorisée dans une zone à risque d'inondation, les règles suivantes s'appliquent :

1° aucune partie d'une ouverture, notamment une fenêtre, un soupirail et une porte d'accès à un garage, ne doit se trouver sous le niveau de la cote de la zone de faible courant;

2° aucune composante d'un plancher de premier étage ne doit se trouver sous le niveau de la cote de la zone de faible courant;

3° les drains d'évacuation doivent être munis de clapets anti-retour;

4° les structures, les fondations et les dalles au sol situées sous le niveau de la cote de la zone de faible courant doivent être conçues conformément aux exigences de la partie 4 de la division B du Code et les calculs et détails de conception doivent démontrer la capacité des structures à résister à cette crue en y intégrant les calculs relatifs à :

   a) l'imperméabilisation;

   b) la stabilité des structures;

   c) l'armature nécessaire;

   d) la résistance du béton à la tension et à la compression;

   e) la capacité de pompage pour évacuer les eaux d'infiltration;

5° dans un bâtiment situé dans la zone de faible courant, la section du réseau d'évacuation d'eaux pluviales qui reçoit les eaux provenant d'un espace situé sous le niveau de la cote de la zone de faible courant doit être équipée d'une pompe de relevage automatique d'une capacité minimale de 2,5 L/s. Le tuyau d'évacuation de cette pompe doit être raccordé au réseau d'évacuation d'eaux pluviales du bâtiment au-dessus du niveau de la cote de la zone de faible courant et être muni d'un clapet anti-retour;

6° les sections d'un branchement d'égout pluvial, d'un collecteur principal pluvial et d'une descente pluviale situées sous le niveau de la cote de la zone de faible courant doivent être étanches et sans ouvertures de drainage.

Lorsque l'immunisation d'une construction implique le remblayage du terrain, il doit se limiter à une protection immédiate autour de la construction et non être étendu à l'ensemble du terrain; la pente moyenne, du sommet du remblai adjacent à la construction projetée, jusqu'à son pied, ne doit pas être inférieure à 33 1/3 % (rapport de 1 vertical et de 3 horizontal).

11-018, a. 20; 11-018-3, a. 20.

SOUS-SECTION V
PROTECTION CONTRE LES REFOULEMENTS D'ÉGOUT

21. Lorsqu'une réglementation municipale en vigueur sur le territoire de l'arrondissement exige des mesures de protection contre les refoulements d'égout dans les bâtiments, les règles suivantes s'appliquent :

1° le pied des murs de fondation extérieurs doit être drainé au moyen de tuyaux ou de drains posés à l'extérieur des fondations conformément au Code. Ces tuyaux ou drains doivent acheminer l'eau de drainage vers une fosse de retenue située à l'intérieur du bâtiment;

2° les surfaces extérieures adjacentes au bâtiment en contrebas du terrain avoisinant, tel une descente de garage ou une entrée extérieure, doivent être drainées par un tuyau d'évacuation acheminant les eaux pluviales vers une fosse de retenue située à l'intérieur du bâtiment;

3° une descente pluviale extérieure ne doit pas être raccordée directement ou indirectement au tuyau de drainage des semelles de fondation.

Malgré le paragraphe 1° du premier alinéa, le tuyau de drainage peut être installé à l'intérieur des fondations dans le cas d'un mur mitoyen ou d'un mur extérieur construit à la limite de propriété.

11-018, a. 21; 11-018-3, a. 21.

SOUS-SECTION VI
ÉLÉMENTS DE FORTIFICATION

22. Aux fins de la présente sous-section, sont des éléments de fortification ou de protection d'un bâtiment :

1° les matériaux utilisés, assemblés ou maintenus en vue de blinder ou de fortifier un bâtiment contre les projectiles d'armes à feu, l'utilisation d'explosifs, le choc ou la poussée de véhicules ou tout autre type d'assaut, notamment :

a) les plaques de protection faites de métal ou de tout autre matériau disposées à l'intérieur ou à l'extérieur d'un bâtiment;

b) le verre de type laminé ou tout autre verre ou matériau pare-balles disposé près des fenêtres, dans les fenêtres ou dans les portes;

c) les volets et les rideaux de protection pare-balles ou offrant une résistance aux explosifs et aux chocs, faits de quelque matériau que ce soit et attachés aux fenêtres, portes ou toute autre ouverture du bâtiment;

d) les portes blindées ou spécialement renforcées;

2° une tour d'observation.

11-018, a. 22.

23. Est prohibé, tout élément de fortification ou de protection d'un bâtiment qui est utilisé, en tout ou en partie, pour l'un des usages suivants :

1° habitation;

2° hôtel, hôtel-appartement;

3° maison de chambres;

4° restaurant, traiteur;

5° débits de boissons alcooliques;

6° salle de spectacles;

7° établissement exploitant l'érotisme;

8° club au sens de la Loi sur les permis d'alcool (RLRQ, chapitre P-9.1);

9° salle de danse;

10° salle de réunion;

11° salle d'activités communautaire ou socioculturelle;

12° bureau;

13° centre d'activités physiques;

14° salle d'amusement, salle d'amusement familiale;

15° salle de billard;

16° établissement de jeux récréatifs.

11-018, a. 23.

24. Pour tout autre usage que ceux prévus à l’article 23, est prohibé tout élément de fortification ou de protection d’un bâtiment lorsque l’utilisation d’un ou plusieurs de ces éléments n’est pas justifiée par la nature des activités qui ont cours dans ce bâtiment, par la valeur du patrimoine qu’il abrite ou par la nécessité de protéger la santé, la vie ou la sécurité publique.

Sans limiter la portée de ce qui précède, un consulat, une institution financière, un bureau de change, un édifice gouvernemental, une bijouterie, un musée ou un laboratoire de produits toxiques ou dangereux, est présumé justifier l’utilisation d’un ou plusieurs éléments de fortification ou de protection.

11-018, a. 24.

25. L’autorité compétente peut, au moyen d’un avis, ordonner au propriétaire, à l’entrepreneur ou à tout autre personne intéressée, de suspendre des travaux d’installation ou de cesser l’utilisation d’éléments de fortification ou de protection prohibés en vertu des articles 23 et 24. Il peut également, par cet avis, ordonner l’enlèvement de ces éléments dans un délai d’au plus 10 jours.

À défaut par la personne mentionnée au premier alinéa de se conformer à l’avis dans le délai prescrit, l’autorité compétente peut prendre toutes les mesures nécessaires pour rendre le bâtiment conforme à la présente sous-section.

Le coût des travaux effectués par l’autorité compétente peut être recouvré du propriétaire et constitue une créance prioritaire sur le bâtiment sur lequel les travaux ont été exécutés, au même titre et selon le même rang que les créances visées au paragraphe 5 de l’article 2651 du Code civil du Québec. Ces frais sont également garantis par une hypothèque légale sur l’immeuble.

11-018, a. 25.

SOUS-SECTION VII
CONSTRUCTION DURABLE

11-018-3, a. 22.

25.1. La structure du toit d’un bâtiment de construction incombustible de plus de 3 étages en hauteur de bâtiment et de plus de 250 m² doit, lorsque la pente de toit est inférieure à 2 unités à la verticale dans 12 unités à l’horizontale (2 :12) ou à 16,7 %, être conçue pour recevoir un toit végétalisé de type 1 en plus des charges prescrites par le Code.

11-018-3, a. 22.

25.2. Lors d'un accroissement en aire de bâtiment de plus de 250 m² à un bâtiment de construction incombustible de plus de 3 étages en hauteur de bâtiment, la structure du toit de la partie agrandie doit, lorsque la pente de toit est inférieure à 2 unités à la verticale dans 12 unités à l'horizontale (2 :12) ou à 16,7 %, être conçue pour recevoir un toit végétalisé de type 1 en plus des charges prescrites par le Code.

11-018-3, a. 22.

25.3. Les articles 25.1 et 25.2 ne s'appliquent pas au toit :

1° d'une construction hors toit;

2° d'une mezzanine dont l'aire ne dépasse pas 40 % de l'aire de l'étage qu'elle surmonte.

11-018-3, a. 22.

25.4. Sauf pour les bâtiments ou parties de bâtiment visés par le Règlement sur la subvention à la réalisation de logements coopératifs et à but non lucratif (02-102), la résistance thermique totale de la toiture d'un bâtiment ayant un usage principal du groupe C, tel que défini au Code, doit être égale ou supérieure à RSIT 9.0 (RT-51).

11-018-3, a. 22.

25.5. Malgré les dispositions de la partie 11 du Code, les lanterneaux, fenêtres et portes-fenêtres desservant une habitation doivent être conformes à l'homologation « Energystar » selon les critères établis par Ressources naturelles Canada pour la zone climatique 2 joints à l'annexe C du présent règlement.

11-018-3, a. 22.

SECTION III
EXIGENCES NORMATIVES PARTICULIÈRES S'APPLIQUANT AUX BÂTIMENTS EXEMPTÉS DE L'APPLICATION DU CODE DE CONSTRUCTION DU QUÉBEC, CHAPITRE I – BÂTIMENT

26. Malgré toute autre prescription des parties 1 à 10 de la division B du Code, les articles de la présente section s'appliquent aux bâtiments exemptés.

11-018, a. 26; 11-018-3, a. 23.

27. Lorsqu'une construction combustible est permise pour un bâtiment, un mur adjacent à la limite de propriété ou situé à proximité de celle-ci, pour lequel le Code exige une construction incombustible, peut, malgré cette exigence, être composé d'une ossature combustible à laquelle est rattaché un parement conforme à l'article 7.

11-018, a. 27.

SOUS-SECTION I
CONSTRUCTION DURABLE – TOIT VÉGÉTALISÉ

11-018-3, a. 24.

27.1. La structure du toit d'un bâtiment de plus de 3 étages en hauteur de bâtiment et de plus de 250 m² doit, lorsque la pente de toit est inférieure à 2 unités à la verticale dans 12 unités à l'horizontale (2 :12) ou à 16,7 %, être conçue pour recevoir un toit végétalisé de type 1 en plus des charges prescrites par le Code.

11-018-3, a. 24.

27.2. Lors d'un accroissement en aire de bâtiment de plus de 250 m² à un bâtiment ayant une hauteur de bâtiment de plus de 3 étages, la structure du toit de la partie agrandie doit, lorsque la pente de toit est inférieure à 2 unités à la verticale dans 12 unités à l'horizontale (2 :12) ou à 16,7 %, être conçue pour recevoir un toit végétalisé de type 1 en plus des charges prescrites par le Code.

11-018-3, a. 24.

27.3. Les articles 27.1 et 27.2 ne s'appliquent pas au toit :

1° d'une construction hors toit;

2° d'une mezzanine dont l'aire ne dépasse pas 40 % de l'aire de l'étage qu'elle surmonte.

11-018-3, a. 24.

27.4. Sauf pour un toit qui est constitué d'une dalle de béton et qui a une hauteur d'au plus de 2 m, mesurée entre le niveau moyen du sol et la partie la plus élevée de la membrane d'étanchéité, un toit végétalisé doit respecter les normes suivantes :

1° comporter les composantes suivantes installées au-dessus d'un assemblage traditionnel de toit :

a) de la végétation;

b) un substrat ou un milieu de croissance;

c) une couche de filtrage;

d) un système de drainage;

e) un système ou une couche de rétention d'eau;

f) une barrière qui empêche les racines de percer la membrane d'étanchéité du toit et qui est conforme à la norme ANSI/GRHC/SPRI VR-1 2011 « *Procedure for investigating resistance to root penetration on vegetative roofs* » jointe à l'annexe D du présent règlement;

2° ne pas être aménagé sur un toit dont la couverture est composée de bardeaux ou de tuiles;

3° sous réserve du paragraphe 4°, être aménagé sur un bâtiment de construction incombustible;

4° être de type 1 lorsqu'aménagé sur un bâtiment de construction combustible;

5° former une séparation coupe-feu d'un degré de résistance au feu égal à celui exigé par le Code, sans être inférieur à 45 minutes, lorsqu'aménagé au-dessus du toit d'un bâtiment qui est de construction combustible et qui n'est pas protégé par gicleurs;

6° comporter des ouvertures dans le platelage de toit pour permettre l'évacuation des gaz et de la fumée lorsqu'aménagé au-dessus d'un vide sous toit qui est de construction combustible et qui n'est pas protégé par gicleurs. Ces ouvertures doivent :

a) avoir une surface minimale de 0,7 m^2 et aucune dimension inférieure à 760 mm;

b) être protégées contre les intempéries;

c) être pourvues d'un couvercle qui peut être enlevé facilement sans l'aide d'outil spécial;

d) être facilement accessibles et convenablement identifiées;

e) être prévues à raison d'une ouverture par compartiment de vide sous toit visé au paragraphe 7°;

7° dans le cas où un vide sous toit de construction combustible n'est pas protégé par gicleurs et a une aire supérieure à 300 m², être divisé en compartiments dont l'aire individuelle est d'au plus 300 m². Ces compartiments doivent être isolés les uns des autres par des coupe-feu conformes au paragraphe 1 de l'article 3.1.11.7. de la division B du Code. Toutefois ces compartiments ne sont pas exigés lorsque les caractéristiques suivantes sont rencontrées :

a) le bâtiment a une aire de bâtiment d'au plus 300 m²;

b) le toit végétalisé occupe au plus 50 % de l'aire totale d'un toit ou de celle d'une section de toit lorsque cette dernière est isolée du reste du toit;

8° sous réserve du paragraphe 9°, comporter des dispositifs appropriés, conçus et positionnés de façon à empêcher l'érosion des composantes lorsqu'aménagé sur un toit incliné formant un angle supérieur à 10 degrés (17 %) par rapport à l'horizontale;

9° comporter des dispositifs appropriés, conçus et positionnés de façon à empêcher l'érosion des composantes et leur glissement lorsqu'aménagé sur un toit incliné formant un angle supérieur à 14 degrés (25 %) par rapport à l'horizontale;

10° être aménagé sur un toit conçu, selon les exigences de la partie 4 de la division B du Code et celles des normes mentionnées dans la présente sous-section;

11° sous réserve des paragraphes 12° et 13°, en plus des charges et surcharges mentionnées à la section 4.1. de la division B du Code, les calculs doivent aussi tenir compte des charges associées à un toit végétalisé en pleine saturation, qui sont déterminées conformément aux normes ASTM E2397-11 « *Standard practice for determination of dead loads and live loads associated with vegetative (green) roof systems »* et *ASTM E2399-11 « Standard test method for maximum media density for dead load analysis of vegetative (green) roof systems* » jointes à l'annexe E du présent règlement;

12° lorsque la charge associée au substrat de croissance saturé ne peut être déterminée en fonction des normes mentionnées au paragraphe 11°, elle doit être calculée sur la base d'une densité de 2 000 kg/m³ (ou 125 livres/pi³);

13° les calculs de la résistance structurale du toit doivent aussi tenir compte :

a) des surcharges dues aux autres matériaux et aux équipements destinés à un toit végétalisé;

b) des surcharges dues à l'usage lorsque le toit végétalisé est accessible conformément à la sous-section 4.1.8. de la division B du Code;

14° être conçu pour résister aux effets de soulèvement causés par le vent et à l'érosion, selon les règles de l'art notamment celles décrites dans la norme ANSI/SPRI RP-14 « *Wind Design Standard for Vegetative Roofing Systems* » jointe à l'annexe F du présent règlement;

15° les calculs mentionnés aux paragraphes 13° et 14° doivent être faits par une personne compétente en la matière;

16° la charge hydraulique en provenance des eaux du toit, doit être calculée conformément au Chapitre III, Plomberie, du Code, en présumant que le toit végétalisé est entièrement saturé d'eau avant la précipitation de 15 minutes, déterminée selon les données climatiques mentionnées à la sous-section 1.1.3. de la division B du Code;

17° le drainage doit se faire adéquatement sous la couche de substrat de croissance et ne doit permettre aucune infiltration de ce substrat ou de toute autre matière vers les avaloirs de toit;

18° à l'intérieur d'un bassin d'un toit végétalisé ou d'une section de toit végétalisé, les avaloirs ne doivent pas être de type à débit contrôlé défini au Chapitre III, Plomberie, du Code;

19° le système de drainage doit être sélectionné selon la norme ASTM E2398-11 *« Standard Test Method for Water Capture and Media Retention of Geo-composite Drain Layers for Green Roof Systems »* jointe à l'annexe G du présent règlement;

20° lorsque des parapets sont prévus sur le pourtour d'un toit, des analyses et calculs doivent être faits conformément aux exigences de l'article 4.1.6.4. de la division B du Code, afin de s'assurer que la capacité structurale du toit puisse supporter la charge de l'eau de pluie accumulée, advenant le cas où les avaloirs de toit seraient bloqués;

21° l'aire individuelle d'un toit végétalisé ou d'une section de toit végétalisé ne doit pas dépasser :

a) 300 m² lorsque le bâtiment est de construction combustible;

b) 900 m² lorsque le bâtiment est de construction incombustible;

22° aucune dimension d'un toit végétalisé ou d'une section de toit végétalisé ne doit être supérieure à 30 m;

23° lorsque le bâtiment comporte un toit végétalisé de type 2 ou a une aire de bâtiment supérieure à 300 m² et comporte un toit végétalisé de type 1, il doit être prévu une zone libre de végétation d'une largeur :

a) d'au moins 0,5 m autour des avaloirs de toit, mesurée à partir du centre de l'avaloir;

b) d'au moins 0,5 m sur le pourtour d'un toit végétalisé ou d'une section de toit végétalisé;

c) d'au moins 0,5 m entre un toit végétalisé et tout équipement situé sur le toit, notamment les appareillages de plomberie et de ventilation, les tuyaux, conduits, antennes et joints d'expansion;

d) d'au moins 1 m entre 2 sections contiguës de toit végétalisé respectant une des conditions énoncées aux paragraphes 21° ou 22°;

e) d'au moins 1,2 m entre un toit végétalisé et :

i) une construction hors-toit;

ii) l'axe d'un mur coupe-feu;

iii) un mur extérieur appartenant au même bâtiment;

iv) une limite de propriété, à l'exception de celle bordant une voie publique;

v) des lanterneaux, pergolas et terrasses;

24° lorsque le bâtiment a une aire de bâtiment d'au plus 300 m² et comporte un toit végétalisé de type 1, il doit être prévu une zone libre de végétation d'une largeur :

a) d'au moins 0,35 m autour d'un avaloir de toit mesurée à partir du centre de l'avaloir;

b) d'au moins 0,5 m sur le pourtour d'un toit végétalisé ou d'une section de toit végétalisé;

c) d'au moins 0,3 m entre un toit végétalisé et tout équipement situé sur le toit, notamment les appareillages de plomberie et de ventilation, les tuyaux, conduits, antennes, joints d'expansion et les lanterneaux;

d) d'au moins 0,5 m entre un toit végétalisé et une construction hors-toit;

25° une zone libre de végétation exigée doit être isolée de la section adjacente du toit végétalisé par une bordure dont la partie supérieure doit être au moins au même niveau que le dessus du substrat de croissance et dont la présence ne nuit pas au drainage du toit;

26° les zones libres de végétation exigées doivent être revêtues de matériaux incombustibles;

27° le dessus d'une zone libre de végétation exigée autour d'un avaloir doit être constitué de matériaux incombustibles qui facilitent le drainage;

28° la largeur des zones libres de végétation peut être réduite à 0,5 m lorsque les éléments visés aux sous-paragraphes i), ii), et v) du sous-paragraphe e) du paragraphe 23° sont de construction incombustible ou sont revêtus de matériaux incombustibles;

29° lorsqu'un toit végétalisé est accessible, il est considéré comme ayant un usage au sens du Code. Un toit végétalisé est considéré comme accessible lorsque des personnes peuvent y avoir accès pour d'autres fonctions que l'entretien;

30° un toit végétalisé doit être muni d'un système d'irrigation intégré ou d'au moins un robinet dédié à l'arrosage, installé sur le toit ou à tout autre endroit approprié;

31° avant la pose d'un toit végétalisé, le propriétaire doit effectuer ou faire effectuer, à ses frais, un essai d'étanchéité selon l'une des méthodes reconnues par l'industrie.

Le présent article ne s'applique pas aux toitures ou parties de toiture destinées à la culture de végétation dans les serres, bacs ou pots.

11-018-3, a. 24.

SOUS-SECTION II
SAILLIES COMBUSTIBLES – PATRIMOINE

11-018-3, a. 24.

27.5. Malgré le paragraphe 2 de l'article 3.1.10.7. de la division B du Code, une saillie combustible d'un bâtiment combustible peut se trouver à moins de 1,2 m de l'axe du mur coupe-feu ou d'une limite de propriété dans les cas suivants :

1° la saillie est située à 1 m ou moins au-dessus du niveau du sol;

2° le bâtiment comporte au plus 2 logements et la saillie ne se trouve pas à moins de 1,2 m de l'axe d'un autre mur coupe-feu ou d'une autre limite de propriété ne bordant pas une voie publique.

11-018-3, a. 24.

27.6. Malgré l'article 27.5 et le paragraphe 1 de l'article 3.2.3.6., le paragraphe 6 de l'article 9.10.14.5. et le paragraphe 5 de l'article 9.10.15.5. de la division B du Code, les mains courantes et les marches d'un escalier situées sur un mur extérieur faisant face à une rue et desservant une aire de plancher située à au plus 1 étage au-dessus du premier étage, peuvent être de construction combustible.

11-018-3, a. 24.

27.7. Les garde-corps exigés à l'article 9.8.8.1. de la division B du Code, desservant un usage autre qu'un établissement industriel et qui protègent un niveau situé à une hauteur d'au plus 4,2 m au-dessus du niveau adjacent peuvent ne pas respecter les exigences relatives à la conception des garde-corps du paragraphe 3 de l'article 3.3.1.18. et de l'article 9.8.8.6. de la division B du Code.

11-018-3, a. 24.

27.8. Une armoire de rangement installée sur un balcon peut être assimilée à une saillie aux conditions suivantes :

1° sa superficie est d'au plus 2,5 m²;

2° la partie du mur extérieur du bâtiment auquel elle est adossée doit avoir la même composition que celle de l'ensemble du mur;

3° sauf pour un bâtiment qui comporte au plus 2 logements, toute partie du plancher et du toit située à moins de 1,2 m d'une limite de propriété ou de l'axe d'un mur coupe-feu doit être de construction incombustible;

4° la face intérieure du mur qui est adjacent ou situé à moins de 1,2 m d'une limite de propriété ne bordant pas une voie publique ou de l'axe d'un mur coupe-feu doit être recouverte d'un matériau incombustible assurant un degré de résistance au feu d'au moins 1 heure;

5° la face extérieure du mur qui est adjacente ou située à moins de 1,2 m d'une limite de propriété ne bordant pas une voie publique ou de l'axe d'un mur coupe-feu doit être recouverte d'un matériau incombustible assurant une résistance au feu d'au moins 1 heure et d'un parement incombustible résistant aux intempéries;

6° lorsque 2 armoires de rangement sont superposées, la partie inférieure de l'assemblage plancher-plafond qui les sépare doit être recouverte d'un matériau incombustible assurant une résistance au feu d'au moins 1 heure.

11-018-3, a. 24.

SOUS-SECTION III
CONCEPTION DES AIRES ET DES ESPACES DANS UNE HABITATION

11-018-3, a. 24.

27.9. Malgré le deuxième alinéa de l'article 14.1, dans une suite protégée par gicleurs et pourvue d'un système de ventilation mécanique complet incluant l'aire éclairée en second-jour, l'ouverture entre les deux aires formant des pièces combinées peut être munie de portes à condition que celles-ci ne réduisent pas la surface de l'ouverture prescrite lorsqu'elles sont en position ouverte.

11-018-3, a. 24.

28. Dans un bâtiment à logements qui ne comporte pas un autre usage principal, une mezzanine située à l'intérieur d'une suite peut ne pas être considérée comme un étage dans le calcul de la hauteur de bâtiment, si toutes les conditions suivantes sont réunies :

1° le bâtiment est régi par la partie 9 de la division B du Code et comporte au plus 8 logements;

2° l'aire cumulée des mezzanines non superposées à l'intérieur d'une suite ne dépasse pas 40 % de l'aire de cette suite, sur l'étage qu'elles surmontent;

3° la projection des mezzanines sur le plan du plancher de l'étage qu'elles surmontent, ne dépasse pas les limites périphériques de la suite;

4° le bâtiment comporte au plus 4 niveaux de plancher, autres que ceux situés au dessous du premier étage;

5° chaque mezzanine communique avec la partie d'aire de plancher qu'elle surmonte par un escalier ouvert;

6° chaque suite qui comporte une mezzanine est isolée du reste du bâtiment par une séparation coupe-feu d'au moins 1 h.

Toutefois, à des fins d'application des sous-sections 9.9.9. et 9.10.18. de la division B du Code, les mezzanines visées au premier alinéa constituent un étage.

Lorsqu'une mezzanine constitue le dernier niveau d'un bâtiment comportant 4 niveaux de plancher autres que ceux situés au-dessous du premier étage, elle doit être desservie par une issue, sans qu'il soit nécessaire de descendre un étage pour atteindre cette issue.

Malgré le paragraphe 2 de l'article 9.10.18.2. de la division B du Code, un système d'alarme incendie est exigé dans une habitation qui comporte des mezzanines visées au premier alinéa lorsque le bâtiment a plus de 3 niveaux de plancher autres que ceux situés au-dessous du premier étage et qu'il contient plus de 4 logements.

Lorsqu'un tel système d'alarme incendie est requis, en plus des composantes exigées par le Code, un détecteur de chaleur permettant à la fois la détection d'une température fixe maximale et l'élévation de température, doit être installé dans chaque logement et dans chaque pièce ne faisant pas partie d'un logement.

11-018, a. 28; 11-018-3, a. 25.

SOUS-SECTION IV
MOYENS D'ÉVACUATION

11-018-3, a. 26.

29. Les exigences des articles 9.9.4.2., 9.9.4.4. et 9.10.8.8. de la division B du Code ne s'appliquent pas à un passage extérieur qui ne sert pas d'unique moyen d'évacuation pour une suite dont l'autre moyen d'évacuation est indépendant du premier.

11-018, a. 29.

29.1. Malgré l'article 9.8.3.1. de la division B du Code, un escalier extérieur qui ne dessert que des logements et qui ne constitue pas leur seule issue peut être tournant en totalité ou être tournant en une ou plusieurs parties aux conditions suivantes :

1° il dessert un niveau situé à au plus un étage au-dessus du premier étage;

2° il dessert au plus 2 logements par étage;

3° il comporte des girons égaux d'au moins 225 mm, lorsque mesurés à 500 mm de l'extrémité la plus étroite;

4° la rotation entre 2 niveaux s'effectue dans le même sens.

11-018-3, a. 27.

29.2. Malgré l'article 9.8.3.1. de la division B du Code, un escalier hélicoïdal autorisé en vertu des paragraphes 3 ou 4 de l'article 9.8.4.5. de la division B du Code, peut être tournant en totalité ou être tournant en une ou plusieurs parties lorsque chaque partie tournante permet de tourner d'au moins 180 degrés.

11-018-3, a. 27.

29.3. Malgré le paragraphe 1 de l'article 9.8.2.1. de la division B du Code, lorsqu'un logement comporte au moins 2 moyens d'évacuation, l'un d'eux peut être un escalier extérieur d'une largeur libre minimale de 760 mm, aux conditions suivantes :

1° l'escalier ne dessert que des logements;

2° l'escalier dessert au plus 2 logements par aire de plancher.

11-018-3, a. 27.

29.4. Malgré le paragraphe 1 de l'article 9.8.4.3. de la division B du Code, il n'est pas obligatoire que les marches dansantes d'un escalier d'issue extérieur desservant au plus deux logements par étage soient conformes à l'article 3.4.6.9. de la division B du Code, si elles répondent aux conditions suivantes :

1° elles ont un giron d'au moins 150 mm mesuré au point le plus étroit;

2° elles ont un giron d'au moins 230 mm mesuré à 300 mm du point le plus étroit;

3° elles tournent dans la même direction.

11-018-3, a. 27.

SOUS-SECTION V
DISPOSITIONS DIVERSES

11-018-3, a. 28.

30. Lorsqu'un bâtiment de protection civile municipal, notamment une usine de traitement et de stockage d'eau, une station de pompage ou une caserne de pompiers, fait l'objet d'une transformation, sa capacité de résister aux charges sismiques peut déroger à l'article 10.4.1.3. de la division B du Code si les exigences suivantes sont satisfaites :

1° elle n'est pas diminuée par l'effet de la transformation;

2° elle est rehaussée au minimum à 60 % du niveau de protection sismique exigé par la partie 4 de la division B du Code, si la transformation a pour conséquence l'une des situations suivantes :

a) accroître la hauteur de bâtiment;

b) modifier le système de résistance aux charges latérales du bâtiment.

11-018, a. 30; 11-018-3, a. 29.

31. À l'égard d'une transformation à un bâtiment ou une partie de bâtiment dont un permis de construction a été émis avant le 23 janvier 2020 et qui ne constitue pas un agrandissement en aire de bâtiment, en aire de plancher ou en hauteur de bâtiment, les exigences relatives à l'aménagement des pièces et à la sécurité prévues aux chapitres VII, IX ainsi qu'à la section I du chapitre X.I du Règlement sur la salubrité, l'entretien et la sécurité des logements (03-096) de la Ville de Montréal peuvent être appliquées au lieu de celles du Code, dans l'une ou l'autre des situations suivantes :

1° la transformation d'une partie d'un bâtiment à l'intérieur de laquelle est déjà exercé un usage résidentiel de type logement ou maison de chambres;

2° la transformation d'une partie d'un bâtiment à l'intérieur de laquelle a déjà été exercé un usage résidentiel de type logement ou maison de chambres, sans avoir subi de travaux de modification.

Toutefois, en aucun cas, la transformation ne doit avoir pour effet de diminuer le niveau de salubrité ou de sécurité existant du bâtiment en deçà des exigences du Code.

11-018, a. 31; 11-018-3, a. 30.

CHAPITRE III
DISPOSITIONS ADMINISTRATIVES

SECTION I
PERMIS DE CONSTRUCTION

SOUS-SECTION I
OBLIGATIONS ET MODALITÉS D'UNE DEMANDE DE PERMIS DE CONSTRUCTION

32. Il est interdit d'effectuer sans permis :

1° la construction d'un bâtiment;

2° la transformation d'un bâtiment au sens du Code;

3° la modification, le remplacement ou l'ajout d'un élément de construction d'un bâtiment visé par un règlement de zonage, un plan d'implantation et d'intégration architectural ou tout autre réglementation municipale;

4° la relocalisation d'un bâtiment;

5° l'installation d'une maison mobile;

6° la mise en conformité d'un bâtiment.

11-018, a. 32; 11-018-3, a. 31.

33. Malgré l'article 32, un permis n'est pas requis :

1° pour l'installation ou la construction d'un bâtiment temporaire sur un chantier nécessaire à la réalisation de travaux de construction ou utilisé pour la vente ou la location d'unités de logement;

2° pour l'installation, la construction ou l'agrandissement d'un bâtiment secondaire dont la superficie totalise au plus 15 m^2.

11-018, a. 33; 11-018-3, a. 32.

34. La demande de permis exigée à l'article 32 doit être faite par le propriétaire ou son mandataire.

Cette demande doit :

1° identifier par les numéros de lots le terrain sur lequel doivent être exécutés les travaux;

2° indiquer les usages du projet et les usages des parties de tout bâtiment visé par le projet;

3° décrire les travaux projetés;

4° indiquer la valeur estimée des travaux telle qu'elle est définie au règlement annuel sur les tarifs;

5° indiquer le nom, l'adresse, le numéro de téléphone et l'adresse courriel du propriétaire, de l'architecte, de l'ingénieur et de tout autre concepteur ou entrepreneur;

6° être accompagnée :

a) du document intitulé « fiche bâtiment / déclaration de conformité », dont la forme et le contenu sont déterminés par ordonnance du comité exécutif conformément à l'article 35 du présent règlement, complété et signé par :

i) le propriétaire ou son mandataire;

ii) le concepteur, le cas échéant;

b) de tout plan, élévation, coupe et détail dessinés à l'échelle et de tout renseignement nécessaire pour permettre de vérifier si le projet est conforme à la réglementation municipale applicable;

c) de tout plan d'aménagement de nouveau logement dessiné à l'échelle 1 :50 indiquant les dimensions des aires et des espaces ainsi que la superficie de la surface utile;

d) le sous-paragraphe a) ne s'applique pas aux travaux suivants :

i) le remplacement des portes et fenêtres sans modification de leurs dimensions;

ii) le remplacement d'un revêtement de toiture;

iii) l'aménagement d'un toit végétalisé;

iv) tous autres travaux qui ne sont pas considérés comme une transformation au sens du Code;

7° être accompagnée :

a) dans le cas d'une construction neuve, d'un plan de cadastre et d'un plan projet d'implantation préparés par un arpenteur-géomètre comprenant notamment;

i) l'identification cadastrale, les dimensions et la superficie du terrain;

ii) les dimensions des constructions, existantes et projetées, ainsi que leur localisation par rapport aux limites de terrain et entre elles;

iii) les niveaux géodésiques du terrain, existants et projetés, du plancher du rez-de-chaussée du bâtiment projeté, et de toute rue, égout, aqueduc adjacents au terrain visé par la demande;

iv) la localisation de toute servitude, existante ou projetée, grevant le terrain;

v) la délimitation de la ligne des hautes eaux et de la rive, le cas échéant;

vi) la délimitation des zones de grand et de faible courant, le cas échéant;

vii) un relevé des arbres existants, le cas échéant;

viii) les aménagements extérieurs, incluant notamment les aires de stationnement, les voies d'accès, les aires de chargement et de déchargement et les entrées charretières;

ix) la localisation de tout élément existant sur le domaine public face au terrain visé, incluant notamment un arbre, une borne d'incendie, une conduite de gaz, un poteau, un appareil ou un équipement lié à la distribution électrique, à la télécommunication, à l'éclairage des rues et aux feux de circulation;

b) dans le cas d'un agrandissement en superficie d'un bâtiment existant :

i) d'un plan projet d'implantation comprenant les mêmes renseignements exigés au paragraphe 7° du deuxième alinéa du présent article lorsqu'ils sont nécessaires pour permettre de vérifier si le projet est conforme à la réglementation municipale applicable;

ii) d'un certificat de localisation;

8° être accompagnée du paiement du montant fixé au règlement annuel sur les tarifs sauf pour une demande de permis qui concerne un des projets suivants, pour laquelle le paiement doit être effectué avant la délivrance du permis :

a) projet visé par le Règlement sur la subvention à la réalisation de logements coopératifs et à but non lucratif (02-102);

b) projet d'une coopérative d'habitation dont la mission consiste à développer du logement à but non lucratif;

c) projet d'habitation d'un organisme à but non lucratif;

9° dans le cas où la demande de permis est effectuée par un mandataire, être accompagnée d'une procuration du propriétaire du bâtiment. Lorsqu'il s'agit d'un immeuble détenu en copropriété divise, le requérant ou son mandataire doit fournir l'autorisation du syndicat de la copropriété pour tous travaux devant être exécutés dans une partie commune;

10° être accompagnée des calculs et des plans relatifs à tout ouvrage de rétention des eaux pluviales, signés et scellés par une personne habilitée par la loi.

La demande doit également :

1° dans le cas de l'installation, de la construction ou de l'agrandissement d'un bâtiment dans un parc de maisons mobiles, être accompagnée des documents suivants :

a) une autorisation écrite du propriétaire du parc de maisons mobiles, ou de son représentant, permettant le projet visé et attestant que la maison mobile et ses bâtiments accessoires, le cas échéant, sont implantés dans les limites de l'emplacement locatif décrit au bail;

b) un plan montrant les limites du terrain ou de l'emplacement locatif;

2° dans le cas où la réglementation d'arrondissement autorise qu'un bâtiment soit desservi par une installation septique et un ouvrage de captage des eaux souterraines, être accompagnée d'un plan de localisation des composantes de l'installation et d'une description de leur capacité, le cas échéant;

3° dans le cas de la construction, de la reconstruction ou de l'agrandissement au sol d'un bâtiment principal dans un site de remblayage hétérogène, être accompagnée des documents suivants :

a) des relevés géotechniques déterminant la présence de gaz souterrain, la possibilité de tassement éventuel du sol, l'agressivité du sol causée par la présence de sulfates et la présence de substances dangereuses;

b) suite aux relevés effectués, des recommandations quant aux mesures appropriées à prendre pour rendre le site propre à la construction;

c) une permission écrite du ministre de l'Environnement obtenue en conformité avec l'article 65 de la Loi sur la qualité de l'environnement (RLRQ, chapitre Q-2);

4° dans le cas où ils sont requis par la section II du présent chapitre, être accompagnée des documents nécessaires pour l'étude des mesures différentes ou solutions de rechange;

5° dans le cas de l'aménagement d'un toit végétalisé visé par le premier paragraphe du premier alinéa de l'article 27.4, être accompagnée des documents suivants :

a) la fiche de toit végétalisé dûment complétée et signée par le concepteur relativement à la résistance structurale, aux effets de soulèvement dus au vent et à la capacité portante du toit lorsque les parapets sont requis;

b) les plans de structure du toit et des éléments qui le supportent.

Sauf si l'autorité compétente permet le dépôt de documents en version numérique, tous les documents exigés en vertu du présent article doivent être fournis en deux exemplaires sur support papier. Des exemplaires supplémentaires devront être fournis pour une demande de permis assujettie à des dispositions nécessitant une évaluation particulière.

11-018, a. 34; 11-018-1, a. 1; 11-018-2, a. 1; 11-018-3, a. 33.

35. Le comité exécutif peut déterminer par ordonnance :

1° la forme et le contenu du document intitulé « fiche bâtiment / déclaration de conformité » requis selon le sous-paragraphe a) du paragraphe 6° du deuxième alinéa de l'article 34;

2° la forme et le contenu du document intitulé « fiche toit végétalisé » requis selon le sous-paragraphe a) du paragraphe 5° du troisième alinéa de l'article 34.

11-018, a. 35; 11-018-3, a. 34.

36. Toute révision de la demande de permis exigée à l'article 32 qui comporte une modification de la description des travaux énoncée dans cette demande, doit faire l'objet d'une nouvelle demande établie de la même façon que la demande initiale.

Dans l'éventualité où il y a un changement de propriétaire de l'immeuble, la demande de permis est réputée avoir été déposée et le permis émis au nom du nouveau propriétaire. Le permis peut ainsi être modifié, sans frais, afin d'y changer uniquement le nom du propriétaire.

L'exigence du premier alinéa ne s'applique pas lorsque la modification de la description des travaux découle d'un commentaire ou d'une demande de modification provenant d'une instance décisionnelle ou d'un comité consultatif de la Ville.

11-018, a. 36; 11-018-3, a. 35.

37. Lorsque, aux termes d'un avis donné par écrit au requérant d'un permis, à l'adresse du requérant indiquée sur la demande de permis, l'autorité compétente a requis de compléter, préciser ou corriger les renseignements exigés et que le requérant ne s'est pas conformé à cet avis dans un délai qu'elle fixe, d'au plus 60 jours de sa date de signification, la demande de permis est caduque.

11-018, a. 37.

SOUS-SECTION II
CONDITIONS DE DÉLIVRANCE D'UN PERMIS DE CONSTRUCTION

38. Le permis est délivré au propriétaire si toutes les conditions suivantes sont respectées :

1° la demande est conforme aux règlements de zonage et de construction et, le cas échéant, aux règlements adoptés en vertu des articles 116 et 145.21 de la Loi sur l'aménagement et l'urbanisme (RLRQ, chapitre A-19.1);

2° le demandeur a fourni les renseignements requis pour permettre à l'autorité compétente de remplir le formulaire prévu à l'article 120.1 de la Loi sur l'aménagement et l'urbanisme (RLRQ, chapitre A-19.1);

3° dans le cas où le terrain visé par la demande de permis de construction est inscrit sur la liste des terrains contaminés constituée par la Ville en application de l'article 31.68 de la Loi sur la qualité de l'environnement (RLRQ, chapitre Q-2) et fait l'objet d'un plan de réhabilitation approuvé par le ministre, la demande est accompagnée d'une attestation d'un expert établissant que le projet est compatible avec les dispositions du plan de réhabilitation mentionné ci-dessus;

4° la demande de permis est accompagnée d'une déclaration écrite du demandeur établissant que le permis demandé concerne ou non un bâtiment destiné à être utilisé comme résidence pour personnes âgées telle que définie au deuxième alinéa de l'article 118.1 de la Loi sur l'aménagement et l'urbanisme (RLRQ, chapitre A-19.1);

5° dans le cas où la demande de permis concerne un projet assujetti à un plan d'implantation et d'intégration architecturale, les plans relatifs à l'implantation et à l'architecture du bâtiment ont fait l'objet de l'approbation requise;

6° la demande de permis est accompagnée de toute autorisation requise en vertu d'un règlement municipal.

11-018, a. 38; 11-018-3, a. 36.

SOUS-SECTION III
VALIDITÉ ET CADUCITÉ D'UN PERMIS DE CONSTRUCTION

39. Un permis est périmé et les droits qu'il confère au propriétaire sont perdus dans l'un ou l'autre des cas suivants :

1° les travaux autorisés par le permis ne sont pas commencés dans les 12 mois qui suivent la date de délivrance du permis à l'exception d'un permis délivré pour la construction ou l'agrandissement d'un bâtiment d'une hauteur de plus de 4 étages ou dont l'aire de bâtiment dépasse 2000 m² pour lequel le délai est de 18 mois;

2° les travaux sont interrompus pendant plus de 6 mois;

3° les travaux ne sont pas complétés dans les 18 mois qui suivent la date de délivrance du permis, à l'exception d'un permis délivré pour la construction ou l'agrandissement d'un bâtiment d'une hauteur de plus de 4 étages ou dont l'aire de bâtiment dépasse 2000 m² pour lequel le délai est de 36 mois.

Pour pouvoir être exécutés, tous travaux non réalisés doivent alors faire l'objet d'une nouvelle demande de permis.

11-018, a. 39; 11-018-2, a. 2.

40. Sur réception d'une demande écrite du propriétaire ou de son mandataire, présentée avant l'expiration du délai de péremption, l'autorité compétente peut prolonger une seule fois les délais de 18 et 36 mois mentionnés au paragraphe 3° du premier alinéa de l'article 39, respectivement de 6 et 12 mois.

11-018, a. 40; 11-018-2, a. 3; 11-018-3, a. 37.

41. Dans le cas où les travaux ne sont pas débutés, un permis est renouvelé sur demande si toutes les conditions suivantes sont respectées :

1° la demande de renouvellement est présentée avant l'expiration du délai de péremption prévu à l'article 39;

2° la réglementation municipale applicable en vigueur à la date du renouvellement permet la réalisation du projet visé par l'autorisation originale;

3° le montant fixé au règlement annuel sur les tarifs pour un tel renouvellement est payé.

11-018, a. 41.

42. Un permis ne peut être renouvelé qu'une seule fois.

11-018, a. 42; 11-018-2, a. 4.

43. Lorsque des travaux sont interrompus pendant plus de 6 mois ou ne sont pas complétés dans les délais prévus au paragraphe 3° du premier alinéa de l'article 39, l'autorité compétente peut, sur avis de 30 jours, ordonner au propriétaire du terrain, à l'entrepreneur des travaux ou à tout autre intéressé de retirer les constructions, installations, matériaux et appareils qui sont sur le terrain, de refermer toute excavation, de nettoyer et de niveler le terrain.

11-018, a. 43.

44. Si une personne visée à l'article 43 ne se conforme pas à l'ordre qu'elle a reçu ou si l'autorité compétente ne peut trouver le propriétaire ou son représentant, les travaux qui ont été ordonnés peuvent être exécutés par la Ville aux frais du propriétaire du terrain.

Ces frais constituent une créance prioritaire sur l'immeuble, au même titre et selon le même rang que les créances visées au paragraphe 5 de l'article 2651 du Code civil du Québec. Ces frais sont également garantis par une hypothèque légale sur cet immeuble.

11-018, a. 44.

45. Après en avoir avisé le titulaire par écrit, l'autorité compétente peut suspendre ou révoquer un permis dans l'une ou l'autre des situations suivantes :

1° lorsque l'une des conditions de la délivrance du permis n'a pas été respectée;

2° lorsqu'il a été accordé par erreur ou sur la foi de renseignements inexacts;

3° lorsque les travaux exécutés sont non conformes aux plans approuvés.

11-018, a. 45.

46. Le titulaire d'un permis révoqué doit le retourner à l'autorité compétente dans les 10 jours de la révocation.

11-018, a. 46.

SECTION II
MESURES DIFFÉRENTES ET SOLUTIONS DE RECHANGE

47. Quiconque souhaite proposer à l'autorité compétente des mesures différentes ou des solutions de rechange doit fournir des documents qui satisfont aux exigences de la présente section afin de démontrer la conformité de ces mesures ou solutions au Code.

11-018, a. 47.

48. Les documents mentionnés à l'article 47 doivent comprendre :

1° une analyse du Code décrivant les méthodes d'analyse et justifications permettant de déterminer que la mesure différente ou la solution de rechange proposée permettra d'atteindre au moins le niveau de performance exigé par le Code;

2° le cas échéant, des renseignements sur toute exigence d'entretien ou d'exploitation spéciale, y compris toute exigence liée à la mise en service d'un composant d'un bâtiment, nécessaires afin que la mesure différente ou la solution de rechange soit conforme au Code une fois le bâtiment construit.

11-018, a. 48.

49. L’analyse du Code mentionnée au paragraphe 1° du premier alinéa de l’article 48 doit comprendre les objectifs, les énoncés fonctionnels et les solutions acceptables qui s’appliquent, de même que toute hypothèse, facteur limitatif ou restrictif, procédure de mise à l’essai, étude technique ou paramètre de performance du bâtiment permettant de soutenir une évaluation de la conformité au Code.

11-018, a. 49.

50. L’analyse du Code mentionnée au paragraphe 1° du premier alinéa de l’article 48 doit comprendre des renseignements sur la compétence, l’expérience et les antécédents de la personne ou des personnes responsables de la conception proposée.

11-018, a. 50.

51. Les renseignements soumis en vertu de l’article 48 doivent être suffisamment détaillés pour transmettre l’intention de la conception et pour soutenir la validité, l’exactitude, la pertinence et la précision de l’analyse du Code.

11-018, a. 51.

52. Lorsque la conception d’un bâtiment comprend des mesures différentes ou des solutions de rechange proposées pour lesquelles les responsabilités de différents aspects de la conception sont partagées entre plusieurs personnes, le propriétaire du bâtiment ou son mandataire doit désigner une seule personne qui coordonnera la préparation de la conception, l’analyse du Code et les documents mentionnés à la présente section.

11-018, a. 52.

SECTION III
INSPECTION

SOUS-SECTION I
GÉNÉRALITÉS

53. Le propriétaire et, le cas échéant, l'entrepreneur doivent :

1° faire en sorte que les plans et devis tels qu’approuvés relativement aux travaux visés par le permis soient disponibles sur le site des travaux, à tout moment durant les heures de travail, aux fins d'inspection par l'autorité compétente;

2° afficher d'une façon bien visible le permis ou une copie conforme de celui-ci sur le site durant toute la durée des travaux;

3° informer l'autorité compétente du début des travaux.

11-018, a. 53; 11-018-3, a. 38.

54. Sur présentation d'une pièce d'identité, l'autorité compétente peut, pour les fins de l'application du présent règlement, visiter, examiner et prendre en photos toute propriété immobilière et mobilière.

Toute personne doit permettre à l'autorité compétente de pénétrer dans un bâtiment sans nuire à l'exécution de ses fonctions.

11-018, a. 54.

55. L'autorité compétente peut, au moyen d'un avis, ordonner au propriétaire d'un bâtiment construit sans permis de présenter une demande en vue d'obtenir le permis requis, dans un délai d'au plus 10 jours qu'elle fixe dans l'avis.

11-018, a. 55.

56. L'autorité compétente peut, au moyen d'un avis, ordonner au propriétaire, à l'entrepreneur des travaux ou à tout autre intéressé, de suspendre des travaux de construction :

1° effectués sans permis;

2° non conformes au permis délivré;

3° non conformes à la réglementation municipale.

11-018, a. 56; 11-018-3, a. 39.

SOUS-SECTION II
CERTIFICATS ET ATTESTATIONS

11-018; 11-018-3, a. 40.

57. Dans le cas de la construction ou de l'agrandissement au sol d'un bâtiment principal, le propriétaire doit, dans les 30 jours suivant la mise en place des fondations, fournir à l'autorité compétente un certificat de localisation préparé par un arpenteur-géomètre, comprenant notamment :

1° l'identification cadastrale, les dimensions et la superficie du terrain;

2° les dimensions des constructions (existantes et projetées) ainsi que leur localisation par rapport aux limites de terrain et entre elles;

3° les niveaux géodésiques du sommet des fondations, du terrain et de toute rue adjacente au terrain;

4° la localisation de toute servitude, existante ou projetée, grevant le terrain;

5° la délimitation de la ligne des hautes eaux et de la rive, le cas échéant;

6° la délimitation des zones de grand et de faible courant, le cas échéant;

7° toute autre cote ou mesure permettant de vérifier si les travaux sont conformes à la réglementation municipale applicable.

11-018, a. 57; 11-018-3, a. 41.

58. Suite à des travaux de construction dans une zone à risque d'inondation, le propriétaire doit présenter à l'autorité compétente une attestation de la conformité de la construction aux mesures d'immunisation prévues à l'article 20. Ce certificat doit être produit par une personne compétente en la matière.

11-018, a. 58; 11-018-3, a. 42.

SOUS-SECTION III
DESSINS D'ATELIER, ESSAIS ET EXPERTISES

59. À la demande de l'autorité compétente, le propriétaire doit fournir, préalablement à la réalisation des travaux, tous les documents permettant de s'assurer que le bâtiment ou la construction est conforme à la réglementation municipale, notamment les dessins d'atelier et plans de montage de la structure, le cas échéant.

11-018, a. 59.

60. À la demande de l'autorité compétente, le propriétaire doit effectuer ou faire effectuer, à ses frais, des essais, des analyses ou des expertises sur les matériaux, assemblages, dispositifs, systèmes, installations ou appareils. Il doit remettre à l'autorité compétente ces résultats de façon à s'assurer que le bâtiment ou la construction est conforme à la réglementation municipale applicable.

11-018, a. 60.

60.1. Lors de l'aménagement d'un toit végétalisé, le propriétaire doit produire à l'autorité compétente, une copie du rapport de l'essai d'étanchéité exigé au paragraphe 31^{o} de l'article 27.4.

___

11-018-3, a. 43.

SECTION IV
CONSTRUCTIONS ILLÉGALES, DÉROGATOIRES OU DANGEREUSES

61. L'autorité compétente peut, au moyen d'un avis, ordonner au propriétaire d'un bâtiment ou d'une construction non conforme à la réglementation municipale applicable, de l'y rendre conforme ou de le démolir dans un délai qu'elle fixe, d'au plus 90 jours.

Le propriétaire doit se conformer à l'avis prévu au premier alinéa, à défaut, l'autorité compétente peut démolir les bâtiments ou constructions illégaux.

___

11-018, a. 61.

62. Lorsqu'un bâtiment dérogatoire est détruit ou a perdu au moins la moitié de sa valeur par suite d'un incendie ou de quelque autre cause, sa reconstruction ou sa réfection, selon le cas, doit être effectuée conformément au présent règlement.

___

11-018, a. 62; 11-018-3, a. 44.

63. Lorsqu'un bâtiment ou une construction présente une condition dangereuse, en raison de travaux, d'un feu, d'un manque de solidité ou pour quelque autre cause, le propriétaire doit prendre toutes les mesures nécessaires, y compris la démolition de tout ou partie de ce bâtiment ou construction, pour supprimer cette condition dangereuse.

À défaut par le propriétaire de se conformer au premier alinéa, l'autorité compétente peut effectuer les travaux et prendre toutes les mesures nécessaires, y compris la démolition, pour assurer la sécurité du public.

___

11-018, a. 63.

64. Le propriétaire d'un bâtiment vacant doit le fermer de façon à en empêcher l'accès par l'une ou l'autre de ses ouvertures, telles que portes, fenêtres, accès au toit, trappes et cheminées.

Lorsqu'un bâtiment vacant n'est pas fermé conformément au premier alinéa, l'autorité compétente peut procéder elle-même à sa fermeture.

___

11-018, a. 64.

65. Dans le cas d'un bâtiment devenu impropre à l'occupation, un avis de l'autorité compétente au propriétaire et aux occupants est nécessaire avant sa fermeture ou sa démolition par celle-ci.

11-018, a. 65.

66. Le coût des travaux effectués par l'autorité compétente en vertu des articles 61, 63 et 64 peut être recouvré du propriétaire et constitue une créance prioritaire sur l'immeuble sur lequel ils ont été exécutés, au même titre et selon le même rang que les créances visées au paragraphe 5 de l'article 2651 du Code civil du Québec. Ces frais sont également garantis par une hypothèque légale sur cet immeuble.

11-018, a. 66.

67. La présente section n'a pas pour effet de limiter l'application d'autres dispositions législatives ou réglementaires en vertu desquelles la Ville peut requérir la remise en état de constructions ou de bâtiments ni celles en vertu desquelles le directeur du Service de sécurité incendie est autorisé à prendre ou à imposer certaines mesures en présence d'un danger grave ou imminent pour la sécurité publique.

11-018, a. 67.

SECTION V
DISPOSITIONS PÉNALES

68. Commet une infraction quiconque :

1° fait une fausse déclaration pour l'obtention d'un permis;

2° fait une fausse déclaration dans un document prescrit par le présent règlement ou fait usage d'un tel document alors qu'il en connaît la fausseté;

3° à l'égard d'un bâtiment ou d'un ouvrage visé par le chapitre II, construit, modifie ou permet la construction ou la modification d'un bâtiment ou d'un ouvrage contrairement à une norme énoncée à ce chapitre;

4° contrevient à l'une des dispositions du chapitre III.

11-018, a. 68.

69. Quiconque contrevient à l’article 68 commet une infraction et est passible :

1° s’il s’agit d’une personne physique :

a) pour une première infraction, d’une amende de 1 000 $;

b) pour toute récidive, d’une amende de 2 000 $;

2° s’il s’agit d’une personne morale :

a) pour une première infraction, d’une amende de 2 000 $;

b) pour toute récidive, d’une amende de 4 000 $.

11-018, a. 69; 11-018-2, a. 5; 11-018-3, a. 45.

70. *[Abrogé]*.

11-018, a. 70; 11-018-3, a. 46.

71. Nonobstant l'article 69, quiconque contrevient à l'article 32 commet une infraction et est passible d'une amende égale au coût de la demande de permis.

Pour toute récidive, le contrevenant est passible d’une amende égale au double du montant de l'amende prévue au premier alinéa.

Toutefois, si le coût de la demande de permis est inférieur aux amendes minimales prévues à l'article 69, ces dernières s'appliquent.

11-018, a. 71.

SECTION VI
DISPOSITIONS TRANSITOIRES ET FINALES

72. Les exigences normatives d’un règlement de construction en vigueur avant l’entrée en vigueur du présent règlement peuvent être utilisées en lieu et place de celles prévues au présent règlement, à la condition que la demande de permis, incluant tous les documents d’accompagnement requis par le présent règlement, soit soumise à la Ville pour approbation dans les 6 mois de l’entrée en vigueur du présent règlement.

Les exigences normatives du règlement de construction en vigueur avant l’entrée en vigueur d'une modification au présent règlement peuvent être utilisées en lieu et place de celles prévues au nouveau règlement, à la condition que la demande de permis, incluant tous les documents d’accompagnement requis par le présent règlement, soit soumise à la

Ville pour approbation dans les 6 mois de l'entrée en vigueur de cette modification réglementaire.

11-018, a. 72; 11-018-3, a. 47.

73. Le Règlement sur la construction et la transformation de bâtiments (R.R.V.M., chapitre C-9.2) est abrogé à l'exception des paragraphes 4° et 5° du premier alinéa de l'article 6.

11-018, a. 73.

74. Le Règlement sur l'entretien des bâtiments (07-034) de la Ville de Montréal est modifié :

1° par le remplacement, à l'article 12, du nombre « 13 » par le nombre « 11 »;

2° par l'ajout, après l'article 16, des articles suivants :

« **16.1.** Une installation de plomberie qui est dans un état tel qu'elle est une cause d'insalubrité constitue une nuisance et le propriétaire doit prendre toute les mesures nécessaires pour supprimer cette condition insalubre.

Pour l'application du premier alinéa, il existe une condition insalubre, notamment :

1° lorsqu'il n'y a pas d'eau dans les appareils sanitaires;

2° lorsque la tuyauterie d'évacuation est obstruée au point de ne plus permettre le fonctionnement de la chasse d'eau des appareils;

3° lorsque le défaut d'étanchéité de la tuyauterie permet la circulation de rongeurs, vermine, gaz ou fumée;

4° lorsque le défaut d'étanchéité d'un branchement d'eau ou d'un branchement d'égout donne lieu à des infiltrations d'eau dans la propriété desservie ou dans toute autre propriété voisine.

16.2. Le propriétaire d'un bâtiment doit entretenir et maintenir en bon état de fonctionnement tout clapet anti-retour.

16.3. Le propriétaire d'un bâtiment vacant doit boucher les ouvertures du réseau d'évacuation. ».

11-018, a. 74.

75. Le Règlement sur les éléments de fortification et de protection des bâtiments (R.R.V.M., chapitre E-1.1) est abrogé.

11-018, a. 75.

76. Le Règlement relatif aux appareils à combustibles solides (09-012) de la Ville de Montréal est abrogé.

11-018, a. 76.

77. Le Règlement sur la salubrité, l'entretien et la sécurité des logements (03-096) de la Ville de Montréal est modifié par le remplacement, au premier alinéa de l'article 1, des définitions de « autorité compétente » et de « Code de construction » par les suivantes :

« « autorité compétente » : la directrice du Service du développement et des opérations;

« Code de construction » : le Code tel que définit dans le règlement relatif à la construction des bâtiments applicable sur le territoire de l'arrondissement; ».

11-018, a. 77.

78. Le Règlement intérieur de la Ville sur la délégation de pouvoirs du conseil de la Ville aux conseils d'arrondissement (02-002) est modifié par le remplacement du sous paragraphe a) du paragraphe 2° du premier alinéa de l'article 1 par le suivant :

« a) la construction des bâtiments à l'exception de l'approbation des solutions de rechange et des mesures différentes prévue dans un tel règlement; ».

11-018, a. 78.

79. Le Règlement de construction no 2527 de la Ville de Lachine est modifié :

1° par l'abrogation des articles 1.1.4 et 1.2.3;

2° par la suppression, à l'article 1.2.6, de la définition de « mur insonorisé »;

3° par l'abrogation des articles 3.3, 3.7, 3.8 et 4.1 à 4.3.

11-018, a. 79.

80. Le Règlement de construction no 643 de la Ville de Saint-Pierre est modifié :

1° par l'abrogation de l'article 3.1;

2° par la suppression du cinquième alinéa de l'article 4.1;

3° par l'abrogation des articles 4.3, 4.4, 4.7, 4.9, 4.9.1, 4.9.2, 4.10.1, 4.10.3, 4.10.4 et 4.12 à 4.12.8;

4° par la suppression des deuxième, troisième, quatrième, cinquième, sixième et septième alinéas de l'article 4.13;

5° par l'abrogation des articles 4.14 à 4.16.2, 4.21.3, 4.21.5, 4.21.8, 4.21.10, 4.21.11, 4.23 et 4.24;

6° par la suppression du deuxième alinéa de l'article 4.25;

7° par l'abrogation de l'article 4.26;

8° par la suppression du deuxième alinéa de l'article 4.27.

11-018, a. 80.

81. Le Règlement de construction no 2099 de la Ville de LaSalle est modifié :

1° par l'abrogation du paragraphe a) du premier alinéa de l'article 1.1.5;

2° par l'abrogation de l'article 1.1.6;

3° par la suppression, aux paragraphes c) et d) du premier alinéa de l'article 2.2, des mots « et permis »;

4° par le remplacement de l'intitulé du chapitre 3 par le suivant :

« DISPOSITIONS RELATIVES À L'OBTENTION D'UN CERTIFICAT D'AUTORISATION, D'UN CERTIFICAT D'AUTORISATION D'AFFICHAGE OU D'UN CERTIFICAT D'OCCUPATION »;

5° par le remplacement de l'intitulé de l'article 3.1 par le suivant :

« CERTIFICATS ET PROCÉDURES DE CONTRÔLE »;

6° par l'abrogation de l'article 3.1.1;

7° par la suppression du paragraphe d) du deuxième alinéa de l'article 3.1.2;

8° par la suppression, à l’article 3.1.5, des mots « un permis ou », « de permis de construction ou », « le permis ou », « permis de construction ou », « de permis ou », « permis et » et « permis ou »;

9° par la suppression des paragraphes g), h) et i) du deuxième alinéa de l’article 3.1.5.2.1;

10° par la suppression du paragraphe h) du premier alinéa de l’article 3.1.5.2.1.1;

11° par la suppression, à l’article 3.1.5.3.1, des mots « , selon le cas, »;

12° par l’abrogation des articles 3.1.6 à 3.1.6.5;

13° par la suppression des paragraphes a) et f) du premier alinéa de l’article 3.1.7;

14° par la suppression, à l’article 3.1.9, des mots « d’un permis et », « de permis ou », « du permis de construction et », « d’un permis ou », « du permis ou », « permis et », « permis de construction ou » et « le permis de construction ou »;

15° par l’abrogation des articles 3.1.9.1.1 et 3.1.9.1.2;

16° par le remplacement de l’intitulé de l’article 3.1.10 par le suivant :

« TARIF DU CERTIFICAT »;

17° par la suppression, au premier alinéa de l’article 3.1.10, des mots « d’un permis de construction et »;

18° par la suppression, à l’article 3.1.11, des mots « d’un permis de construction, » et par le remplacement des mots « au Code national du bâtiment et tout autre » par les mots « à tout »;

19° par la suppression, à l’article 3.1.12, des mots « permis, un »;

20° par l’abrogation des articles 3.2 à 3.2.10;

21° par l’abrogation de l’article 4.1;

22° par la suppression, au paragraphe b) du premier alinéa de l’article 4.1.1.1, des mots « tout permis et » et « permis et »;

23° par la suppression du paragraphe e) du premier alinéa de l’article 4.1.1.1;

24° par la suppression, au paragraphe f) du premier alinéa de l’article 4.1.1.1, des mots « le permis ou » et « du permis de construction ou »;

25° par l’abrogation des articles 4.2.1 à 4.2.5;

26° par le remplacement du premier alinéa de l’article 4.2.6.1 par le suivant :

« Tout bâtiment principal de quatre (4) étages et plus doit être muni d’une chute à déchets. »;

27° par l’abrogation des articles 4.2.6.2 à 4.2.6.4.2;

28° par le remplacement de l’article 4.2.6.5 par le suivant :

« Tout bâtiment principal construit après le 1er juin 1997, de 7 logements et plus ou de 6 logements et plus localisé sur une rue privée, doit être muni d’une chambre à déchets. »;

29° par l’abrogation des articles 4.2.6.7 à 4.3.2.8, 5.2.1 et 5.2.3;

30° par la suppression, à l’article 5.2.4, des mots « composé de tout matériel non combustible »;

31° par l’abrogation des articles 5.3 et 5.5;

32° par la suppression du quatrième alinéa de l’article 6.4;

33° par l’abrogation des deuxième et troisième alinéas de l’article 7.1.4.3;

34° par la suppression de la cédule « A ».

11-018, a. 81.

82. Le Règlement no 1564 sur la construction à l’intérieur des limites du territoire de la municipalité de la Ville de Montréal-Nord est modifié :

1° par l’abrogation de l’article 7;

2° par la suppression, au premier alinéa de l’article 18, des mots « agrandissement », « permis ou » et « d’un permis ou »;

3° par la suppression, à l’article 29, des deuxième et troisième phrases de la définition de « habitable » et par la suppression à ce même article de la définition de « maison préfabriquée (modulaire, usinée) »;

4° par l’abrogation des articles 30 et 59;

5° par l’abrogation du paragraphe 3) de l’article 69;

6° par l’abrogation des articles 70 et 72;

7° par le remplacement, à l’article 75, des mots et nombres « des articles 76, 77 et 78 » par « de l’article 76 »;

8° par la suppression, à l’article 76, du nombre « , 59 »;

9° par l’abrogation des articles 77 et 78.

11-018, a. 82.

83. Le Règlement de construction no 1178 de la Ville d’Outremont est modifié :

1° par l’abrogation de l’article 1.3;

2° par la suppression du deuxième alinéa de l’article 2.1;

3° par l’abrogation des articles 2.2, 3.5 et 3.6.4;

4° par le remplacement de l’intitulé du chapitre 4 par le suivant :

« OBLIGATION D’OBTENIR UN CERTIFICAT D’AUTORISATION »;

5° par l’abrogation de l’article 4.1;

6° par le remplacement, à l’article 4.2, des mots « réfection aux composantes structurales ou architecturales d’une construction » par les mots « réparation tel qu’indiqué au paragraphe 2 de l’annexe B »;

7° par la suppression, à l’article 4.4, des mots « permis ni »;

8° par la suppression, à l’article 4.5, du nombre « 4.1, »;

9° par l’abrogation des articles 5.5 à 5.6.2, 5.8.4, 5.10, 5.12 à 6.2, 6.5 à 6.8.1, 6.9 à 6.11 et 6.12.1;

10° par l’abrogation du paragraphe 2° du premier alinéa de l’article 6.12.4;

11° par l’abrogation des articles 6.13, 6.14.4, 6.19 et 6.22 à 6.22.5;

12° par la suppression de l’annexe A;

13° par la suppression, au paragraphe 1 de l'annexe B, des mots « de permis de construction ni »;

14° par la suppression des trois derniers sous-paragraphes du paragraphe 2 de l'annexe B;

15° par la suppression, à l'annexe B, du paragraphe « 3. Travaux de construction ».

11-018, a. 83.

84. Le Règlement de construction no 1884 de la Ville de Saint-Léonard est modifié :

1° par le remplacement du premier alinéa de l'article 1.2.5 par le suivant :

« Pour l'interprétation de ce règlement, à moins que le contexte n'indique un sens différent, tout mot ou expression a le sens et la signification qui lui est attribué au chapitre 7 de ce règlement. Si un mot ou une expression n'y est pas spécifiquement noté à ce chapitre, il s'emploi au sens communément attribué à ce mot ou à cette expression. »;

2° par le remplacement de l'intitulé du chapitre 3 par le suivant :

« DISPOSITIONS RELATIVES À L'OBTENTION D'UN CERTIFICAT D'AUTORISATION »;

3° par le remplacement de l'article 3.1 par le suivant :

« 3.1 CERTIFICAT REQUIS

Les dispositions des articles 3.1.2 à 3.2 exclusivement concernent les certificats requis. »;

4° par la suppression du premier alinéa de l'article 3.1.1;

5° par la suppression, dans l'intitulé de l'article 3.1.3, des mots « PERMIS OU »;

6° par la suppression, au premier alinéa de l'article 3.1.3, des mots « un permis de construction ou »;

7° par la suppression du paragraphe d) du premier alinéa de l'article 3.1.3;

8° par la suppression, dans l'intitulé de l'article 3.2, des mots « UN PERMIS DE CONSTRUCTION OU »;

9° par la suppression, à l'article 3.2, des mots « un permis de construction, »;

10° par la suppression, dans l'intitulé de l'article 3.2.1, des mots « DE PERMIS DE CONSTRUCTION OU »;

11° par la suppression, à l'article 3.2.1, des mots « de permis de construction, »;

12° par la suppression, dans l'intitulé de l'article 3.2.2, des mots « DE PERMIS ET »;

13° par la suppression, à l'article 3.2.2, des mots « de permis de construction, », « le permis de construction ou » et « le permis ou »;

14° par la suppression, dans l'intitulé de l'article 3.2.3, des mots « DE PERMIS ET »;

15° par la suppression, à l'article 3.2.3, des mots « de permis ou » et « de permis de construction ou »;

16° par la suppression des sous-paragraphes i) à v) du paragraphe b) du premier alinéa de l'article 3.2.3;

17° par la suppression, à l'article 3.2.3.1, des mots « de permis ou »;

18° par la suppression, dans l'intitulé de l'article 3.3, des mots « DE PERMIS ET »;

19° par la suppression, à l'article 3.3.1, des mots « de permis ou »;

20° par la suppression, à l'article 3.3.2, des mots « permis ou le », « , selon le cas, » et « de permis ou »;

21° par la suppression, à l'article 3.3.3, des mots « permis ou » et « permis ou de »;

22° par la suppression, dans l'intitulé de l'article 3.4, des mots « D'UN PERMIS ET »;

23° par la suppression, à l'article 3.4, des mots « d'un permis de construction, »;

24° par l'abrogation des paragraphes a) et e) du premier alinéa de l'article 3.4.1;

25° par la suppression, dans l'intitulé de l'article 3.5, des mots « D'UN PERMIS DE CONSTRUCTION ET »;

26° par la suppression, à l'article 3.5, des mots « d'un permis de construction, »;

27° par la suppression, dans l'intitulé de l'article 3.5.1, des mots « DU PERMIS DE CONSTRUCTION ET »;

28° par la suppression, à l'article 3.5.1, des mots « permis ou », « du permis ou » et « permis de construction ou »;

29° par le remplacement du paragraphe b) du premier alinéa de l'article 3.5.1 par le suivant :

« b) les travaux de construction ou d'installation de la piscine ou de l'antenne accessoire ne sont pas terminés dans un délai de deux (2) mois de la date d'émission du certificat; »;

30° à l'article 3.5.1, par la suppression du paragraphe d) du premier alinéa et par l'abrogation du deuxième alinéa;

31° à l'article 3.6.1, par la suppression des mots « d'un permis de construction ou » et « permis et » et par le remplacement des mots « , du règlement de zonage et du Code national du bâtiment » par les mots « et du règlement de zonage »;

32° par l'abrogation des articles 3.6.2 à 3.6.4;

33° par la suppression, dans l'intitulé de l'article 3.8, des mots « DU PERMIS ET »;

34° par la suppression, à l'article 3.8, des mots « d'un permis de construction et »;

35° par la suppression, à l'article 3.9.1, des mots « permis, », « le permis ou » et « du permis de construction ou »;

36° par la suppression des paragraphes d), e), f) et h) du premier alinéa de l'article 3.9.1;

37° par l'abrogation du paragraphe c) du premier alinéa de l'article 3.9.2;

38° par l'abrogation de tous les articles du chapitre 4 à l'exception :

a) de l'article 4.1 qui est remplacé par le suivant :

« Fait partie intégrante de ce règlement le Code national de prévention des incendies du Canada 1990 et ses amendements. Tels amendements entrent en vigueur à la date que le conseil détermine par résolution. »;

b) des articles 4.7 et 4.9;

39° par l'abrogation du deuxième alinéa de l'article 6.5;

40° par l'abrogation de la cédule « A ».

11-018, a. 84.

85. Le Règlement de construction de l'arrondissement d'Anjou (07-011) est abrogé.

11-018, a. 85.

86. Le Règlement sur la construction et la transformation de bâtiments sur le territoire de l'arrondissement de Saint-Laurent (08-004) est abrogé.

11-018, a. 86.

87. Le Règlement de construction pour application sur le territoire de l'arrondissement de Verdun et abrogeant le Règlement de construction 1750 (05-036) est modifié :

1° par l'abrogation des articles 17, 19, 21 à 23, 25, 26 et 27;

2° par le remplacement, à l'article 28, des nombres « 30 » et « 32 » par « 29 » et « 30 »;

3° par la suppression des paragraphes a) et e) du premier alinéa de l'article 29;

4° par l'abrogation des articles 32, 33, 37 à 40 et 42 à 47;

5° par la suppression des paragraphes d), e) et f) du premier alinéa de l'article 48;

6° par l'abrogation des articles 50 à 52, 55 et 58.

11-018, a. 87.

88. Le Règlement de construction no 93-554 de la Ville de Roxboro est modifié :

1° par la suppression, à l'article 12, de la définition des mots « mur coupe-feu ou pare-feu »;

2° par l'abrogation des paragraphes 1° et 4° du premier alinéa de l'article 17;

3° par l'abrogation des articles 18 à 21 et 23;

4° par la suppression, à l'article 27, des mots « et les constructions gonflables »;

5° par l'abrogation des articles 32, 33, 35 et 36;

6° par la suppression, à l’article 38, des mots « composé de matériaux non combustibles »;

7° par l’abrogation des articles 57 à 68.

11-018, a. 88.

89. Le Règlement 1049 concernant la construction de la Ville de Pierrefonds est modifié :

1° par l’abrogation des articles 15 à 17.1;

2° par la suppression des premier et quatrième alinéas de l’article 18;

3° par l’abrogation des articles 19 et 20;

4° par l’abrogation du premier alinéa de l’article 21;

5° par l’abrogation des articles 22 à 23.1, 25 à 27.1, 37 et 44.

11-018, a. 89.

90. Le Règlement sur la construction et la transformation de bâtiments applicable au territoire de l’arrondissement de l’Île-Bizard–Sainte-Geneviève (08-006) est modifié :

1° par l’abrogation des articles 1 à 5, 10 à 40, 42 et 44 à 47;

2° par le remplacement, à l’article 48, de « 41, 42, 43, 44 ou 47 » par « 41 ou 43 »;

3° par l’abrogation des articles 49 et 50;

4° par la suppression, à l’article 52, des paragraphes 1° à 5° du premier alinéa et par le remplacement du paragraphe 6° du premier alinéa par le suivant :

« 6° contrevient à l’une des dispositions de la section I du chapitre III et de la section IV du chapitre IV. ».

11-018, a. 90.

91. Le Règlement de construction no 321 de la Ville de l'Île-Bizard est modifié :

1° par la suppression du deuxième alinéa de l'article 2.3.3.2;

2° au premier alinéa de l'article 2.3.6, par la suppression des paragraphes b) et f) et, au paragraphe c), des mots « composée seulement de matériaux non combustibles, à l'exception des matériaux de revêtement du toit »;

3° par l'abrogation des annexes A-3, A-4 et A-6.

11-018, a. 91.

92. Le Règlement de permis et certificats no 2528 de la Ville de Lachine est modifié :

1° par l'abrogation du chapitre IV, à l'exception des paragraphes f), g) et h) du premier alinéa de l'article 4.1.4;

2° par la suppression, au tableau de l'article 5.1, des lignes concernant les projets relatifs à la « Rénovation d'une construction » et aux « Travaux de plomberie »;

3° par l'abrogation des articles 5.2.3 et 5.2.8;

4° par la suppression du paragraphe 2° du premier alinéa de l'article 7.1;

5° par la suppression, au sous-paragraphe b) du paragraphe 3° du premier alinéa de l'article 7.1, de la ligne « -rénovation d'une construction »;

6° par la suppression du sous-paragraphe e) du paragraphe 3° du premier alinéa de l'article 7.1.

11-018, a. 92.

93. Le Règlement sur les permis et certificats no 1527 de la Ville d'Anjou est modifié :

1° par l'abrogation des articles 5.1 à 5.2.3;

2° par la suppression des paragraphes 1° et 2° du premier alinéa de l'article 5.3;

3° par l'abrogation des articles 5.4 à 5.8;

4° par la suppression, au premier alinéa de l'article 6.1, des mots « ayant subit des dommages lors d'un incendie; »;

5° par l'abrogation, dans l'intitulé de l'article 6.2.2.2.3, des mots « suite à un incendie »;

6° par l'abrogation, à l'article 6.2.2.2.3, des mots « ayant subi des dommages lors d'un incendie ».

11-018, a. 93.

94. Le Règlement concernant les permis et certificats no 1176 de la Ville d'Outremont est modifié :

1° par la suppression, à l'article 2.3, des définitions « Code du bâtiment » et « Escalier de secours »;

2° par l'abrogation des chapitres 5 et 6.

11-018, a. 94.

95. Le Règlement sur les permis et certificats pour l'ensemble du territoire de l'arrondissement de l'Île-Bizard–Sainte-Geneviève (R.C.A., 280011) est modifié :

1° par le remplacement, au premier alinéa de l'article 1, de la définition de « Code » par la suivante :

« « Code » : Tel que définit dans le règlement de construction applicable sur le territoire de l'arrondissement; ».

11-018, a. 95.

96. Le Règlement no 1565 concernant les permis et certificats relatifs au règlement d'urbanisme de la municipalité de la Ville de Montréal-Nord est modifié :

1° par l'abrogation des trois premiers alinéas de l'article 26;

2° par l'abrogation de l'article 36;

3° par la suppression, à l'article 44, des mots « de permis de construire ou », « de permis ou » et « du permis ou »;

4° par la suppression, dans l'intitulé du chapitre 4, des mots « DE CONSTRUIRE OU »;

5° par la suppression des sous-paragraphes A), B), C), H), I) et J) du paragraphe 1) de l'article 46;

6° par l'abrogation de l'article 66;

7° par la suppression, à l'article 72, du nombre « 26 ».

11-018, a. 96.

97. Le Règlement numéro RCA08-08-0003 sur la régie interne des permis et des certificats de l'arrondissement de Saint-Laurent est modifié :

1° par la suppression, dans l'intitulé de l'article 2.6, des mots « DU PERMIS OU »;

2° par la suppression, au premier alinéa de l'article 2.6, des mots « permis de construction ou le »;

3° par l'abrogation du paragraphe 2° du premier alinéa de l'article 2.10;

4° par le remplacement du paragraphe 5° du premier alinéa de l'article 4.1 par les suivants :

« 5° le déplacement d'une construction;

5.1° la démolition d'une construction autre que la démolition d'un bâtiment principal visé par le règlement numéro 03-08-0002;

5.2° la réparation d'une construction; »;

5° par l'abrogation du paragraphe 5° du premier alinéa de l'article 4.2.

11-018, a. 97.

98. Le Règlement des permis et des certificats no 1051 de la Ville de Pierrefonds est modifié :

1° par l'abrogation des articles 23 et 24;

2° par la suppression du paragraphe 5° du premier alinéa de l'article 25;

3° par l'abrogation des articles 26 à 28 et 30 à 35.2;

4° par la suppression des paragraphes 11° et 16° du premier alinéa de l'article 40;

5° par la suppression, au paragraphe 3° du premier alinéa de l'article 42, du mot « , remises »;

6° par la suppression des paragraphes 11° et 13° du premier alinéa de l'article 42;

7° par la suppression des paragraphes 11° et 12° du premier alinéa de l'article 48.

11-018, a. 98.

99. Le Règlement des permis et certificats no 93-558 de la Ville de Roxboro est modifié :

1° par la suppression, à la définition de « maison modèle » au premier alinéa de l'article 13, des mots « Code national du bâtiment du Canada faisant partie intégrante du » et « numéro 93-554 »;

2° par la suppression, dans l'intitulé de l'article 21, des mots « d'un permis de construction et »;

3° par la suppression, au premier alinéa de l'article 21, des mots « le permis de construction ou »;

4° par l'abrogation des articles 29 et 30;

5° par la suppression du paragraphe 4° du premier alinéa de l'article 31;

6° par l'abrogation des articles 32 à 38;

7° par la suppression du paragraphe 2° du premier alinéa de l'article 65.

11-018, a. 99.

ANNEXE A
CODE DE CONSTRUCTION DU QUÉBEC (RLRQ, CHAPITRE B-1.1, R.2) (CHAPITRE I, BÂTIMENT, ET CODE NATIONAL DU BÂTIMENT – CANADA 2010 (MODIFIÉ))

11-018-3, a. 48.

ANNEXE B
NFPA-130 – ÉDITION 2017 « *STANDARD FOR FIXED GUIDEWAY TRANSIT AND PASSENGER RAIL SYSTEMS* »

____
11-018-3, a. 48.

ANNEXE C
HOMOLOGATION « ENERGYSTAR » (CRITÈRES ÉTABLIS PAR RESSOURCES NATURELLES CANADA POUR LA ZONE CLIMATIQUE 2)

____
11-018-3, a. 48.

ANNEXE D
ANSI/GRHC/SPRI VR-1 2011 « *PROCEDURE FOR INVESTIGATING RESISTANCE TO ROOT PENETRATION ON VEGETATIVE ROOFS* »

____
11-018-3, a. 48.

ANNEXE E
ASTM E2397-11 « *STANDARD PRACTICE FOR DETERMINATION OF DEAD LOADS AND LIVE LOADS ASSOCIATED WITH VEGETATIVE (GREEN) ROOF SYSTEMS » ET ASTM E2399-11 « STANDARD TEST METHOD FOR MAXIMUM MEDIA DENSITY FOR DEAD LOAD ANALYSIS OF VEGETATIVE (GREEN) ROOF SYSTEMS* »

____
11-018-3, a. 48.

ANNEXE F
ANSI/SPRI RP-14 « *WIND DESIGN STANDARD FOR VEGETATIVE ROOFING SYSTEMS* »

____
11-018-3, a. 48.

ANNEXE G
ASTM E2398-11 « *STANDARD TEST METHOD FOR WATER CAPTURE AND MEDIA RETENTION OF GEO-COMPOSITE DRAIN LAYERS FOR GREEN ROOF SYSTEMS* »

____
11-018-3, a. 48.

Cette codification du Règlement sur la construction et la transformation de bâtiments (11-018) contient les modifications apportées par les règlements suivants :

- *15-069* *Règlement concernant les appareils et les foyers permettant l'utilisation d'un combustible solide, adopté à l'assemblée du 17 août 2015;*
- *11-018-1* *Règlement modifiant le Règlement sur la construction et la transformation de bâtiments (11-018), adopté à l'assemblée du 21 septembre 2015;*
- *11-018-2* *Règlement modifiant le Règlement sur la construction et la transformation de bâtiments (11-018), adopté à l'assemblée du 19 décembre 2016;*
- *11-018-3* *Règlement modifiant le Règlement sur la construction et la transformation de bâtiments (11-018), adopté à l'assemblée du 16 décembre 2019.*

ANNEXE A

CODE DE CONSTRUCTION DU QUÉBEC (RLRQ, CHAPITRE B-1.1, R.2)
(CHAPITRE I, BÂTIMENT, ET CODE NATIONAL DU BÂTIMENT
– CANADA 2010 (MODIFIÉ))

Ce code peut être consulté sans frais en accédant au site Internet du Conseil national de recherches Canada (CNRC) et en sélectionnant l'onglet intitulé « Publications de Codes Canada », à partir de l'adresse suivante :

https://nrc.canada.ca/fr/

ANNEXE B

NFPA® 130

Standard for Fixed Guideway Transit and Passenger Rail Systems

2017

NFPA®

See ALERT

IMPORTANT NOTICES AND DISCLAIMERS CONCERNING NFPA® STANDARDS

NOTICE AND DISCLAIMER OF LIABILITY CONCERNING THE USE OF NFPA STANDARDS

NFPA® codes, standards, recommended practices, and guides ("NFPA Standards"), of which the document contained herein is one, are developed through a consensus standards development process approved by the American National Standards Institute. This process brings together volunteers representing varied viewpoints and interests to achieve consensus on fire and other safety issues. While the NFPA administers the process and establishes rules to promote fairness in the development of consensus, it does not independently test, evaluate, or verify the accuracy of any information or the soundness of any judgments contained in NFPA Standards.

The NFPA disclaims liability for any personal injury, property, or other damages of any nature whatsoever, whether special, indirect, consequential or compensatory, directly or indirectly resulting from the publication, use of, or reliance on NFPA Standards. The NFPA also makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

In issuing and making NFPA Standards available, the NFPA is not undertaking to render professional or other services for or on behalf of any person or entity. Nor is the NFPA undertaking to perform any duty owed by any person or entity to someone else. Anyone using this document should rely on his or her own independent judgment or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

The NFPA has no power, nor does it undertake, to police or enforce compliance with the contents of NFPA Standards. Nor does the NFPA list, certify, test, or inspect products, designs, or installations for compliance with this document. Any certification or other statement of compliance with the requirements of this document shall not be attributable to the NFPA and is solely the responsibility of the certifier or maker of the statement.

See ALERT

ALERT: THIS STANDARD HAS BEEN MODIFIED BY A TIA OR ERRATA

Users of NFPA codes, standards, recommended practices, and guides ("NFPA Standards") should be aware that NFPA Standards may be amended from time to time through the issuance of a Tentative Interim Amendment (TIA) or corrected by Errata. An official NFPA Standard at any point in time consists of the current edition of the document together with any TIAs and Errata then in effect.

To determine whether an NFPA Standard has been amended through the issuance of TIAs or corrected by Errata, go to www.nfpa.org/docinfo to choose from the list of NFPA Standards or use the search feature to select the NFPA Standard number (e.g., NFPA 13). The document information page provides up-to-date document-specific information as well as postings of all existing TIAs and Errata. It also includes the option to register for an "Alert" feature to receive an automatic email notification when new updates and other information are posted regarding the document.

ISBN: 978-145591396-1 (PDF)

IMPORTANT NOTICES AND DISCLAIMERS CONCERNING NFPA® STANDARDS

ADDITIONAL NOTICES AND DISCLAIMERS

Updating of NFPA Standards

Users of NFPA codes, standards, recommended practices, and guides ("NFPA Standards") should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of Tentative Interim Amendments or corrected by Errata. An official NFPA Standard at any point in time consists of the current edition of the document together with any Tentative Interim Amendments and any Errata then in effect. In order to determine whether a given document is the current edition and whether it has been amended through the issuance of Tentative Interim Amendments or corrected through the issuance of Errata, consult appropriate NFPA publications such as the National Fire Codes® Subscription Service, visit the NFPA website at www.nfpa.org, or contact the NFPA at the address listed below.

Interpretations of NFPA Standards

A statement, written or oral, that is not processed in accordance with Section 6 of the Regulations Governing the Development of NFPA Standards shall not be considered the official position of NFPA or any of its Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

Patents

The NFPA does not take any position with respect to the validity of any patent rights referenced in, related to, or asserted in connection with an NFPA Standard. The users of NFPA Standards bear the sole responsibility for determining the validity of any such patent rights, as well as the risk of infringement of such rights, and the NFPA disclaims liability for the infringement of any patent resulting from the use of or reliance on NFPA Standards.

NFPA adheres to the policy of the American National Standards Institute (ANSI) regarding the inclusion of patents in American National Standards ("the ANSI Patent Policy"), and hereby gives the following notice pursuant to that policy:

NOTICE: The user's attention is called to the possibility that compliance with an NFPA Standard may require use of an invention covered by patent rights. NFPA takes no position as to the validity of any such patent rights or as to whether such patent rights constitute or include essential patent claims under the ANSI Patent Policy. If, in connection with the ANSI Patent Policy, a patent holder has filed a statement of willingness to grant licenses under these rights on reasonable and nondiscriminatory terms and conditions to applicants desiring to obtain such a license, copies of such filed statements can be obtained, on request, from NFPA. For further information, contact the NFPA at the address listed below.

Law and Regulations

Users of NFPA Standards should consult applicable federal, state, and local laws and regulations. NFPA does not, by the publication of its codes, standards, recommended practices, and guides, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

NFPA Standards are copyrighted. They are made available for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of safe practices and methods. By making these documents available for use and adoption by public authorities and private users, the NFPA does not waive any rights in copyright to these documents.

Use of NFPA Standards for regulatory purposes should be accomplished through adoption by reference. The term "adoption by reference" means the citing of title, edition, and publishing information only. Any deletions, additions, and changes desired by the adopting authority should be noted separately in the adopting instrument. In order to assist NFPA in following the uses made of its documents, adopting authorities are requested to notify the NFPA (Attention: Secretary, Standards Council) in writing of such use. For technical assistance and questions concerning adoption of NFPA Standards, contact NFPA at the address below.

For Further Information

All questions or other communications relating to NFPA Standards and all requests for information on NFPA procedures governing its codes and standards development process, including information on the procedures for requesting Formal Interpretations, for proposing Tentative Interim Amendments, and for proposing revisions to NFPA standards during regular revision cycles, should be sent to NFPA headquarters, addressed to the attention of the Secretary, Standards Council, NFPA, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101; email: stds_admin@nfpa.org.

For more information about NFPA, visit the NFPA website at www.nfpa.org. All NFPA codes and standards can be viewed at no cost at www.nfpa.org/docinfo.

NFPA® 130

Standard for

Fixed Guideway Transit and Passenger Rail Systems

2017 Edition

This edition of NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems,* was prepared by the Technical Committee on Fixed Guideway Transit and Passenger Rail Systems. It was issued by the Standards Council on May 13, 2016, with an effective date of June 2, 2016, and supersedes all previous editions.

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

This edition of NFPA 130 was approved as an American National Standard on June 2, 2016.

Origin and Development of NFPA 130

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

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

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

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

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

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

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

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

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

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

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

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

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

Technical Committee on Fixed Guideway Transit and Passenger Rail Systems

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

Jarrod Alston, Arup, MA [SE]

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

Mark Chan, Bay Area Rapid Transit District (BART), CA [U]

John F. Devlin, Aon Fire Protection Engineering Corporation, MD [I]

Katherine Fagerlund, JENSEN HUGHES/Sereca, Canada [SE]

Charles J. Giblin III, Maryland State Fire Marshal's Office, MD [E]
Rep. International Fire Marshals Association

William P. Grizard, American Public Transportation Association, DC [U]

Kevin P. Harrison, Fire Department City of New York, NY [E]

Bernard J. Kennedy, IV, U.S. Department of Transportation, MA [RT]
Rep. U.S. Department of Transportation

Thomas P. Kenny, New York City Transit Authority, NY [U]
Rep. Metropolitan Transportation Authority

William E. Koffel, Koffel Associates, Inc., MD [M]
Rep. Automatic Fire Alarm Association, Inc.

Joseph F. Krempasky, Washington Metropolitan Area Transit Authority, DC [U]

Pierre Laurin, Toronto Transit Commission, Canada [U]

Kevin M. Lewis, Bombardier Transportation, PA [M]

Silas K. Li, Parsons Brinckerhoff, Inc., NY [SE]

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

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

Luc Martineau, Societe de Transport de Montreal (STM), Canada [U]

Daniel M. McKinney, AECOM Transportation, CA [SE]

John Nelsen, Seattle Fire Department, WA [E]

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

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

Julian Sandu, Chicago Transit Authority, IL [U]

Michael J. Thomas, Los Angeles City Fire Department, CA [E]

Robert C. Till, John Jay College of Criminal Justice, NJ [SE]

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

Steven C. White, MTA-Long Island Rail Road, NY [E]
Rep. Metropolitan Transportation Authority

John Powell White, IFT/Fire Cause Analysis, CA [SE]

Stephen B. Wilchek, National Railroad Passenger Corporation (Amtrak), NY [U]

Alternates

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

Michel Champagne, Societe De Transport De Montreal (STM), Canada [U]
(Alt. to Luc Martineau)

Ervin Cui, Aon Fire Protection Engineering Corporation, IL [I]
(Alt. to John F. Devlin)

Bruce Dandie, RRT PTY LTD, Australia [SE]
(Alt. to Robert C. Till)

Gary L. English, Seattle Fire Department, WA [E]
(Alt. to John Nelsen)

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

Michael J. Ferreira, JENSEN HUGHES, MD [SE]
(Alt. to Katherine Fagerlund)

Daniel P. Finnegan, Siemens Industry, Inc., IL [M]
(Alt. to William E. Koffel)

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

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

Ritch D. Hollingsworth, LTK Engineering Services, PA [SE]
(Alt. to Steven W. Roman)

Donald Iannuzzi, New York City Transit Authority, NY [U]
(Alt. to Thomas P. Kenny)

Scott W. McAleese, Chicago Transit Authority, IL [U]
(Alt. to Julian Sandu)

Neil E. Nott, Washington Metropolitan Area Transit Authority (WMATA), VA [U]
(Alt. to Joseph F. Krempasky)

James R. Quiter, Arup, CA [SE]
(Alt. to Jarrod Alston)

Susan Reed Tanaka, Toronto Transit Commission, Canada [U]
(Alt. to Pierre Laurin)

William R. Segar, Bombardier Transportation, PA [M]
(Alt. to Kevin M. Lewis)

Dilip S. Shah, AECOM Technical Services, Inc., CA [SE]
(Alt. to Daniel M. McKinney)

Joseph P. Streany, Metro North Railroad, NY [E]
(Alt. to Steven C. White)

Don Tangarone, National Railroad Passenger Corporation (Amtrak), PA [U]
(Alt. to Stephen B. Wilchek)

Anthony Tedesco, Fire Department City of New York, NY [E]
(Alt. to Kevin P. Harrison)

Joshua Teo, Bay Area Rapid Transit District (BART), CA [U]
(Alt. to Mark Chan)

Nonvoting

Arnold Dix, School Medicine, UWS, Australia [SE]

Frank J. Cihak, FJC Transit Consultants, VA [SE]
(Member Emeritus)

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

Edward K. Farrelly, E. Farrelly & Associates, NJ
(Member Emeritus)

Chad Duffy, 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 pertaining to fire safety requirements for underground, surface, and elevated fixed guideway transit and passenger rail systems including stations, trainways, emergency ventilation systems, vehicles, emergency procedures, communications and control systems and for life safety from fire and fire protection in stations, trainways, and vehicles. Stations shall pertain to stations accommodating occupants of the fixed guideway transit and passenger rail systems and incidental occupancies in the stations.

Contents

NFPA 130

Standard for

Fixed Guideway Transit and Passenger Rail Systems

2017 Edition

IMPORTANT NOTE: This NFPA document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading "Important Notices and Disclaimers Concerning NFPA Standards." They can also be obtained on request from NFPA or viewed at www.nfpa.org/disclaimers.

UPDATES, ALERTS, AND FUTURE EDITIONS: New editions of NFPA codes, standards, recommended practices, and guides (i.e., NFPA Standards) are released on scheduled revision cycles. This edition may be superseded by a later one, or it may be amended outside of its scheduled revision cycle through the issuance of Tentative Interim Amendments (TIAs). An official NFPA Standard at any point in time consists of the current edition of the document, together with all TIAs and Errata in effect. To verify that this document is the current edition or to determine if it has been amended by TIAs or Errata, please consult the National Fire Codes® Subscription Service or the "List of NFPA Codes & Standards" at www.nfpa.org/docinfo. In addition to TIAs and Errata, the document information pages also include the option to sign up for alerts for individual documents and to be involved in the development of the next edition.

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

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. 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 I. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

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

Chapter 1 Administration

1.1 Scope.

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

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

1.1.3 This standard shall not cover requirements for the following:

(1) Conventional freight systems
(2) Buses and trolley coaches
(3) Circus trains
(4) Tourist, scenic, historic, or excursion operations
(5) Any other system of transportation not included in the definition of *fixed guideway transit system (see 3.3.63.1)* or *passenger rail system (see 3.3.63.2)*
(6)* Shelter stops

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

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

1.3 Application.

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

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

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

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

1.4* Equivalency. Nothing in this standard is intended to prevent or discourage the use of new methods, materials, or devices, provided that sufficient technical data are submitted to the authority having jurisdiction to demonstrate that the new method, material, or device is equivalent to or superior to the requirements of this standard with respect to fire performance and life safety.

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

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

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

1.5 Units and Formulas.

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

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

Chapter 2 Referenced Publications

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

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

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

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 2016 edition.

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems,* 2016 edition.

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

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems,* 2017 edition.

NFPA 70® , *National Electrical Code®,* 2017 edition.

NFPA 72® , *National Fire Alarm and Signaling Code,* 2016 edition.

NFPA 91, *Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Particulate Solids,* 2015 edition.

NFPA *101®* , *Life Safety Code®,* 2015 edition.

NFPA 110, *Standard for Emergency and Standby Power Systems,* 2016 edition.

NFPA 220, *Standard on Types of Building Construction,* 2015 edition.

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

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source,* 2015 edition.

NFPA 262, *Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces,* 2015 edition.

NFPA 275, *Standard Method of Fire Tests for the Evaluation of Thermal Barriers,* 2013 edition.

NFPA 286, *Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth,* 2015 edition.

NFPA 703, *Standard for Fire Retardant–Treated Wood and Fire-Retardant Coatings for Building Materials,* 2015 edition.

2.3 Other Publications.

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

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

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

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

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

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

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

ASHRAE Handbook — Fundamentals, 2013.

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

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

ASTM C1166, *Standard Test Method for Flame Propagation of Dense and Cellular Elastometric Gaskets and Accessories,* 2006 (2011).

ASTM D2724, *Standard Test Methods for Bonded, Fused, and Laminated Apparel Fabrics*, 2007 (2015).

ASTM D3574, *Standard Test Methods for Flexible Cellular Materials — Slab, Bonded, and Molded Urethane Foams*, 2011.

ASTM D3675, *Standard Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source*, 2014.

ASTM D7568, *Standard Specification for Polyethylene-Based Structural-Grade Plastic Lumber for Outdoor Applications*, 2013.

ASTM E84, *Standard Test Method for Surface Burning Characteristics of Building Materials*, 2015a.

ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 2015.

ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C*, 2012.

ASTM E162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*, 2015a.

ASTM E648, *Standard Test Method for Critical Radiant Flux of Floor-Covering Systems Using a Radiant Heat Energy Source*, 2015.

ASTM E662, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*, 2015.

ASTM E814, *Standard Test Method for Fire Tests of Through-Penetration Fire Stops*, 2013a.

ASTM E1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 2015a.

ASTM E1537, *Standard Test Method for Fire Testing of Upholstered Furniture*, 2013.

ASTM E1590, *Standard Test Method for Fire Testing of Mattresses*, 2013.

ASTM E2061, *Standard Guide for Fire Hazard Assessment of Rail Transportation Vehicles*, 2012.

ASTM E2652, *Standard Test Method for Behavior of Materials in a Tube Furnace with a Cone-Shaped Airflow Stabilizer, at 750°C*, 2012.

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

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

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

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

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

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

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

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

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

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

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

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

IEEE 1202, *Flame Testing of Cables for use in Cable Tray*, 2012.

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

ANSI/UL 44, *Standard for Safety Thermoset-Insulated Wires and Cables*, 2014.

ANSI/UL 83, *Standard for Safety Thermoplastic-Insulated Wires and Cables*, 2014.

ANSI/UL 263, *Standard for Fire Tests of Building Construction and Materials,* 2014.

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

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

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

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

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

2.3.11 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

NFPA 72® , *National Fire Alarm and Signaling Code,* 2016 edition.

NFPA 92, *Standard for Smoke Control Systems,* 2015 edition.

NFPA *101®* , *Life Safety Code®,* 2015 edition.

NFPA 253, *Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source,* 2015 edition.

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

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

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

NFPA 502, *Standard for Road Tunnels, Bridges, and Other Limited Access Highways,* 2017 edition.

NFPA 921, *Guide for Fire and Explosion Investigations,* 2014 edition.

NFPA 1994, *Standard on Protective Ensembles for First Responders to CBRN Terrorism Incidents,* 2012 edition.

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

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

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

3.2.5 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

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

3.3.2 Ancillary Area/Ancillary Space. The nonpublic areas or spaces of the stations usually used to house or contain operating, maintenance, or support equipment and functions.

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

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

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

3.3.6 Certified. A system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of this standard, authorizes the manufacturer to use a label on listed products that comply with the requirements of this standard, and establishes a follow-up program conducted by the certification organization as a check on the methods the manufacturer uses to determine continued compliance with the requirements of this standard. [**1994,** 2012]

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

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

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

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

3.3.11 Critical Radiant Flux. The level of incident radiant heat energy in units of W/cm^2 on a floor covering system at the most distant flameout point. [**253,** 2015]

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 Decibel. The logarithmic units associated with sound pressure level.

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

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

3.3.14 Emergency Communications System. A system for the protection of life by indicating the existence of an emergency situation and communicating information necessary to facilitate an appropriate response and action. [**72,** 2016]

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

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

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

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

3.3.18 Fire Command Center. The principal attended or unattended room or area where the status of the detection, alarm communications, control systems, and other emergency systems is displayed and from which the system(s) can be manually controlled. [**72,** 2016]

3.3.19 Fire Emergency. The existence of, or threat of, fire or the development of smoke or fumes, or any combination thereof, that demands immediate action to mitigate the condition or situation. [**502,** 2017]

3.3.20 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.

3.3.21 Fire Load.

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

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

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

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

3.3.24 Fire Soot Release Rate. Rate of soot release for a given fire scenario expressed as a function of time (g/s or lbs/s).

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

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

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

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

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

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

3.3.31* Heat Release Rate (HRR). The rate at which heat energy is generated by burning. [**921,** 2014]

3.3.31.1 ***Average Heat Release Rate (HRR_{180}).*** The average heat release rate per unit area, over the time period starting at time to ignition and ending 180 seconds later, as measured in ASTM E1354 (kW/m^2).

3.3.31.2* ***Fire Heat Release Rate.*** Rate of energy release for a given fire scenario or fire test, expressed as a function of time.

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

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

3.3.34 Noncombustible (Material). See Section 4.6.

3.3.35 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.

3.3.36 Occupancy.

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

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

3.3.37 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.

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

3.3.39 Passenger Load.

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

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

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

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

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

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

3.3.43 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 E162.

3.3.44 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.

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

3.3.46 Smoke. The airborne solid and liquid particulates and gases evolved when a material undergoes pyrolysis or combustion, together with the quantity of air that is entrained or otherwise mixed into the mass. [**92,** 2015]

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

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

3.3.49 Soot. Black particles of carbon produced in a flame. [**921,** 2014]

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

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

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

3.3.53 Specific Optical Density (D_s). The optical density, as measured in ASTM E662, over unit path length within a chamber of unit volume, produced from a specimen of unit surface area, that is irradiated by a heat flux of 2.5 W/cm^2 for a specified period of time.

3.3.54* Speech Interference Level (SIL). A calculated quantity providing a guide to the interfering effect of noise on speech intelligibility; measured in decibels.

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

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

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

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

3.3.57 System. See 3.3.62.1, Fixed Guideway Transit System, or 3.3.62.2, Passenger Rail System.

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

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

3.3.60 Track.

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

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

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

3.3.62 Transportation Systems.

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

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

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

3.3.63 Vehicle.

3.3.63.1 *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.

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

Chapter 4 General

4.1 Fire Safety of Systems.

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

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

4.2 Goals.

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

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

4.2.2 This standard is prepared with the intent of providing minimum requirements for those instances where noncombustible materials (as defined in Section 4.6) are not used due to other consideration in the design and construction of the system elements.

4.3 Objectives.

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

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

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

4.4 Fire Scenarios.

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

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

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

4.6* Noncombustible Material.

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

(1) A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors, when subjected to fire or heat. [***101:*** 4.6.13.1(1)]
(2) A material that is reported as passing ASTM E136. [***101:*** 4.6.13.1(2)]
(3) A material that is reported as complying with the pass/fail criteria of ASTM E136 when tested in accordance with the test method and procedure in ASTM E2652. [***101:*** 4.6.13.1(3)]

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

Chapter 5 Stations

5.1 General.

5.1.1 Applicability.

5.1.1.1 This chapter shall apply to all portions of stations.

5.1.2* Relationship to Local Codes.

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

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

5.1.3 Use and Occupancy.

5.1.3.1 The primary purpose of a station shall be for the use of the passengers who normally stay in a station structure for a period of time no longer than that necessary to wait for and enter a departing passenger-carrying vehicle or to exit the station after arriving on an incoming passenger-carrying vehicle.

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

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

5.2 Construction.

5.2.1 Safeguards During Construction.

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

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

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

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

5.2.2 Construction Type.

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

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

5.2.3 Flammable and Combustible Liquids Intrusion.

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

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

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

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

5.2.4 Compartmentation.

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

(1)* Stairs and escalators used by passengers shall not be required to be fire-separated.
(2) Public areas on different levels in open stations shall be permitted to be interconnected.

(3) Public areas on different levels in enclosed stations shall be permitted to be interconnected, provided fire separation is not required for smoke control or other fire protection purposes.

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

5.2.4.3 Ancillary Spaces. Fire resistance ratings of separations between ancillary occupancies shall be established as required by NFPA *101* and in accordance with ASTM E119 and ANSI/UL 263.

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

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

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

5.2.5 Interior Finish.

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

(1) The materials shall be noncombustible in accordance with Section 4.6.
(2) The materials shall comply with the following requirements when tested in accordance with NFPA 286:
    (a) Flames shall not spread to the ceiling during the 40 kW (135 kBtu/hr) exposure.
    (b) Flames shall not spread to the outer extremities of the sample on any wall or ceiling.
    (c) Flashover, as described in NFPA 286, shall not occur.
    (d) The peak heat release rate shall not exceed 800 kW (2730 kBtu/hr).
    (e) The total smoke released throughout the test shall not exceed 1000 m^2 (10,764 ft^2).
(3) The materials shall comply with a flame spread index not exceeding 25 and a smoke development index not exceeding 450 when tested in accordance with ASTM E84, except that the materials in 5.2.5.1(4) shall be required to be tested in accordance with NFPA 286.
(4) The following materials shall not be permitted to be used as interior wall and ceiling materials, unless they meet the requirements in 5.2.5.1(2) when tested in accordance with NFPA 286:
    (a) Foam plastic insulation, whether exposed or covered by a textile or vinyl facing
    (b) Textile wall or ceiling coverings
    (c) Polypropylene
    (d) High-density polyethylene.

5.2.5.2 Materials used as interior floor finish materials in enclosed stations shall be noncombustible or shall exhibit a critical radiant flux not less than 0.8 W/cm^2 (0.7 $Btu/ft^2 \cdot sec$) when tested in accordance with ASTM E648.

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

5.2.6 Exposed Insulation.

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

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

5.2.7 Combustible Furnishings and Contents.

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

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

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

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

5.2.7.4 Lockers shall be constructed of noncombustible materials.

5.3* Means of Egress.

5.3.1* General.

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

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

5.3.2 Occupant Load.

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

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

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

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

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

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

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

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

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

5.3.3* Capacity and Location of Means of Egress.

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

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

5.3.3.3* For stations where the concourse is protected from exposure to the effects of a fire at the platform by distance, geometry, fire separation, an emergency ventilation system designed in accordance with Chapter 7, or as determined by an appropriate engineering analysis, that concourse shall be permitted to be defined as a point of safety.

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

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

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

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

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

5.3.4* Platforms, Corridors, and Ramps.

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

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

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

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

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

5.3.5 Stairs and Escalators.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5.3.6 Elevators.

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

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

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

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

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

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

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

5.3.7* Doors, Gates, and Exit Hatches.

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

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

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

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

5.3.8 Fare Barriers.

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

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

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

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

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

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

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

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

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

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

5.3.10* Platform Edge Provisions.

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

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

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

5.3.11 Means of Egress Lighting.

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

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

5.3.11.3 In addition to the requirements of 5.3.11.1 and 5.3.11.2:

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

5.4 Fire Protection.

5.4.1* Fire Command Center.

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

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

5.4.2 Protective Signaling Systems.

5.4.2.1 Enclosed stations shall be protected by a fire alarm system designed, installed, and maintained in accordance with *NFPA 72* .

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

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

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

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

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

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

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

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

5.4.4 Automatic Fire Suppression Systems.

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

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

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

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

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

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

5.4.5 Standpipe and Hose Systems.

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

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

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

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

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

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

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

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

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

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

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

5.4.7 Ventilation.

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

5.4.8 Emergency Power.

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

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

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

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

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

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

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

Chapter 6 Trainways

6.1 General.

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

6.1.2 Occupancy.

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

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

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

6.2 Construction.

6.2.1 Safeguards During Construction.

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

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

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

6.2.1.4 Reducers or adapters shall meet the following criteria:

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

6.2.1.5 Risers shall meet the following criteria:

(1) Be identified with signs as outlined in 6.4.5.7
(2) Be readily accessible for fire department use
(3) Be protected from accidental damage

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

6.2.2 Construction Type.

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

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

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

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

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

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

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

6.2.3 Flammable and Combustible Liquids Intrusion.

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

6.2.4* Compartmentation.

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

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

6.2.5 Combustible Components.

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

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

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

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

6.2.6 Walking Surfaces.

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

6.2.7 Coverboard or Protective Material.

6.2.7.1 Coverboard or protective material shall comply with 6.2.7.2 or 6.2.7.3.

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

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

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

6.2.8 Rail Ties.

6.2.8.1 Rail ties used in enclosed locations shall be noncombustible materials in accordance with Section 4.7.

6.2.8.2 Rail ties used outdoors at switch or crossover locations shall be made of materials that comply with one of the following:

(1) Materials that comply with 6.2.8.1
(2) Fire retardant–treated wood in accordance with NFPA 703
(3) Pressure-treated wood materials that exhibit a flame spread index of not more than 75 when tested in accordance with ASTM E84
(4) Plastic composite materials that comply with the requirements of ASTM D7568 and exhibit a flame spread index of not more than 75 in accordance with ASTM E84
(5) Wood encased in concrete such that only the top surface is exposed

6.2.8.3 Rail ties used outdoors at locations other than switch or crossover locations shall comply with one of the following:

(1) Materials that comply with 6.2.8.1 or 6.2.8.2
(2) Pressure treated wood materials
(3) Plastic composite materials that comply with the requirements of ASTM D7568

6.2.9 Green Track.

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

6.2.9.2 The design of green track shall be based upon a fire hazard analysis of environmental factors.

6.3 Emergency Egress.

6.3.1 Location of Egress Routes.

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

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

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

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

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

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

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

6.3.1.7 Determination of exit and cross-passageways spacing shall be determined from the ends of contiguous tunnels. See 7.1.2.1.

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

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

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

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

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

6.3.2 Size of Egress Routes.

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

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

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

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

6.3.3* Egress Components.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

6.3.4 Traction Power Protection.

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

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

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

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

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

6.3.5 Signage, Illumination, and Emergency Lighting.

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

6.3.5.2 System egress points shall be illuminated.

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

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

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

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

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

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

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

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

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

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

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

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

6.4 Fire Protection and Life Safety Systems.

6.4.1 Emergency Access.

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

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

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

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

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

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

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

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

6.4.2 Blue Light Stations.

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

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

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

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

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

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

6.4.4 Automatic Fire Detection.

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

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

6.4.5 Standpipe and Hose Systems.

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

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

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

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

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

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

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

6.4.5.6 Acceptable water supplies shall include the following:

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

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

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

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

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

6.4.6 Portable Fire Extinguishers.

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

6.4.7 Ventilation.

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

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

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

6.4.8 Emergency Power.

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

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

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

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

Chapter 7 Emergency Ventilation System

7.1 General.

7.1.1* This chapter defines the requirements for the environmental conditions and the mechanical and nonmechanical ventilation systems used to meet those requirements for a fire emergency in a system station, trainway, or both as required by 5.4.7 and 6.4.7.

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

7.1.2.1* For length determination, all contiguous enclosed trainway and 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 station
(2) In an underground or enclosed trainway that is greater in length than 1000 ft (305 m)

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

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

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

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

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

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

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

7.2 Design.

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

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

7.2.1.1 Where the airflow rates required to accomplish 7.2.1(1), 7.2.1(2), or approved alternative performance criteria are dependent upon the unimpaired function of the air distribution system, that system shall be designed to continue operation when exposed to the conditions generated during the design incident for the duration determined as per 7.2.1(5).

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

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

7.2.3 The design shall encompass the following:

(1)* Fire scenarios and fire profiles
(2) Station and trainway geometries
(3) The effects of elevation, elevation differences, ambient temperature differences, and ambient wind
(4) A system of fans, shafts, and devices for directing airflow in stations and trainways
(5) A program of predetermined emergency response procedures capable of initiating prompt response from the operations control center 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

7.2.4 Criteria for the system reliability analysis in 7.2.3(6) shall be established and approved.

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

(1) Fire in trainway or station
(2) Local incident within the electrical utility that interrupts power to the emergency ventilation system
(3) Derailment
(4) The loss of a fan that results in the most adverse effect on the ventilation system performance

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

7.2.6* Time of Tenability.

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

7.2.6.2 For stations, the time shall be greater than the calculated egress time used to establish egress capacity in 5.3.3.

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

7.3 Emergency Ventilation Fans.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

7.4 Airflow Control Devices.

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

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

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

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

7.5 Testing.

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

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

7.6 Shafts.

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

7.6.2 If the configuration required by 7.6.1 is not possible, surface openings shall be protected by other means to prevent smoke from re-entering the system.

7.6.3 Adjacent structures and property uses also shall be considered.

7.7 Emergency Ventilation System.

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

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

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

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

7.8 Power Supply for Emergency Ventilation Systems.

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

7.8.1.1 Alternatively, the design of the power for the emergency ventilation system shall be permitted to be based upon the results of the electrical reliability analysis according to 7.2.3(6), as approved.

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

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

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

Chapter 8 Vehicles

8.1 Applicability.

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

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

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

8.3 Equipment Arrangement.

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

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

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

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

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

8.4 Flammability and Smoke Emission.

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

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

8.4.1.2 The ASTM E662 maximum test limits for smoke emission (specific optical density) shall be based on both the flaming and the nonflaming modes.

8.4.1.3* Testing of a complete seat assembly (including cushions, fabric layers, and upholstery) according to ASTM E1537 using the pass/fail criteria of California Technical Bulletin 133 and testing of a complete mattress assembly (including foam and ticking) according to ASTM E1590 using the pass/fail criteria of California Technical Bulletin 129 shall be permitted in lieu of the test methods prescribed herein, provided the assembly component units remain unchanged or new (replacement) assembly components possess fire performance properties equivalent to those of the original components tested.

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

8.4.1.3.2 The requirements of 8.4.1.5 through 8.4.1.8 shall be met.

8.4.1.4 Testing shall be performed without upholstery.

8.4.1.5 The surface flammability and smoke emission characteristics shall be demonstrated to be permanent after dynamic testing according to ASTM D3574, Test I_2 or Test I_3, both using Procedure B, except that the test samples shall be a minimum of 150 mm (6 in.) × 450 mm (18 in.) × the thickness used in end-use configuration, or multiples thereof. If Test I_3 is used, the size of the indentor described in Section 96.2 of ASTM D3574 shall be modified to accommodate the specified test specimen.

8.4.1.6 The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by washing, if appropriate, in accordance with the manufacturer's recommended procedure. If a washing procedure is not provided by the manufacturer, the fabric shall be washed in accordance with ASTM E2061, Annex A1.

8.4.1.7 The surface flammability and smoke emission characteristics shall be demonstrated to be permanent by dry cleaning, if appropriate, according to ASTM D2724.

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

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

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

8.4.1.11 Carpeting used as a wall or ceiling covering shall be tested according to ASTM E162 and ASTM E662 and shall meet the respective criteria of $I_s \leq 35$, D_s (1.5) ≤ 100, and D_s (4.0) ≤ 200. *(See 8.4.1.1 and 8.4.1.2.)*

8.4.1.12 If padding is used in the actual installation, floor covering shall be tested with padding in accordance with NFPA 253 or ASTM E648.

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

8.4.1.14* See Section 8.5.

8.4.1.15* Portions of the vehicle body that separate the major ignition source, energy sources, or sources of fuel load from vehicle interiors shall have fire resistance as determined by a fire hazard analysis acceptable to the authority having jurisdiction that addresses the location and quantity of the materials used, as well as vulnerability of the materials to ignition, flame spread, and smoke generation. These portions shall include equipment-carrying portions of a vehicle's roof and the interior structure separating the levels of a bi-level car but do not include a flooring assembly subject to Section 8.5. In those cases, the use of the ASTM E119 test procedure shall not be required.

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

8.5 Fire Performance.

8.5.1 Assembly Testing.

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

8.5.1.1.1 Test Sample Size and Loading.

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

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

Category	Function of Material	Test Method	Performance Criteria
Cushioning	All individual flexible cushioning materials used in seat cushions, mattresses, mattress pads, armrests, crash pads, and grab rail padding [a–e]	ASTM D3675	$I_s \le 25$
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 175
Fabrics	Seat upholstery, mattress ticking and covers, curtains, draperies, window shades, and woven seat cushion suspensions[a–c, f–h]	14 CFR 25, Appendix F, Part I (vertical test)	Flame time ≤ 10 sec Burn length ≤ 6 in.
		ASTM E662	D_s (4.0) ≤ 200
Other vehicle components	Seat and mattress frames, wall and ceiling lining and panels, seat and toilet shrouds, toilet seats, trays and other tables, partitions, shelves, opaque windscreens, combustible signage, end caps, roof housings, articulation bellows, exterior shells, nonmetallic skirts, battery case material, and component boxes and covers[a,b,i–k]	ASTM E162	$I_s \le 35$
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Thermal and acoustical insulation[a,b]	ASTM E162	$I_s \le 25$
		ASTM E662	D_s (4.0) ≤ 100
	HVAC ducting[a,b]	ASTM E162	$I_s \le 25$
		ASTM E662	D_s (4.0) ≤ 100
	Floor covering[b,k,l]	ASTM E648	CRF ≥ 5 kW/m^2
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Light diffusers, windows, and transparent plastic windscreens[b,i]	ASTM E162	$I_s \le 100$
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
	Adhesives and sealants[a,b]	ASTM E162	$I_s \le 35$
		ASTM E662	D_s (1.5) ≤ 100D_s (4.0) ≤ 200
Elastomers[a,b,i,j]	Window gaskets, door nosings, intercar diaphragms, seat cushion suspension diaphragms, and roof mats	ASTM C1166	Flame propagation ≤ 100 mm (4 in.)
		ASTM E662	D_s (1.5) ≤ 100 D_s (4.0) ≤ 200
Wire and cable	All	See 8.6.7.1.1.1 through 8.6.7.1.3.	See 8.6.7.1.1.1 through 8.6.7.1.3.
Structural components[m]	Flooring,[n] other[o]	ASTM E119	Pass

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

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

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

8.5.1.2 Roof Assembly.

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

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

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

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

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

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

8.5.1.3.1.1 Unexposed side thermocouples shall be installed in accordance with or ASTM E119.

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

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

(A) Penetrations shall be installed in the test assembly in accordance with Section 7 of ASTM E814.

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

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

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

(1)* Twice the maximum expected time period under normal circumstances for a vehicle to stop completely and safely from its maximum operating speed, plus the time necessary to evacuate a full load of passengers from the vehicle under approved conditions
(2)* 15 minutes for automated guideway transit (AGT) vehicles and low floor vehicles, 30 minutes for all other passenger-carrying vehicles
(3) 15 minutes for roof assemblies

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

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

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

8.5.3 Equipment Lockers.

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

8.5.3.2 Penetrations and access panels located between the locker and the passenger and crew areas shall be tested in accordance with ASTM E814 and shall have an F rating of 15 minutes.

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

8.6 Electrical Fire Safety.

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

8.6.2 Clearance and Creepage.

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

8.6.2.2* Air Clearance. The air clearance distances between voltage potentials (up to 2000 V) and ground shall comply with the following formula:
Clearance (mm) = 3.175 + (0.0127 × nominal voltage)
[Clearance (in.) = 0.125 + (0.0005 × nominal voltage)]

8.6.2.3 Creepage Distance.

8.6.2.3.1 Creepage distance for voltage potentials (up to 2000 V) to ground in ordinary enclosed environments shall comply with the following formula:
Creepage (mm) = 3.175 + (0.047625 × nominal voltage)
[Creepage (in.) = 0.125 + (0.001875 × nominal voltage)]

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

8.6.3 Propulsion Motors.

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

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

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

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

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

8.6.3.6 The current value used in determining the minimum size of motor leads shall be no less than 50 percent of the maximum load current seen under the most severe normal duty or as determined by root-mean-square (rms) calculation, whichever is greater.

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

8.6.4 Motor Control.

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

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

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

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

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

8.6.5 Propulsion and Braking System Resistors.

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

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

8.6.5.3 Forced ventilated resistors shall be mounted as follows:

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

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

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

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

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

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

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

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

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

8.6.6 Current Collectors.

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

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

8.6.6.3 For vehicles that have more than one current collector, all current-carrying components shall be sized for continuous operation in the event power collection to the vehicle is restricted to a single collector.

8.6.7 Wiring.

8.6.7.1 Electrical Insulation.

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

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

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

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

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

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

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

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

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

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

8.6.7.3 Cable and Wire Sizes.

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

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

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

8.6.7.4 Wiring Methods.

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

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

8.6.7.4.2 Firestops shall be provided in raceways.

8.6.7.4.3 Wires connected to different sources of energy shall not be cabled together or be run in the same conduit, raceway, tubing, junction box, or cable unless all such wires are insulated for the highest rated voltage in such locations or unless physical separation is provided.

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

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

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

8.6.7.4.6 Splices outside of junction boxes shall be approved.

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

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

8.6.8 Overload Protection.

8.6.8.1 Propulsion Line Breaker.

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

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

8.6.8.2 Main Fuse Protection.

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

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

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

8.6.8.3 Auxiliary Circuits.

8.6.8.3.1 Circuits used for purposes other than propelling the vehicle shall be connected to the main cable at a point between the current collector and the protective device for the traction motors.

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

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

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

(1) Battery charging systems shall be designed to prevent overcharging of the battery.
(2) The battery shall be designed with an emergency cutoff system.
(3) The battery installation area shall be provided with a heat, smoke, or other fire detection system as appropriate for the environment in which it will operate.
(4) The battery installation area shall be separated from the car interior by the use of materials that are noncombustible, in accordance with the requirements of ASTM E136.
(5) The battery installation area shall not use materials with hygroscopic properties.
(6) The battery installation area shall be provided with sufficient diffusion and ventilation of the gases from the battery to prevent the accumulation of an explosive mixture.
(7) Battery casing material shall comply with Table 8.4.1.

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

8.8 Emergency Egress Facilities.

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

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

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

8.8.3 Emergency Lighting.

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

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

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

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

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

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

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

8.8.5.1 Interior.

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

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

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

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

8.9 Protective Devices.

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

8.9.2 Communications.

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

(1) A public address (PA) system whereby the train crew personnel, and, at the option of the authority, the operations control center can make announcements to the passengers
(2) A radio system whereby the train operator can communicate with the operations control center
(3) An intercommunication system whereby the train crew can communicate with one another
(4) At the option of the authority, a device that can be used by passengers to alert the operator of an emergency

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

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

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

8.9.3 Portable Fire Extinguishers.

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

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

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

8.9.4 Lightning Protection.

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

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

8.9.4.2.1 Lightning SPDs shall be properly protected against mechanical injury.

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

8.9.5 Heater Protection.

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

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

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

8.9.6 Testing and Maintenance.

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

(1) IEEE 16
(2) IEEE 11
(3) Any additional tests specified by the authority having jurisdiction

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

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

8.10 Vehicle Support and Guidance System.

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

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

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

8.11 Engineering Analysis Option.

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

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

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

8.11.2* Basis for Engineering Analysis.

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

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

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

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

8.11.5 Sources of Data.

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

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

8.11.6 Maintenance of Design Features.

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

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

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

Chapter 9 Emergency Procedures

9.1 General.

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

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

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

9.2 Emergency Management.

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

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

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

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

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

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

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

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

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

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

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

9.6 Operations Control Center (OCC).

9.6.1 The authority shall operate an OCC for the operation and supervision of the system, designed in accordance with Section 10.2.

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

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

9.7 Liaison.

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

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

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

9.8 Command Post.

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

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

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

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

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

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

9.9* Auxiliary Command Post. When an emergency operation requires an auxiliary command post because of the extent of the operation, the person in command shall establish an auxiliary command post(s) that will function as a subordinate control.

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

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

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

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

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

9.11 Training, Exercises, Drills, and Critiques.

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

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

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

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

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

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

9.13 Removing and Restoring Traction Power.

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

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

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

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

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

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

Chapter 10 Emergency Communications System

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

10.1.1 Emergency communications systems shall be designed, installed, commissioned, inspected, tested, and maintained in accordance with *NFPA 72*, except as modified herein.

10.2 Operations Control Center (OCC).

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

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

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

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

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

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

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

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

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

10.3 Public Safety Radio Enhancement System.

10.3.1 Enclosed stations and trainways shall be provided with a public radio enhancement system.

10.3.2 Radio coverage shall be provided throughout enclosed stations as a percentage of floor area as specified in *NFPA 72* .

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

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

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

10.4* Two-Way Wired Emergency Services Communication Systems.

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

10.4.2 The system shall have a telephone network of fixed telephone lines and handsets capable of communication 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 In addition to those locations identified in *NFPA 72* , two-way wired emergency communications system telephone handsets shall be provided at the following locations:

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

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

10.5* One-Way Emergency Communications Systems.

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

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

11.1 General.

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

11.1.2 Application. These systems include the following:

(1) Train control (signaling systems) as described in 7.2.4, 8.9.2.3, and in this chapter
(2) Emergency communication systems as described in 6.4.2, 8.9.2.1, 8.9.2.2, 9.8.4, and Section 9.9
(3) Traction power systems as described in 6.4.2, 7.2.4, 9.13.4, and 9.13.5
(4) Supervisory control and data acquisition (SCADA) systems as they apply to fire emergencies

11.2 Train Control.

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

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

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

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

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

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

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

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

11.3 Functionality, Reliability, and Availability of Control Systems.

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

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

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

Chapter 12 Wire and Cable Requirements

12.1 General.

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

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

12.2 Flame Spread and Smoke Release.

12.2.1 Wires and cables used in enclosed stations and trainways shall be listed as being resistant to the spread of fire and shall have reduced smoke emissions, by complying with one of the following:

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

12.3 Temperature, Moisture, and Grounding Requirements.

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

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

12.3.2 Ground wires shall comply with the following:

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

12.4 Wiring Installation Methods.

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

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

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

(1) Type MI cable with or without an overall protected nonmetallic covering complying with 12.4.1 and 12.4.2
(2) Type MC cable employing a smooth or corrugated impervious metal sheath or MC cable with an overall nonmetallic covering complying with 12.4.1 and 12.4.2
(3) Conductors in electrical metallic tubing, flexible metallic tubing, intermediate metal conduit, or rigid metal conduit all without an overall nonmetallic covering

12.4.4 The emergency power, emergency lighting, and emergency communications circuits shall be protected from physical damage by system vehicles or other normal system operations and from fires in the system for at least 1 hour, but not less than the time of tenability, when exposed to fire conditions corresponding to the time-temperature curve in the ASTM E119 fire resistance test by any of the following:

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

12.5 Fire-Resistive Cables.

12.5.1 Fire-resistive cables shall be certified or listed as having been tested to the normal (ASTM E119) time-temperature curve in accordance with ANSI/UL 2196.

12.5.2 The cables shall comply with the requirements for no less than a 1-hour fire resistance rating when testedin accordance with ANSI/UL 2196.

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

(1) Be tested as a complete system, in both the vertical and horizontal orientation, of conductors, cables, and raceways, as applicable
(2) For fire-resistive cables intended for installation in a raceway, be tested in the type of raceway in which they are intended to be installed
(3) Have installation instructions that describe the tested assembly, with only the components included in the tested assembly acceptable for installation

Annex A Explanatory Material

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

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

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

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

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

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

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

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

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

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

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

A.3.3.10 Concourse. A concourse is distinct from a platform because it can be more open, and passenger speeds can be different from those prescribed for a platform, platform stair, or escalator.

A.3.3.16 Engineering Analysis. *Engineering analysis* is a broad term that encompasses a range of different objectives and performance criteria. The complexity of the analysis and the factors requiring consideration are situation dependent and require the user to have sufficient understanding of the objectives, assumptions, and analysis tools being implemented.

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

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

A.3.3.16.1 Fire Hazard Analysis. The term *fire hazard analysis* generally refers to analyses that are performed relative to the specific fire performance of materials, components, and assemblies for the purposes of addressing the subsequent contribution to the overall fire hazard and the resulting impact on occupant fire safety. A fire hazard analysis can provide an estimate of the potential severity of fires that can develop under defined fire scenarios. This analysis can encompass consideration of factors that include but are not limited to, quantities of materials, vulnerability of materials and components to ignition, propensity for flame spread, and smoke generation.

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

A.3.3.21.1 Effective Fire Load. The effective fire load can include vehicle(s), luggage, fuel, and wayside facilities or structures, that, because of the fuel package configuration, separation, and combustion characteristics, would be expected to be released in a design fire incident.

A.3.3.21.2 Total Fire Load. The total fire load can include vehicle(s), luggage, fuel, and wayside facilities or structures.

A.3.3.31 Heat Release Rate (HRR). The heat release rate of a fuel is related to its chemistry, physical form, and availability of oxidant and is ordinarily expressed as Btu/sec or kilowatts (kW). [**921,** 2014]

A.3.3.31.2 Fire Heat Release Rate. The rate of energy release can be expressed in absolute terms [in large scale fire tests or in fire modeling, typically in kW (Btu/s)] or in relative terms, per unit area [in small scale fire tests, typically in kW/m^2 (Btu/ft^2)].

A.3.3.54 Speech Interference Level (SIL). Speech interference level (SIL) is one-fourth of the sum of the band sound pressure levels for octave bands with normal midband frequencies of 500, 1000, 2000, and 4000 Hz.

A.3.3.55.2 Open Station. Direct dispersion is passing to atmosphere without ducting, without accumulation in occupied areas, and without entering or passing through another occupied level of the station.

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

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

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

A.4.4.1 The standard was created to address the issue of entrapment and injury of large numbers of people who routinely use fixed guideway transit systems as a result of fire in the system. The document has evolved to now include passenger rail systems. The basis of the document — providing the minimum life safety from fire and fire protection requirements — still stands. It is not intended for the document to provide design basis for non-fire events such as explosions or other random acts of sabotage.

A.4.4.2 The location and size of a fire can greatly affect the degree of hazard to system occupants. Therefore, the system design must consider specific fire scenarios that could occur. Fire location and size are examples of factors that fire scenarios must consider:

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

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

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

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

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

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

A.4.6 The provisions of Section 4.6 do not require inherently noncombustible materials to be tested in order to be classified as noncombustible materials.

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

A.4.7 Fire-life safety systems comprise interdependent mechanical, electrical, communications, control, fire protection, structural, architectural, and other elements, all of which must function as a system to achieve the designed result. It is critical that all primary and supporting elements are protected to a similar level of reliability for the design incident exposure.

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

A.5.2.1.4 See A.6.3.4.3.

A.5.2.4.1(1) This requirement is intended to refer to stairs and escalators used for normal revenue service. Fire-separated exit stairs can also be required in order to satisfy the requirements of 5.3.3.6 for alternate egress or 5.3.5.5 for the proportion of escalators counted as means of egress.

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

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

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

A.5.2.7.1 The fire hazard analysis should determine that the fire does not propagate beyond the component of fire origin and that a level of fire safety is provided within the station commensurate with this standard. Computer modeling, material fire testing, or full-scale fire testing should be conducted, as appropriate, to assess fire performance in potential fire scenarios.

A.5.2.7.2 Rubbish containers that are used in the station on a temporary basis (e.g., during cleaning operations) should be manufactured of noncombustible materials or of materials that comply with a peak heat release rate not exceeding 300 kW/m^2 (26.4 $Btu/ft^2 \cdot sec$) when tested in accordance with ASTM E1354 at an incident heat flux of 50 kW/m^2 (4.4 $Btu/ft^2 \cdot sec$), in the horizontal orientation.

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

A.5.3.1 Where codes other than NFPA *101* are in effect, reference to NFPA *101* can be replaced by reference to relevant requirements in the locally applicable building code.

A.5.3.2.1 In that the peak ridership data are used to determine occupant load (and, consequently, required egress capacity), the basis for those data should be considered carefully.

The term *peak period* is intended to imply the time within the peak hour having the maximum passenger flow rate. For many systems, this period ranges between 10 minutes and 20 minutes in duration. Where peak hour ridership numbers are used, a surge factor should be applied as a distribution curve correction to account for the peak within the hour. Factors of 1.3 to 1.5 are typical for many systems. Other surge factors ranging from 1.15 to 2.75 have been reported.

In new systems, a survey of actual usage should be made within 2 years of completion of the project to verify design predictions. In operating systems, patronage levels should be projected to determine the need for expansion of the system or significant operating changes. Verification by survey should be made following any extension or significant operating change or at a maximum of 5-year intervals.

A.5.3.2.2 Consideration of control of the access to platforms might be necessary so that the station occupant load does not exceed the station egress capacity.

A.5.3.2.3(2) At multilevel, multiline, or multiplatform stations, it can be reasonable to consider only entraining (or entraining plus detraining) loads for nonincident levels for determining required egress capacity at points where egress troutes converge. Nonincident platform loads that do not adversely impact the egress route need not be considered.

A.5.3.2.5 The determination of maximum occupant load at a platform often requires comparison of calculations based on different peak periods. For example, to determine the maximum peak period platform occupant load for stations serving predominantly commuter ridership, the calculations described in 5.3.2.5(1) through 5.3.2.5(7) can be computed based on both the a.m. and the p.m. peak ridership for each platform and then compared to determine the maximum platform occupant load.

A.5.3.2.5(3) It is important that the load/headway capture the potential buildup of passengers that might occur before an emergency event is recognized as requiring evacuation. The determination of the appropriate accumulation factor should reflect system-specific characteristics such as the following:

(1) The type of system (e.g., automated/driverless vs. manually driven)
(2) The amount and type of surveillance
(3) The distance between stations and train headways

For systems with longer headways, a factor of two headways might be adequate to approximate accumulation and response time. For systems with very short headways, a fixed time (e.g., 5 minutes to 10 minutes) might be more appropriate to approximate the potential passenger buildup.

Consideration should also be given to whether the entraining and train loads should be subject to the same accumulation factor.

A.5.3.2.5(4) The nonincident service is not contributing detraining load.

A.5.3.3 The means of egress capacity factors and travel speeds are consistent with observed pedestrian movement within congested areas of passenger stations as represented by level of service E/F in *Pedestrian Planning and Design*, by Fruin. Patronage can vary for different user groups periodically or change over time. Modification could be warranted based on engineering analysis.

A.5.3.3.1 The stipulated time is only intended as a baseline for determining the required capacity and maximum travel distances for platform egress routes. It is not intended that this calculation be required to account for delays due to premovement time or to products of combustion or debris along an egress route or delays due to the movement of those who are unable to achieve self-evacuation.

A.5.3.3.2 See A.5.3.3.1.

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

A.5.3.3.5 The determination of a common path of travel from the ends of a platform should consider the configuration (e.g., width and enclosure) of the platform versus the anticipated exposure to a train on fire at the platform. Where the platform is sufficiently wide to allow passengers to move away from the radiation effects of the train fire, it is reasonable to consider the egress from that platform as not creating a common path of travel.

A.5.3.3.6(1) This requirement is intended to replace the requirement in 7.3.1.1.2 of NFPA *101* , that the loss of one egress route must leave at least 50 percent of the egress capacity available. This approach is in recognition of the following design factors:

(1) Station design inherently requires primary circulation routes to be obvious and readily accessible such that preference for such routes would be anticipated in the event of an emergency evacuation.
(2) Requirements elsewhere in this standard (e.g., emergency ventilation in Chapter 7) require special protection of primary circulation routes from the effects of a train fire in enclosed stations.
(3) In the event of unavailability of one of the primary circulation routes due to another fire condition, the occupant load to be evacuated would be substantially less than that on which the size of the egress routes is determined, that is, the occupant load would not include the train link load.

A.5.3.3.7 Where automated spreadsheet calculations or computer-based software programs are used, the means of egress analysis should include documentation detailing all input parameters and algorithm(s).

A.5.3.4 Ramps are permitted in stations in accordance with NFPA *101* (and other applicable standards), which allows use of ramps with slopes up to 1:12 (8.33 percent).

A.5.3.4.1 The 2003 and previous editions of NFPA 130 required that exit corridors and ramps be a minimum of 1.73 m (5 ft 8 in.) wide. There is no technical basis for the previous minimum. The intent of 5.3.4.1 is to make NFPA 130 consistent with NFPA *101* relative to the minimum 1120 mm (44 in.) corridor width in the means of egress. NFPA 130 addresses means of egress conditions unique to transit/passenger rail facilities such as open platform edges. In NFPA *101* , means of egress facilities are based upon a function of the persons served (units of width/person served). NFPA 130 introduces a unit of time in determining the required egress width. This is necessary to demonstrate compliance with the performance requirements related to platform evacuation time and reaching a point of safety.

Assuming a 1120 mm (44 in.) wide side platform per 5.3.4.1 the effective platform width for egress is as follows:

[A.5.3.4.1a]

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

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

[A.5.3.4.1b]

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

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

[A.5.3.4.1c]

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

It must be recognized that while strict interpretation of 5.3.4.1 indicates a station could be designed using a 1120 mm (44 in.) wide platform with an open edge and sidewall condition, it is impractical to do so, especially when one considers the other requirements of this standard that will affect the platform width, such as the travel distance to the point(s) of egress, the maximum 4-minute platform evacuation time, and the 6-minute point of safety time.

A.5.3.4.4 For ramps, various studies have reported that there were no statistically significant differences or measurable effect on walking speeds due to grades up to 5 or 6 percent, but that there is a gradual linear decline in speed for steeper grades.

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

(1) The width used to calculate the capacity of stopped escalators should be based on the tread width plus the width permitted for intrusion of handrails per NFPA *101* — for a 1000 mm (40 in.) tread width, the width used to determine egress capacity will be 1228 mm (48 in.).
(2) Where escalators having a nominal width of 1000 mm (40 in.) will be dedicated for operation in the direction of exit travel at speeds of at least 30 m/min (98 ft/min), such escalators can be permitted to be counted as having a capacity of 75 p/min. This should be considered appropriate only in conjunction with other provisions of this standard, such as the requirement to discount one escalator at each station level. Such escalators should also be connected to emergency power. This suggested speed is consistent with the maximum speed permitted in ASME A17.1/CSA B44, a bi-national standard. The suggested capacity is consistent with research reported in the *Elevator World* article "Escalator Handling Capacity" and in *Pedestrian Planning and Design*, by Fruin. Other codes regulating transit station design permit escalator capacity to be based on operating capacity (e.g., *Ontario Building Code*, Section 3.13, "Rapid Transit Stations," and London Underground Ltd., *LUL Station Planning Guidelines*, which both permit a capacity of 100 p/min.). Designers are encouraged to research the latest available data. Unpublished research suggests that where the vertical rise exceeds 15 m (50 ft), the capacity and travel speed for stairs should be adjusted downward by approximately 30 percent to account for fatigue. Additionally, the design should provide enlarged landings to allow pedestrians to rest without impeding egress flow.

A.5.3.5.3(2) The vertical component of travel speed is calculated based on the vertical change in elevation between one station level and the next. [See Figure A.5.3.5.3(2).] See also *Application Guidelines for the Egress Element of the Fire Protection Standard for Fixed Guideway Transit Systems* and the example calculations in Annex C.

A.5.3.5.6 Where multiple escalators are provided in the means of egress, the means of egress calculations should consider the potential of more than one escalator on any one level being out of service for repair and therefore impassible.

A.5.3.5.7(1) It is intended that escalators be as noncombustible as possible, with the understanding that certain components such as rollers or headrails might not currently be available in noncombustible materials. The authority having jurisdiction should review each installation proposal for compliance to the greatest extent possible.

A.5.3.5.7(2) The intent is to keep escalators running in the direction of egress in order to provide more efficient evacuation flow. Where escalators are an integral means of egress component in deep stations, the provision of emergency power for the escalators should be considered when supported by risk analysis.

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

A.5.3.6.2(2) Where a station has two elevators or fewer, this requirement should be interpreted as requiring that no elevators are counted as contributing to the available egress capacity.

A.5.3.6.2(3) Elevator capacity can be calculated as described in NIST IR 4730.

A.5.3.6.4(2) See B.4 of NFPA *101* and ASME A17.1/CSA B44 for additional guidance.

A.5.3.6.4(6) The design must also consider and provide for evacuation of other station levels.

A.5.3.6.4(7) Where supported by this analysis, the necessity for emergency recall should be considered.

A.5.3.7 For gates used as fare barriers, refer to 5.3.8. See Chapter 6 for requirements related to platform end gates.

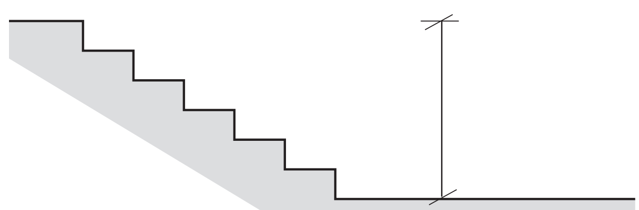


FIGURE A.5.3.5.3(2) Distance Measure for Walk Time Computation.

A.5.3.7.1(2) The stated pedestrian capacity value assumes that the bi-parting doors and gates do not have mullions in the middle of the opening. The edge effect described in 5.3.4.2 need not be subtracted from the clear width. Where mullions are incorporated, the flow value for single-leaf doors should be used.

A.5.3.8.2 "Unimpeded travel in the direction of egress" means that any barriers in the equipment (such as paddles, gates, or turnstiles) either drop away to create a clear opening or swing or revolve freely in the direction of egress with no latching mechanism.

A.5.3.8.4(1) "Clear width" means the clear width between any protrusions with the fare gates open. The stipulated clear widths are appropriate where the length of the equipment console is less than 2500 mm in the egress direction. Where the equipment exceeds 2500 mm length, increased widths are recommended, which should be based on the anthropometric body sway data from NFPA *101*, as follows: Each unit should provide a minimum width of 560 mm (22 in.) clear width at and below a height of 1000 mm (39.5 in.) and 760 mm (30 in.) clear width above that height.

A.5.3.8.6 Refer to A.5.3.8.2.

A.5.3.9 Transit stations are unique in that many are constructed beneath and enveloped by adjacent buildings. The use of horizontal exits for up to 100 percent of the required capacity provided that not more than 50 percent is into a single building addresses conditions in stations that differ from those in NFPA *101*, which envisions a single building subdivision.

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

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

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

A.5.4.2.2 Discrete zone indications are desirable for unmanned stations.

A.5.4.2.6 Separate zones on the annunciator panel to monitor main control valves on standpipe systems should be established.

A.5.4.4.1 Escalators constructed of combustible stairs should be protected with an approved automatic sprinkler or fire suppression system installed in the truss area and designed to control or extinguish a fire.

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

A.5.4.5.4 This requirement is intended to clarify that, with the approval of the local fire department, dry-type systems can be considered in stations regardless of the potential for freezing.

A.5.4.5.4(1) Calculations, including transit and fill times, should be submitted to the authority having jurisdiction to support this requirement.

A.6.1.1 The intent of the standard is to provide a reasonable level of life safety from fire and fire protection to passengers, transit system personnel, authorized visitors, and emergency responders. Generally, protective features such as egress routes in compliance with Chapter 6 are required for these areas, but see 6.4.7.2 for applicable ventilation requirements.

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

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

A.6.1.2.3 Locations requiring such signage may include, entrances to the trainway (e.g., station platforms and portals) and fences or barriers adjacent to the trainway.

A.6.2.1.6 See A.6.3.5.9.

A.6.2.2.1 Most tunnels exposed to prolonged fires are heavily damaged or collapse, resulting in service disruptions, significant structural damage, and most important, loss of lives (Bothe, Wolinski & Breunese 2003, Khoury 2002, and Tatnall 2002). The structural concrete or shotcrete liner can be designed to withstand the fire load up to a certain period of time while accepting some minor repairable damage to the liner. The fire resistance rating of the tunnel liners can be analyzed. Prompt operation of the ventilation system can mitigate damage to the liner.

A.6.2.4 The design of ancillary spaces adjacent to the trainway should be in accordance with the requirements of the local building codes except as specifically described in this standard. This would include requirements for egress from within the spaces and for heating, ventilation, and air-conditioning.

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

A.6.3.1.4 Previous editions of NFPA 130 addressed this requirement by prescribing the maximum travel distance to an exit. The intent of this requirement was often misinterpreted. NFPA *101* requires, at a minimum, that two means of egress be provided within a building or structure and prescribes the maximum travel distance to an exit. This same requirement is applied in NFPA 130. Where two means of egress are required, the maximum travel distance to an exit occurs at the midpoint. For example, in a building with two exits, in the event of a fire adjacent to an exit rendering that exit unavailable, NFPA *101* recognizes that an individual in proximity to the affected exit must travel twice the prescribed exit travel distance to the alternative exit. Since two means of egress are required from any one point in an enclosed trainway, the exits cannot be more than twice the travel distance, or 762 m (2500 ft) apart.

A.6.3.1.6(2) The distance from the station should generally be measured to the end of the station platform. However, the distance can also be measured to an area of relative safety that is beyond the end of the platform, such as an exit stair or, where appropriate and based on evaluation of emergency ventilation airflow, a ventilation inlet.

A.6.3.1.6(7) The hazards to be considered include, but are not limited to, potential contact with live traction power distribution equipment.

A.6.3.2.1 Maintaining a clear space above the walking surface is important to ensure that projections do not encroach into the means of egress. The envelope created by the boundary limits defined by this paragraph is intended to change gradually and symmetrically from point to point. With respect to clearances to the vehicle, the measurements should be to the static vehicle envelope. *(See Figure A.6.3.2.1.)*

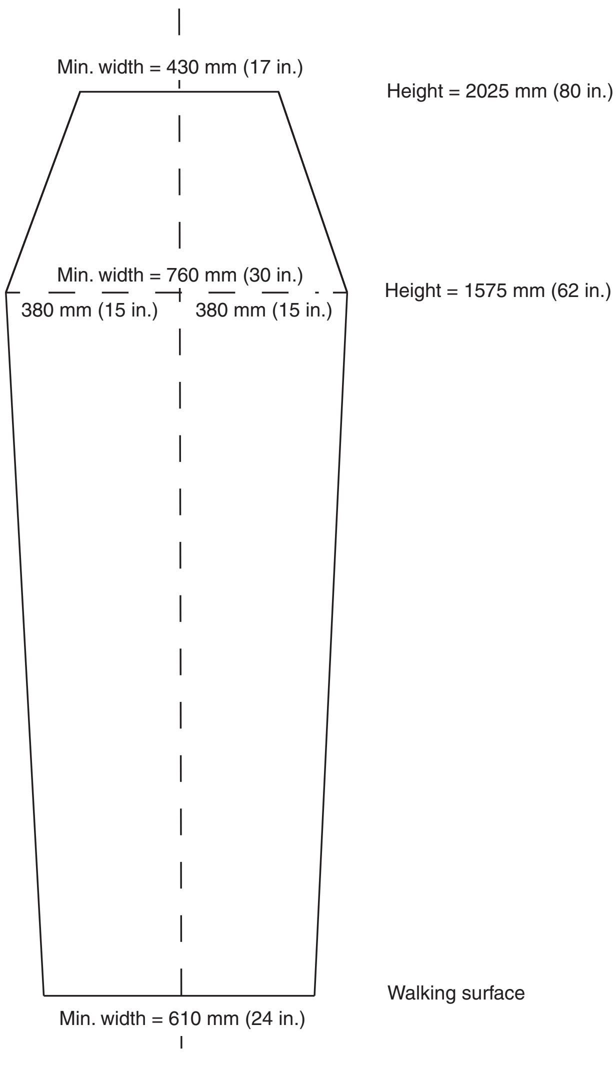


FIGURE A.6.3.2.1 Unobstructed Clear Width for Trainway Walkway.

A.6.3.2.3 With reference to NFPA *101*, Table 7.2.2.2.1.2(B) (where additional width is required for stairs serving an occupant load of 2000 people or more), exit stairs serving trainways are not required to exceed the minimum width, regardless of the occupant load. This is reasonable considering that evacuation flow from a tunnel would be essentially single file, and stairs do not normally converge with other egress routes.

A.6.3.2.4 The stipulated minimum width applies to all means of egress doorways, including those for cross-passages.

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

A.6.3.3.5 It is important that guards be configured so that they do not interfere with either the vehicle dynamic envelope or with egress from the train onto the walkway. For that reason, guards are not required on the trainway side of walkways, provided that the bottom of the trainway is closed by deck or grating so that persons could not fall through the bottom of the guideway.

A.6.3.3.8 It is important that handrails be configured so that they do not interfere with either the vehicle dynamic envelope or with egress from the train onto the walkway. For that reason, handrails are not required on the trainway side of walkways. Likewise, walkways located between trainways are not required to have handrails, provided they are a minimum width of 1120 mm (44 in.).

A.6.3.3.17 Where exit hatches are installed in spaces such as walkways or access areas, appropriate design features such as readily visible signs, markings, or bollards should be provided to prevent blockage of the exit hatch. In addition, provisions should be included in the design to protect the exterior side of the hatch, including the outside latch, from accumulation of ice and snow, which could render the hatch inoperable.

A.6.3.4.1 The primary hazards presented by the electrified third rail in the trainway are electrical shock to employees and other personnel in the trainway and the heat and smoke generated by the cable or third rail caused by combustion resulting from grounding or arcing.

The life safety and fire protection requirements for the traction power substations, tie breaker stations, and power distribution and control cabling are described in other parts of this standard.

A.6.3.5.9 This value is a minimum maintained point measured at any location on the walkway, taking into account the total light loss factor (dirt depreciation, lumen depreciation, etc.) that will be experienced by the luminaire. Required lighting levels should be read in the same manner as they would be in other codes or standards without consideration for obscuration by evacuees. The phrase "during a period of evacuation" is intended to clarify that continuous illumination is not required during normal operations.

A.6.3.5.11 Point illumination can be used to accentuate critical elements within the trainway such as change of walkway elevation, steps, and access points.

A.6.4.2.1 The placement of blue light stations at the ends of station platforms should be governed by specific characteristics of the transportation system and its emergency response procedures. For example, an at-grade system that has stations located on streets and overhead power supply might not need blue light stations at the ends of platforms.

A.6.4.5.2 The authority having jurisdiction might additionally require 65 mm (2½ in.) hose connections to be equipped with a 65 mm × 40 mm (2½ × 1½ in.) reducer.

A.6.4.5.4(1) Calculations, including transit and fill times, should be submitted to the authority having jurisdiction to support this requirement.

A.6.4.7.2 The intent of the standard is to provide a reasonable level of life safety for occupants. However, the risk faced in nonpassenger areas where trains are merely stored or cleaned is significantly different from that in passenger areas (6.4.7.2 and 6.4.7.3 do not apply to maintenance and yards areas). This is because there are fewer ignition sources and fewer people, and the occupants will be either familiar with their surroundings (in the case of staff) or trained to react in hazardous locations (in the case of emergency responders). The standard continues to require ventilation and all other protective features, including compliant egress from these areas. Paragraphs 6.4.7.2 and 6.4.7.3 eliminate the requirement for the emergency ventilation system to meet the tenability criteria for other occupied areas. The standard permits tenability criteria in these areas to be reduced, provided that an engineering analysis shows that a fire in these areas will not impact areas occupied by passengers.

A.6.4.7.3 See A.6.4.7.2.

A.7.1.1 Separate ventilation systems for tunnels and underground stations can be provided but are not required. Annex B provides information on types of mechanical systems for normal and emergency ventilation of trainways and stations and information for determining a tenable environment.

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

A.7.1.2.2 Individual project geometries can impose constraints that make the length requirement of 7.1.2.2(2) onerous to meet. Proposals to the authority having jurisdiction for relief based on engineering analysis might be made to address this. The following elements and performance goals should be considered in the development and justification of an alternative approach. A mechanical system intended for the purpose of emergency ventilation can be considered for waiver from an enclosed trainway if the length of the enclosed trainway is less than or equal to the length of that system's most prevalent train, provided that each vehicle within that most prevalent train permits a protected passenger egress route from each vehicle to the one (or two) adjoining vehicles. A rationale for selection and acceptance of the most prevalent train would be part of the justification. Conversely, a mechanical system intended for the purpose of emergency ventilation should not be waived in an enclosed trainway if the length of the enclosed trainway is equal to or greater than twice the NFPA recommendation *(see 6.2.2.2)* for the maximum distance that an evacuating passenger should have to travel before reaching an emergency exit stairway [381 m (1250 ft)]. The need for a mechanical system intended for the purpose of emergency ventilation should be analyzed further (as approved) if an enclosed trainway meets one of the following criteria:

(1) The length of the enclosed trainway is less than 762 m (2500 ft) but greater than that of the system's most prevalent train.
(2) The length of the enclosed trainway is less than that of the system's most prevalent train and each vehicle within that most prevalent train does not permit a protected passenger egress route from that vehicle to the one (or two) adjoining vehicle(s).

In the event that no analysis is performed or the justification is not approved, the default enclosed trainway design should include an emergency ventilation system.

A.7.2.1(3) The time frame required for achievement of the selected operating mode applies to the ventilation system equipment and not to the establishment of the resultant air flows in the tunnels and stations. This would be the time for the emergency ventilation system to achieve the required speed and direction for all related fans and to reach the required position for all dampers and related emergency devices.

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

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

A.7.2.5 Transition from fixed-block to moving-block (cab-based or communication-based) signaling is being made by many properties to increase train throughputs during rush hour operation. Ventilation zones are fixed elements, and the number of trains allowed in a single zone affects both ventilation plant requirements and the effectiveness of the ventilation response. Traction power blocks are fixed elements and affect the ability to extract non-incident trains from the incident ventilation zone. Signal system track circuits are fixed elements and affect the ability to determine the location of incident and non-incident trains in the incident ventilation zone. Signal system reversing capability and rapidness of executing a reversal in an emergency are key to the effective extraction of non-incident trains. Due to the potential for a valid incident ventilation response to move smoke past (and engulf) a non-incident train, the best protection to passengers is to allow no more than one train in a ventilation zone. Failing that, there should be a viable extraction capability to remove non-incident trains in the same time frame as the activation of the ventilation response. This extraction requires coordination of the three system elements in terms of design with the train operation plans and emergency response plans with respect to how the trains will be operated and how the designed systems will be used during emergency operation. Non-incident trains should be capable of being located and removed from the incident area before the de-energization of the traction power prevents train movement for an extended period or the operation of the ventilation system in response to the fire incident involves the trains in the incident. Examples of the provisions necessary to accomplish this capability are the inclusion of traction power segmentation zones within ventilation zones and the inclusion of sufficiently short track signal circuit lengths to ensure all trains are accurately located.

A.7.2.6 The time of tenability should consider the possibility of one or more egress paths being blocked by fire or smoke (as may be demonstrated by analysis) and for other considerations that are not accounted for in the egress capacity calculations. *(See B.2 for additional information to be considered.)*

A.7.5.1 Factory approval acceptance testing prior to installation should be performed as follows:

(1) Ventilation equipment should comply with all the requirements of one of the applicable standards, which include those published by the Air Movement and Control Association International, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, the International Organization for Standardization, and or UL (formerly, Underwriters Laboratories). If an appropriate standard does not exist, then a test procedure should be submitted for approval.
(2) Tests can consist of prototype testing or of production testing. Prototype testing should include those tests necessary to ensure that the design of the equipment is acceptable, including tests for design temperature exposure time. Production testing should include those tests necessary to ensure that the equipment as produced meets the requirements of the standard.

A.7.5.2 A test plan should be prepared and submitted to the owner and the authority having jurisdiction for review and approval prior to the commissioning tests. The test plan should describe the method of testing and identify pass-fail criteria. As a minimum, the test plan should identify the following items:

(1) The commissioning tests should include individual equipment tests [as indicated in items (2) and (3)] and systemwide tests [as indicated in items (4) through (13)].
(2) The individual fans, dampers, and other devices should be operated to confirm their functionality. As a minimum, ventilation equipment operation should be initiated at the local primary location for fan operation such as an emergency management panel or fire management panel.
(3) The individual fan and ventilation plant airflows should be measured to confirm that the intended airflows are being delivered. At least one test should be made to measure the time required for the fan plant airflows to reach steady-state from a zero-flow start, and at least one test should be made to measure the time required for the fan plant airflows to reverse from full-forward to full-reverse operation. Subsequent tests should be conducted from Operations Central Control to verify remote fan and damper operation.
(4) The no-fire (or cold) station and tunnel airflows provided by the built mechanical ventilation system should be measured to confirm that the airflows meet the requirements determined by the analysis.
(5) The systemwide tests should be witnessed by the owner, the authority having jurisdiction, the designer or the engineer of record, the contractor, and possibly the ventilation equipment suppliers.
(6) The systemwide testing should be done by a qualified airflow measurement specialist or contractor having previous experience in measuring airflows.
(7) Calibrated instruments providing an air velocity measurement accuracy of ±2.5 percent should be used. The number of points to be measured to convert air velocities to airflows should be determined either by the applicable standard used for the factory acceptance preinstallation testing (such as those published by the Air Movement and Control Association International, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, the International Organization for Standardization or UL) or by a CFD analysis. The test data should be electronically recorded for future use.
(8) The fan(s) that are assumed to be operated and not operated by the analysis should be identified for each scenario being tested.
(9) At least one test should be performed to measure the time required for all the fans used in a fire scenario to reach full operating mode.
(10) The tunnel fire scenarios should be assessed and should include the design cases (i.e., those that determine the ventilation equipment functional capacities) and any other scenarios deemed appropriate. The train(s) should be located in the tunnel as per the scenario, and tunnel airflows upstream of the stopped trains should be measured. It is not necessary to test all scenarios.
(11) The station fire scenarios should be assessed and should include the design cases (i.e., those that determine the ventilation equipment's functional capacities) and any other scenarios deemed appropriate. The station geometry can preclude the necessity of locating trains in the station. Airflows through the station entrances and tunnels connected to the station should be measured. It is not necessary to test all scenarios.
(12) The airflows measured should be compared with the "cold flows" predicted by the analysis. If the measured airflows are less than the predicted airflows, the mechanical ventilation system or its operation should be changed and the test repeated until passing results are achieved. Negative tolerances in the results should not be accepted.
(13) The systemwide testing should be documented by one or more reports. The report should include a description of the scenario tested, the instrumentation used, the names and affiliations of those witnessing the tests, and all test results.

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

The requirements of 49 CFR 238, Section 103, are that interior materials be tested and meet certain flammability and smoke criteria and that floor fire endurance be tested. In addition, the requirements contain detailed fire safety analysis requirements for new equipment, to reduce the risk of personal injury and equipment damage caused by a fire to an acceptable level. The fire safety analysis requirements include the use of a formal safety methodology and written documentation of the analysis. In addition, the vehicle design and material selection are required to consider potential ignition sources; the type, quantity, and location of materials; and the availability of rapid and safe egress to the equipment exterior under conditions secure from fire, smoke, and other hazards. The ventilation system is required to not contribute to the lethality of a fire. Passenger railroads are also required to determine the extent to which overheat detection and fire suppression systems must be installed to ensure sufficient time for the safe evacuation of passengers and crew.

In addition to the specific fire safety requirements in 49 CFR 238, Section 103, other sections of the FRA requirements include fire safety–related provisions for passenger rail vehicles. Minimum requirements for fuel tanks for new passenger locomotives are intended to protect the fuel tanks against crushing and puncture in a collision or derailment. Requirements for passenger car electrical systems are also included. Conductor sizes must be selected on the basis of current carrying capacity, temperature, and other characteristics, and power dissipation resistors must be adequately ventilated to prevent overheating and be electrically insulated. The resistors and main battery system must be designed to prevent combustion. Such features can reduce the risk of fire ignition and spread in a collision or derailment and thus affect the necessity for and circumstances of emergency evacuation. Other CFR requirements are for passenger rail car and locomotive crashworthiness, as well as emergency exit and emergency responder access features. Annex E provides guidance relative to fire hazard assessments referenced in Section 8.3 through Section 8.10.

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

A.8.3.2 The purpose of this requirement is to isolate potential ignition sources from fuel and combustible material and to control fire and smoke propagation.

A.8.4.1 It is recommended that testing be conducted on production batches of materials intended to be used on the vehicle. A record of the performance of these materials should be retained by the authority.

It is recognized that the tests cited in 8.4.1 might not accurately predict the behavior of materials under hostile fire conditions. Therefore, the use of tests that evaluate materials in subassemblies and full-scale configurations is encouraged where such tests are more representative of foreseeable fire sources, heat flux levels, and surface area-to-volume ratios found in vehicles designed in conjunction with this standard.

The key fire property measured in the ASTM D3675 and ASTM E162 tests is the radiant panel index (or I_s).

A.8.4.1.1 ASTM E162 might not be suitable for materials that exhibit flaming running or flaming dripping because the test apparatus is not designed to accommodate this kind of burning behavior. A fire hazard analysis seeking to demonstrate the acceptability of such materials as permitted in 8.4.2 should include not only the contribution to the generation of heat and smoke at the original ignition site but also any contribution resulting from burning material that melts and/or flows away from that site. The fire hazard analysis also should address the risk of spread to and ignition of other car components from either of these potential ignition sources.

A.8.4.1.3 The test methods in ASTM E1537 [for upholstered furniture, 19 kW (65 KBtu/hr) exposure] and ASTM E1590 [for mattresses, 18 kW (61 KBtu/hr) exposure] are deemed to be adequate procedures for testing individual items of upholstered furniture or mattresses for purposes of fire hazard assessment in some public occupancies. However, such individual stand-alone (not fixed in place) items are not normally found in rail transportation vehicles. Thus, the applicability of the test methods to rail transportation vehicles has not been validated, and they probably are not sufficiently representative of the situation and might require some modifications for better applicability. The use of alternative ignition sources (by varying the location, the gas flow intensity, or the exposure time) for ASTM E1537 or ASTM E1590 might be a means of addressing some very high challenge fire scenarios that could potentially occur in rail transportation vehicles. Examples of more powerful ignition sources that could be used include a 50 kW gas burner [Hirschler, 1997], shown to be relevant to detention mattresses or the oil burner used for aircraft seat cushions [FAR 25.853(c)], but the measurements should involve the same fire properties as in ASTM E1537 or ASTM E1590. If the ignition source used for a test method is inadequate, the result can be misleading; 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 E1537 and ASTM E1590, respectively.

A.8.4.1.10 If the surface area of any individual small part is less than 100 cm^2 (16 in.^{2}) in end use configuration, materials used to fabricate such a part should be permitted to be tested in accordance with ASTM E1354 as an alternative to both the ASTM E162 flammability test procedure or the appropriate flammability test procedure otherwise specified in Table 8.4.1 and the ASTM E662 smoke generation test procedure. Testing should be at 50 kW/m^2 (4.4 Btu/sec·ft^2) applied heat flux in the horizontal orientation with a retainer frame. Materials tested in accordance with ASTM E1354 should meet the performance criteria of a 180-second average heat release rate of $q''_{180} < 100$ kW/m^2 (8.8 Btu/sec·ft^2) and test average smoke extinction area of $(F_f) < 500$ m^2/kg (2441.2 ft^2/lb).

The typical way in which smoke obscuration test results are reported in the cone calorimeter (ASTM E1354) is as specific extinction area.

A.8.4.1.14 Only one specimen need be tested. A proportional reduction can be made in the dimensions of the specimen, provided the specimen represents a true test of the ability of the structural flooring assembly to perform as a barrier against undervehicle fires.

A.8.4.1.15 ASTM E2061 and APTA PR-PS-RP-005-00 both describe and discuss passenger-carrying vehicle fire scenarios. *(See also Annex E.)*

A.8.4.2 The greater the anticipated effect of the material on fire performance, the more complex the analysis is likely to be.

A.8.5.1.3.2(1) Computer models typically utilize passenger-carrying vehicle fire heat release rate data to predict the size of a vehicle fire that will occur after an interior fire reaches flashover. Vehicle interior fire computer models assume either that a fire is started on the inside of a vehicle or that an undercar fire penetrates into the vehicle interior, igniting any combustible material in the area of penetration. Typically, a floor fire resistance test is conducted only for the approved length of time. Consideration should be given to extending the floor fire exposure until failure. If a test is conducted until failure, it will give designers a better idea as to the length of time it will take for a fire to penetrate into a vehicle and ignite any combustible materials on the vehicle interior.

A.8.5.1.3.2(2) For determination of the minimum floor exposure time, the operating environment should be considered in addition to the time necessary to evacuate passengers from the vehicle. Typical issues that should be considered are the time necessary to shut down power to the affected portion of the trainway, distance to a cross-passageway, distance to an emergency exit, and availability of adequate light to perform a safe evacuation.

A.8.5.1.3.3(2) Since smoke generation is a factor that has a direct effect on a passenger's ability to evacuate a vehicle, observations should be noted during the length of the floor fire exposure as to the origin and quantity of smoke generated from the fire test sample. These observations should be recorded in the fire test report.

A.8.6.2.2 In selecting air clearance distances, special consideration should be given to the presence of contaminants encroaching on the air clearances.

A.8.6.2.3.2 Appropriate creepage distances can be selected from Annex F.

A.8.6.5.1 Resistors dissipate heat at elevated temperatures and are frequently separated by noncombustible shields to avoid ignition of combustible train materials. Direct contact with combustibles is a fire hazard and minimum spacing should be established if combustible materials are required to be used. The clear spacing will vary depending on location, orientation, and fire characteristics of the combustible train materials.

A.8.6.7.1.3 The electrical properties of data and communication cables should comply with requirements for category cable or local electrical requirements. Different system authorities specify data and communication cables that have specific electrical requirement other than voltage.

A.8.8.1 Since 1980, the Federal Railroad Administration (FRA) has required that each rail passenger car be provided with at least four emergency window exits. In 1999, the FRA issued a passenger equipment rule that required each intercity and commuter rail car to be equipped with a minimum number of two side doors per car and at least four emergency window exits for each main level. Each sleeping compartment must also be provided with an emergency window exit. Because fixed guideway vehicles historically have been provided with at least two sets of bi-leaf side doors, one on each side, emergency exit windows usually are not provided.

A.8.8.1.1 After a collision or derailment, the vehicle might come to a rest in an orientation other than upright. When designing alternative means of emergency egress, consideration should be given to reaching the emergency egress, regardless of vehicle orientation. This can be accomplished by the utilization of fixed appurtenances in the vehicle, ladders, or ramps.

A.8.8.3.1 The level of emergency lighting illumination was previously required to meet the requirements of NFPA *101* . However, research conducted by the John A. Volpe Transportation Systems Center (Volpe Center) for the Federal Railroad Administration (FRA), U.S. Department of Transportation, determined that the level of illumination required by NFPA *101* might not be necessary due to the more limited size [25.9 m (85 ft) long and 3.1 m (10 ft) wide)] and configuration of passenger rail vehicles (and by extension, fixed guideway transit vehicles). The Volpe Center performed numerous detailed measurements of illumination levels provided by emergency light facilities installed on many types and ages of intercity and commuter rail vehicles. The majority of fixed guideway transit and passenger rail vehicle emergency lighting systems use fluorescent light fixtures. However, some systems used incandescent fixtures. While the fluorescent light fixtures typically emit higher levels of illumination and are thus preferred, some incandescent light fixtures (depending on their type, power output and location, and pattern) also provide sufficient illumination to allow passengers to identify, reach, and operate emergency egress facilities.

The Federal Aviation Administration (FAA) has conducted many research studies relating to emergency lighting illumination levels for passenger aircraft. The FAA requires different illumination levels at floor level doors and emergency window locations and along the center aisle. The center aisle illumination levels are measured at the armrest height. Due to the different armrest heights exhibited by passenger rail vehicles, the Volpe Center research resulted in the recommendation for a uniform height of 635 mm (25 in.) above the floor height to perform the aisle measurements.

Accordingly, the FRA issued a passenger equipment regulation on May 12, 1999, that specified the Volpe-recommended minimum illumination level for egress door floor locations, minimum illumination average along the center aisle, and a minimum illumination at any point along the aisle for new equipment.

Moreover, the American Public Transportation Association (APTA) standard APTA SS-E-013 addresses passenger rail vehicle emergency lighting. The APTA standard requires minimum emergency lighting levels for new intercity passenger and commuter rail vehicles that are identical to FRA requirements and contains additional guidance in performing the illumination measurements. The APTA emergency lighting standard was updated in 2007 to provide a detailed test methodology. The APTA standard provides guidance that could be applied to fixed guideway transit vehicles.

A.8.8.3.3 Depending on the location of the train, the time necessary to initiate and complete the evacuation of passengers from the fixed guideway transit or passenger rail vehicle to a point of safety can exceed 1 hour. The minimum period of time for the vehicle emergency lighting system power supply is consistent with NFPA *101* , APTA SS-E-013, and the FRA regulation.

A.8.8.4 Until the 2003 edition, NFPA 130 did not address the manual operation of emergency egress (or access) facilities for the vehicle interior or exterior, the interior and exterior marking of the egress/access facility location, or instructions for the use of the emergency egress/access facilities. Several emergency incidents occurred that demonstrated the necessity of providing passengers with a means to manually operate, without tools, means of emergency egress in the event of a power failure. Operational issues to be considered include the need to discourage use under nonemergency conditions while permitting effective passenger use in an emergency, particularly if members of the train crew are injured or otherwise unavailable.

A.8.8.5 The FAA requires the installation of independently powered floor proximity path marking to delineate the path to emergency exits. APTA also has issued a standard that requires this same concept of marking to be installed in intercity and commuter rail cars.

The FRA issued a rule in 1998 that required marking and instructions for the operation of emergency exit windows and doors used for emergency egress. Although the FRA requires that the marking be conspicuous and legible, specific objective performance criteria were not included.

APTA has issued a standard that contains extensive provisions for the marking of and instructions for emergency egress facilities that are operated from inside the vehicle. These minimum performance criteria include letter height, color contrast, and luminance levels.

The APTA standard requires that marking and instructions use either electrically powered or high-performance photo luminescent (HPPL) material. The HPPL material must be charged with adequate light [54 lx (5 ft-candles) for at least 1 hour] but offers the advantage of providing a far greater luminance (brightness) over a far longer time period while not being dependent on emergency power. HPPL material has been certified by the FAA for use as floor proximity path marking on certain aircraft.

A.8.11.1 Annex D provides additional information on the fire hazards associated with burning vehicles and the impact of a burning vehicle on the evacuation of passengers and crew.

A.8.11.2 Section 4.3 includes specific objectives necessary to achieve desired goals. Further guidance relative to the engineering analysis option for compliance could include explanatory material regarding performance-based compliance in other documents, such as NFPA *101* .

A.9.2.4 The following standards might be applicable for training qualification and competency assessment: NFPA 1006, NFPA 472, and NFPA 1670.

A.9.4 Tunnels more than 610 m (2000 ft) in length should be equipped with emergency tunnel evacuation carts (ETECs) at locations to be determined by the authority having jurisdiction.

ETECs should be capable of carrying a capacity of at least four stretchers and a total weight capacity of at least 453.5 kg (1000 lb). ETECs should be constructed of corrosion-resistant materials, be equipped with a “deadman” brake, and safely operate on the rail tracks in the tunnel.

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

A.9.8.1 The command post should be located at a site that is convenient for responding personnel, easily identifiable, and suitable for supervising, coordinating, and communicating with participating agencies.

A.9.8.5 Signs should be designed to be visible day and night and under bad weather conditions.

A.9.9 Any emergency response agency can establish an auxiliary command post to assist with the supervision and coordination of personnel and equipment. This activity is in addition to providing a liaison at the command post.

A.10.1 Comprehensive and dependable communications are essential for an effective and efficiently operated fixed guideway transit system during emergencies.

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

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

A.11.2.1 It is desirable that passengers are evacuated directly to a station platform, rather than to a trainway, to avoid the complications of a trainway evacuation.

A.11.3.1 Different situations that can render a system unavailable include data overloads, both intentional or unintentional; loss of data; loss of a control room due to fire; loss of battery power; and circuits shorted or open.

A.11.3.2 Single points of failure that will affect life safety during fires and the mitigation of those single points of failure should be considered during conceptualization.

A.11.3.3 When it is essential that a control, data, or communication system continue to function during a fire, both thermal and physical protection are likely to be required, since a fire resistance–rated element intended to protect the control, data, or communication system might not offer the expected thermal protection to the unexposed side for the duration of the fire resistance rating.

A.12.1.2 The life safety and fire protection requirements for the traction power substations, the breaker station's power distribution, and control cabling are described in other parts of this standard.

A.12.5.3 When selecting a fire-resistive cable, it is important to understand how it will be installed and if it was tested as a complete system, including splices. Cables that are exposed (not embedded in concrete) should be protected by either a raceway or an armor/sheath *(see 12.4.1)*. There are two basic configurations of fire-resistive cables. Cables enclosed by a metallic sheath or armor, such as Type MI or Type MC, are installed without raceways. Cables that are installed in a raceway, such as Type RHW-2, Type TC, or Type CM are tested as a complete system. Regardless of the fire test standard used to evaluate fire-resistive cables that will be installed in a raceway, it is important to consider that the cables are only one part of the system. Other components of the system include but are not limited to: the type of raceway, the size of raceway, raceway support, raceway couplings, boxes, conduit bodies, splices where used, vertical supports, grounds, and pulling lubricants. Each cable type should be tested to demonstrate compatibility. Only those specific types of raceways tested should be acceptable for installation. Each cable type that is intended to be installed in a raceway should be tested in both a horizontal and vertical configuration while demonstrating circuit integrity.

Annex B Ventilation

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

B.1 General. The purpose of this annex is to provide guidelines for the potential compatibility of the emergency ventilation system with the system employed with normal ventilation of trainways and stations. This annex does not present all factors to be considered in the normal ventilation criteria. For normal ventilation, refer to the *Subway Environmental Design Handbook* (*SEDH*) and the ASHRAE handbooks *Fundamentals*, *Applications*, and *Systems and Equipment*.

Current technology is capable of analyzing and evaluating all unique conditions of each property to provide proper ventilation for normal operating conditions and for pre-identified emergency conditions. The same ventilating devices might or might not serve both normal operating conditions and pre-identified emergency requirements. The goals of the subway ventilation system, in addition to addressing fire and smoke emergencies, are to assist in the containment and purging of hazardous gases and aerosols such as those that could result from a chemical/biological release.

B.2 Tenable Environments.

B.2.1 Environmental Conditions. Some factors that should be considered in maintaining a tenable environment for periods of short duration are defined in B.2.1.1 through B.2.1.5.

B.2.1.1 Heat Effects. *(See also I.1.2.12.)* 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 1.7 $kW \cdot m^{-2}$. Below this incident heat flux level, exposure can be tolerated almost indefinitely 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.

[B.2.1.1a]

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

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

As with toxic gases, an exposed occupant can be considered to accumulate a dose of radiant heat over a period of time. The fraction equivalent dose (FED) of radiant heat accumulated per minute is the reciprocal of t_{Irad}.

Radiant heat tends to be directional, producing localized heating of particular areas of skin even though the air temperature in contact with other parts of the body might be relatively low. Skin temperature depends on the balance between the rate of heat applied to the skin surface and the removal of heat subcutaneously by the blood. Thus, there is a threshold radiant flux below which significant heating of the skin is prevented but above which rapid heating occurs.

Calculation of the time to incapacitation under conditions of exposure to convected heat from air containing less than 10 percent by volume of water vapor can be made using either Equation B.2.1.1b or Equation B.2.1.1c.

As with toxic gases, an exposed occupant can be considered to accumulate a dose of convected heat over a period of time. The fraction equivalent dose (FED) of convected heat accumulated per minute is the reciprocal of t_{Iconv}.

Convected heat accumulated per minute depends on the extent to which an exposed occupant is clothed and the nature of the clothing. For fully clothed subjects, Equation B.2.1.1b is suggested:

[B.2.1.1b]

$$t_{Iconv} = \left(4.1 \times 10^{8}\right) T^{-3.61}$$

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

For unclothed or lightly clothed subjects, it might be more appropriate to use Equation B.2.1.1c:

[B.2.1.1c]

$$t_{Iconv} = \left(5 \times 10^{7}\right) T^{-3.4}$$

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

Equations B.2.1.1b and B.2.1.1c are empirical fits to human data. It is estimated that the uncertainty is ±25 percent.

Thermal tolerance data for unprotected human skin suggest a limit of about 120°C (248°F) for convected heat, above which there is, within minutes, onset of considerable pain along with the production of burns. Depending on the length of exposure, convective heat below this temperature can also cause hyperthermia.

The body of an exposed occupant can be regarded as acquiring a "dose" of heat over a period of time. A short exposure to a high radiant heat flux or temperature generally is less tolerable than a longer exposure to a lower temperature or heat flux. A methodology based on additive FEDs similar to that used with toxic gases can be applied. Provided that the temperature in the fire is stable or increasing, the total fractional effective dose of heat acquired during an exposure can be calculated using Equation B.2.1.1d:

[B.2.1.1d]

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

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 the following:

[B.2.1.1e]

$$t_{exp} = \left(1.125 \times 10^7\right) T^{-3,4}$$

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

This gives the values in Table B.2.1.1.

Table B.2.1.1 Maximum Exposure Time

Exposure Temperature		Without Incapacitation (min.)
°C	°F	
80	176	3.8
75	167	4.7
70	158	6.0
65	149	7.7
60	140	10.1
55	131	13.6
50	122	18.8
45	113	26.9
40	104	40.2

B.2.1.2 Air Carbon Monoxide Content. An exposed occupant can be considered to accumulate a dose of carbon monoxide over a period of time. This exposure to carbon monoxide can be expressed as a fractional effective dose, according to Equation B.2.1.2a; see B.2.1.2.1, reference [1] [page 6, equation (2)]:

[B.2.1.2]

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

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

It has been estimated that the uncertainty associated with the use of Equation B.2.1.2a is ±35 percent. The time at which the FED accumulated sum exceeds a chosen incapacitating threshold value represents the time available for escape for the chosen carbon monoxide exposure. As an example, consider the following:

(1) Time to FED reduced by 35 percent to allow for the uncertainty in Equation B.2.1.2a
(2) Exposure concentration constant

This gives the values in Table B.2.1.2 for a range of threshold values.

A value for the FED threshold limit of 0.5 is typical of healthy adult populations [1], 0.3 is typical in order to provide for escape by the more sensitive populations [1], and the AEGL 2 limits are intended to protect the general population, including susceptible individuals, from irreversible or other serious long-lasting health effects [2].

The selection of the FED threshold limit value should be chosen appropriate for the fire safety design objectives. A value of 0.3 is typical. More conservative criteria may be employed for use by especially susceptible populations. Additional information is available in references [1] and [3].

Table B.2.1.2 Maximum Carbon Monoxide Exposure

Time (min)	Tenability Limit		
	AEGL 2	0.3	0.5
4	–	1706	2844
6	–	1138	1896
10	420	683	1138
15	–	455	758
30	150	228	379
60	83	114	190
240	33	28	47

B.2.1.2.1 The following references are cited in B.2.1.2:

(1) "Life threat from fires — Guidance on the estimation of time available for escape using fire data," ISO/DIS 13571, International Standards Organization, 2006.
(2) "Acute Exposure Guideline Levels for Selected Airborne Chemicals, Volume 8," Committee on Acute Exposure Guideline Levels, Committee on Toxicology, National Research Council. National Academies Press, Washington DC, 2010.
(3) Kuligowski, E. D., "Compilation of Data on the Sublethal Effects of Fire Effluent," Technical Note 1644, National Institute of Standards and Technology, 2009.

B.2.1.3 Smoke Obscuration Levels. Smoke obscuration levels should be maintained below the point at which a sign internally illuminated at 80 lx (7.5 ft-candles) is discernible at 30 m (100 ft) and doors and walls are discernible at 10 m (33 ft).

B.2.1.4 Air Velocities.

B.2.1.4.1 Air velocities in enclosed stations and trainways should be greater than or equal to 0.75 m/sec (150 fpm).

B.2.1.4.2 Air velocities in enclosed stations and trainways that are being used for emergency evacuation or by emergency personnel should not be greater than 11.0 m/sec (2200 fpm).

B.2.1.5 Noise Levels. Criteria for noise levels should be established for the various situations and potential exposures particular to the environments addressed by this standard. The intent of the recommended criteria is to maintain at least a minimal level of speech intelligibility along emergency evacuation routes. This might require additional noise control measures and acoustical treatment to achieve. Exceptions taken to the recommended noise levels for reasons of cost and feasibility should be as few and as slight as reasonably possible. For example, local area exceptions to the recommended acoustic criteria could be required to be applied for defined limited distances along the evacuation path that are near active noise sources. Other means of providing emergency evacuation guidance using acoustic, nonacoustic, or combined methods might be considered. Starting points for various design scenarios should be considered as follows:

(1) Where reliance on unamplified speech is used as part of the emergency response inside a tunnel, the speech interference level (SIL) during emergency response from all active systems measured along the path of evacuation at any point 1.52 m (5 ft) above the walking surface should not exceed 78 dBZ L_{eq} "slow" over any period of 1 minute, using the arithmetic average of unweighted sound pressure level in the 500, 1000, 2000 and 4000 Hz octave bands.
(2) For intelligible communication between emergency evacuation responders and the public, where reliance on amplified speech is used as part of the emergency response within a station, refer to *NFPA 72*.
(3) Where reliance on amplified speech is used as part of the emergency response within a tunnel, the sound pressure level from all active systems measured inside a tunnel along the path of evacuation at any point 1.52 m (5 ft) above the walking surface should be designed to support speech intelligibility of fixed voice communication systems to achieve a measured STI of not less than 0.45 (0.65 CIS) and an average STI of not less than 0.5 (0.7 CIS) as per D.2.4.1 of *NFPA 72*. Refer to Annex D of *NFPA 72* for further information on speech intelligibility for voice communication systems.

B.2.2 Geometric Considerations. Some factors that should be considered in establishing a tenable environment in stations are as follows:

(1) The evacuation path requires a height clear of smoke of at least 2 m (6.6 ft). For low-ceiling areas, selection of the modeling method and the criteria to be achieved should address the limitations imposed by ceiling heights below 3 m (9.84 ft). At low-ceiling areas in an evacuation path, beyond the immediate vicinity of a fire, smoke should be excluded to the greatest extent practicable.
(2) The application of tenability criteria at the perimeter of a fire is impractical. The zone of tenability should be defined to apply outside a boundary away from the perimeter of the fire. This distance will be dependent on the fire heat release rate, the fire smoke release rate, local geometry, and ventilation and could be as much as 30 m (100 ft). A critical consideration in determining this distance will be how the resultant radiation exposures and smoke layer temperatures affect egress. This consideration should include the specific geometries of each application, such as vehicle length, number of vehicles open to each other, fire location, platform width and configuration, and ventilation system effectiveness, among others, and how those factors interact to support or interfere with access to the means of egress.
(3) The beneficial effects of an emergency ventilation system during a fire incident will not become completely available until the system is operated and reaches full capacity. During the time between initiation of a fire incident and the desired ventilation response achieving its full capacity, the smoke can spread into the intended zone of tenability. The ventilation system should have sufficient capacity to counter this pre-ventilation smoke spread. Whenever possible, the design of the space geometry should consider arrangements to minimize the pre-ventilation smoke spread. The overall extent of pre-ventilation smoke spread should also be considered with respect to its potential effect on egress.
(4) During the emergency ventilation response, short-term transient events due to step-like changes in geometry can momentarily provide a significant boost to the fire heat and smoke release rates. Examples include vehicle doors opening or the failure of vehicle windows. The ventilation system should have sufficient capacity to counter such short-term transients affecting smoke spread.

B.2.3 Time Considerations. Some factors that should be considered in establishing the time of tenability are as follows:

(1) The time for fire to ignite and become established
(2) The time for fire to be noticed and reported
(3) The time for the entity receiving the fire report to confirm existence of fire and initiate response
(4) The time for all people who can self-rescue to evacuate to a point of safety
(5) The time for emergency personnel to arrive at the station platform
(6) The time for emergency personnel to search for, locate, and evacuate all those who cannot self-rescue
(7) The time for fire fighters to begin to suppress the fire

B.2.4 Modeling Accuracy. Where modeling is used to determine factors such as temperature, visibility, and smoke layer height, an appropriate sensitivity analysis should be performed.

B.3 Configurations. Configurations can vary among properties, but engineering principles remain constant. The application of those principles should reflect the unique geometries and characteristics of each property.

Enclosed stations and trainways might be configured with the following characteristics:

(1) High or low ceilings
(2) Open or doored entrances
(3) Open or screened platform edges
(4) End-of-station or midtunnel fan shafts
(5) End-of-station or midtunnel vent shafts
(6) Single, double, or varying combinations of tracks in tunnels
(7) Intersecting tunnels
(8) Multilevel stations
(9) Multilevel tunnels
(10) Varying depths below the surface
(11) Varying grades and curvatures of tracks and tunnels
(12) Varying blockage ratios of vehicles to tunnel cross-section
(13) Varying surface ambient conditions
(14) Varying exit points to surface or points of safety

B.4 Draft Control.

B.4.1 For patron comfort in stations, the air velocities induced by train motion should be evaluated carefully by designers. Infrequent exposure to higher velocities can be tolerated briefly but are to be avoided wherever possible. Refer to the *Subway Environmental Design Handbook* (*SEDH*), the *ASHRAE Handbook — Fundamentals,* and the Beaufort Scale.

B.4.2 Draft control can be achieved by the placement of shafts along the tunnel length between stations. Shafts can be arranged with the fan shafts at the ends of stations, with vent shafts midtunnel if required or with vent shafts at the ends of stations and fan shafts midtunnel. End-of-station shaft configurations should be related to the station geometries in the consideration of patron comfort in the station relative to train piston draft effects.

B.5 Temperature Control.

B.5.1 Temperature control for patron comfort in the station can be achieved by circulating ambient air in moderate climates or by providing heating and/or cooling in more extreme regions. Preferred temperature goals should be defined in the criteria developed for the design of an individual property relative to the local climate and the length of station occupancy, such as train headways specific to the property during which the patron would be exposed to the station temperatures.

B.5.2 Temperature control and ventilation for ancillary areas housing special equipment should reflect the optimum operating conditions for the specific equipment to ensure the availability of critical equipment and should also give consideration for intermittent occupancy by maintenance personnel. These systems should be separate from the emergency ventilation system for stations and tunnels and should be considered in the design of the emergency ventilation system.

B.6 Under-Platform Ventilation System.

B.6.1 An under-platform ventilation system should be considered for the extraction of heat from traction and braking devices. Intakes should be provided below the platform level and should be situated relative to the heat-producing devices on a train berthed in a station.

B.6.2 Ceiling ventilation, by powered or gravity design, to aid in the removal of smoke and/or heat should be considered.

B.7 Platform Edge and Screen Doors.

B.7.1 Platform edge doors and platform screen doors are sometimes incorporated into stations for various reasons, such as climate control, separation between passengers and trainway hazards (especially in driverless systems), and ventilation control in enclosed trainways. When used, these system walls and doors should provide resistance rating structural strength relative to the train and ventilation system pressures.

B.7.2 In a tunnel-to-station evacuation scenario, access to the platform level from the trainway should be considered.

B.8 Non-Emergency Ventilation for Enclosed Trainways.

B.8.1 Congested Operations. Where trains might be stopped or delayed in an enclosed trainway for a period of time, the vehicle ventilation system should be capable of maintaining an acceptable level of patron comfort. If not operating in a fire or other emergency scenario, the emergency ventilation fans can be used to augment the vehicle system capability.

B.8.2 Maintenance Activities. Maintenance activities within station and tunnel areas can include heat-, dust-, or fume-producing operations such as grinding, welding, or painting; operation of fuel-powered vehicles or equipment; and other operations that affect tunnel air quality or temperature. If not operating in a fire or other emergency scenario, the tunnel ventilation fans can be used to address the safety and comfort of employees working in the affected tunnel and station areas. In such cases, velocities should consider the comfort levels of employees required to be in the tunnels.

B.8.3 Tunnels in Gassy Ground. Tunnels in gassy ground could be subject to ingress of flammable or other hazardous gases. Gases of concern include hydrogen sulfide (H_2S) and methane (CH_4). The ventilation system should be designed to satisfy two objectives:

(1) To avoid pockets of gases forming
(2) To achieve dilution of gas inflows through a design crack

The ventilation design should be coordinated with the gas detection and alarm system type and the activation levels selected. The design should consider two general conditions:

(1) Ongoing or periodic ventilation requirements to meet expected average gas ingress rates
(2) Reaction to potential abrupt increases in gas ingress, such as might result from future construction, climate events, or seismic activity

Annex C Means of Egress Calculations for Stations

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

C.1 Station Occupant Load. The station platform dimensions are a function of the length of trains served and the train load. Thus the length of a platform at an outlying station might be equal to those of central business district transit stations where the train loads are significantly higher. Consequently, the platform and station occupant loads are a function of the train load and the simultaneous entraining load. This concept differs from that of NFPA *101* , in which the occupant load is determined by dividing the floor area by an occupant load factor assigned to that use. Applying the NFPA *101* approach to determine the station platform occupant load is inappropriate.

C.1.1 Calculating Occupant Load. Projected ridership figures serve as the basis for determining transit system design. Per this standard, the methodology used to determine ridership figures must also include peak ridership figures for new transit systems and existing operating systems. Events at stations such as civic centers, sports complexes, and convention centers that establish occupant loads not included in normal passenger loads must also be included. These ridership figures serve as the basis for calculating train and entraining loads and the station occupant load. The methodology used for determining passenger ridership figures can vary by transit system. The use of statistical methods for determining *calculated train loads* and *calculated entraining loads* will provide a more accurate indication of the required means of egress facilities within a station.

C.1.2 Calculating Evacuation Time. The total evacuation time is the sum of the walking travel time for the longest exit route plus the waiting times at the various circulation elements. The trainway can be considered as an auxiliary exit from the station under certain fire scenarios.

The waiting time at each of the various circulation elements is calculated as follows:

(1) For the platform exits, by subtracting the walking travel time on the platform from the platform exits flow time
(2) For each of the remaining circulation elements, by subtracting the maximum of all previous element flow times

The symbols used in the sample calculations in this annex represent the walking times, flow times, and waiting times as follows:

T = total walking travel time for the longest exit route

T_p = walking travel time on the platform

T_X = walking travel time for the Xth segment of the exit route

F_p = platform exits flow time

F_{fb} = fare barrier flow time

F_c = concourse exits flow time

F_N = flow time for any additional circulation element

$W_p = F_p - T_p$ = waiting time at platform exits

$W_{fb} = F_{fb} - F_p$ = waiting time at fare barriers

$W_c = F_c - \max(F_p \text{ or } F_{fb})$ = waiting time at concourse exits

$W_N = F_N - \max(F_c, F_{fb}, \text{ or } F_p)$ = waiting time at any additional circulation element

Note that the waiting time at any circulation element cannot be less than zero.

C.1.3 Center-Platform Station Sample Calculation. The sample center-platform station is an elevated station with the platform above the concourse, which is at grade *(see Figure C.1.3)*. The platform is 183 m (600 ft) long to accommodate the train length. The vertical distance from the platform to the concourse is 9.1 m (30 ft).

The sample station has one paid area separated from the outside by a fare array containing four electronic fare gates and one 1220 mm (48 in.) handicapped/service gate. In addition, two 1830 mm (72 in.) wide emergency exits are provided. Six open wells communicate between the platform and the concourse. Each well contains one stair or one escalator. Station ancillary spaces are located at the concourse level.

Elevators (not shown in Figure C.1.3) are provided for use by handicapped persons or service personnel. Open emergency stairs are provided at each end of the platform and discharge directly to grade through grille doors with panic hardware.

Escalators are nominal 1220 mm (48 in.) wide. Stairs regularly used by patrons are 1830 mm (72 in.) wide, and emergency stairs are 1220 mm (48 in.) wide. Gates to emergency stairs are 1220 mm (48 in.) wide.

The station occupant load is 2314 persons.

Table C.1.3 lists the data for the exiting analysis of the sample center-platform station.

Test No. 1. Evacuate platform occupant load(s) from platform(s) in 4 minutes or less.

[C.1.3a]

$$F_p \text{ (time to clear platform)} = \frac{\text{Platform occupant load}}{\text{Platform exit capacity}}$$

$$F_p = \frac{2314}{609}$$

$$F_p = 3.80 \text{ minutes}$$

In Test No. 1, the time to clear the platform is found to be 3.80 minutes. This meets the requirement of 5.3.3.1.

Test No. 2. Evacuate platform occupant load from most remote point on platform to a point of safety in 6 minutes or less.

W_p (waiting time at platform exits) = $F_p - T_1$

$W_p = 3.80 - 1.09 = 2.71$ minutes

Concourse occupant load = Platform occupant load − (F_p × emergency stair capacity)

Concourse occupant load = 2314 − 513 = 1801 persons

W_{fb} (waiting time at fare barriers) = $F_f - F_p$

[C.1.3b]

$$F_{fb}\left(\text{fare barrier flow time}\right) = \frac{\text{Concourse occupant load}}{\text{Fare barrier exit capacity}}$$

$$F_{fb} = \frac{1801}{560} = 3.22 \text{ minutes}$$

$W_c = F_{fb} - F_p$

$W_{fb} = 3.22 - 3.80 = 0.000$ minutes

W_c (waiting time at concourse exits) = $[F_c - \max(F_{fb} \text{ or } F_p)]$

[C.1.3c]

$$F_c\left(\text{concourse exit flow time}\right) = \frac{\text{Concourse occupant load}}{\text{Concourse exit capacity}}$$

$$F_c = \frac{1801}{0} = 0.000 \text{ minutes}$$

$W_c = F_c - \max(F_{fb} \text{ or } F_p)$

$W_c = 0.000 - 3.80 = 0.000$ minutes

Total exit time = $T\ W_p\ W_{fb}\ W_c$

Total exit time = 2.23 2.71 0.000 0.000

Total exit time = 4.94 minutes

In Test No. 2, the time to reach a point outside any enclosing structure is found to be 4.94 minutes. This meets the requirement of 5.3.3.2.

If the concourse of this station is considered to meet the point of safety definition by the authority having jurisdiction, the calculation for Test No. 2 would be modified. The time to reach a point of safety would include the walking travel time from the remote point on the platform to the concourse only, plus the waiting time at the platform exits. The area of the concourse would have to be large enough to accommodate the concourse occupant load calculated in Test No. 2.

Table C.1.3 Sample Calculations — Center-Platform Station

Egress Element	mm	in.	p/mm-min	pim	p/min
Platform to concourse (downward)					
Stairs (4)	7320	288	0.0555	1.41	406
Escalators (2*)	1220	48	0.0555	1.41	68
Emergency stairs (2)	2440	96	0.0555	1.41	135
Escalator test: 8.67% (Not > 50%)					609
Through fare barriers					
Fare gates (4) (capacity = 50 per gate)					200
Service gates (1)	1 gate	1 gate	60p/gate/min	60p/gate/min	60
Emergency exit doors (2 x double doors)	3660	144	0.0819	2.08	300
					560
Fare barriers to safe area (fare barriers discharge to outside)					
Stairs	0	0	0.0555	1.41	0
Escalators	0	0	0.0555	1.41	0
Emergency stairs	0	0	0.0555	1.41	0
Escalator test: 0.00% (Not > 50%)					0
Walking Time for Longest Exit Route	**m**	**ft**	**m/min**	**fpm**	**min**
Platform to safe area					
On platform, T_1	41.5	136	37.7	124	1.09
Platform to concourse, T_2	9.1	30	14.6	48	0.62
On concourse, T_3	16.5	54	37.7	124	0.44
Concourse to grade, T_4	0	0	14.6	48	0
On grade to safe area, T_5	3.05	10	37.7	124	0.08
Total walking time, $T = T_1 + T_2 + T_3 + T_4 + T_5$					2.23

*One escalator discounted.

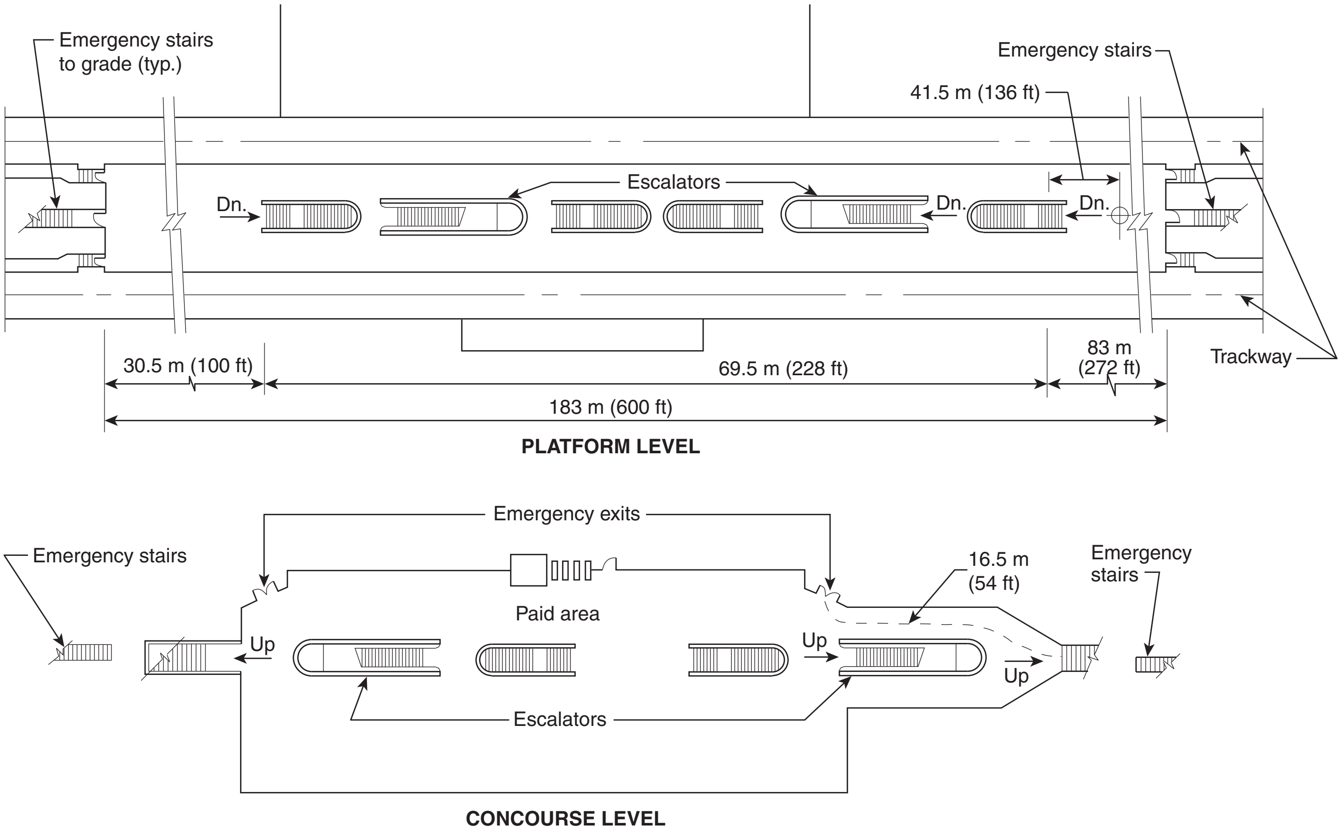


FIGURE C.1.3 Center-Platform Station.

C.1.4 Side-Platform Station Sample Calculation. The sample side-platform station is an enclosed station with a concourse above the platform level but below grade. *(See Figure C.1.4.)* The platform is 183 m (600 ft) long to accommodate the train length. The vertical distance from grade to concourse is 8 m (26 ft). The concourse is 5.5 m (18 ft) above the platform.

The sample station has two entrances normally used by patrons, each containing one escalator and one stair. The entrances are covered at grade level to a point 3.05 m (10 ft) beyond the top of the stairs.

The concourse is divided into two free areas and one paid area separated by fare arrays. Each fare array contains 12 fare gates of the turnstile type and one swinging service gate, 1220 mm (48 in.) wide, equipped with panic hardware for use by handicapped persons and service personnel.

Three open wells, containing two stairs and one escalator, communicate between each platform and the concourse.

Elevators are provided from grade level to concourse and from the concourse to each platform for use by handicapped persons and service personnel. Station ancillary spaces are located at concourse level.

Enclosed emergency stairs that discharge directly to grade are provided at both ends of each platform. Escalators are nominal 1220 mm (48 in.) wide. Stairs regularly used by patrons are 1830 mm (72 in.) wide. Emergency stairs are 1220 mm (48 in.) wide. Doors to emergency stairs are 1220 mm (48 in.) wide.

The station occupant load is 1600 persons, 228 on the outbound platform and 1372 on the inbound platform.

Table C.1.4 lists the data for the exiting analysis of the sample side-platform station.

The egress capacity from platform to concourse meets the criteria of 5.3.3.1 in Test No. 1, where the time to clear the platform is found to be 3.38 minutes for the inbound platform and 0.56 minute for the outbound platform.

In Test No. 2, the total exit time (i.e., the maximum exit time for the two paths examined) is found to be 5.85 minutes. This meets the criteria of 5.3.3.2.

Evacuate platform occupant load(s) from platform(s) in 4 minutes or less.

Inbound platform:

[C.1.4a]

$$F_{p-i}\left(\text{time to clear platform}\right) = \frac{\text{Platform occupant load}}{\text{Platform egress capacity}}$$

$$F_{p-i} = \frac{1372}{406}$$

$$F_{p-i} = 3.38 \text{ minutes}$$

Outbound platform:

C.1.4b]

$$F_{p-o}\left(\text{time to clear platform}\right) = \frac{\text{Platform occupant load}}{\text{Platform egress capacity}}$$

$$F_{p-o} = \frac{228}{406}$$

$$F_{p-o} = 0.56 \text{ minutes}$$

F_p for inbound and outbound occupant loads satisfies the criterion of 4 minutes.

Test No. 2. Evacuate platform occupant load from most remote point on platform to a point of safety in 6 minutes or less.

Inbound platform:

$W_{p\text{-}i}$ (waiting time at platform egress elements) = $F_{p-i} - T_{1_{p\text{-}i}}$

$W_{p\text{-}i}$ = 3.38 – 1.33 = 2.05 minutes

Concourse occupant load = Platform occupant load – ($F_{p\text{-}i}$ × emergency stair capacity)

Concourse occupant load = 1372 – 456 = 916 persons

Outbound platform:

$W_{p\text{-}o}$ (waiting time at platform egress elements) = $F_{p\text{-}o} - T_{1_{p\text{-}o}}$

$W_{p\text{-}o}$ = 0.56 – 0.49 = 0.07 minute

Concourse occupant load = Platform occupant load – ($F_{p\text{-}o}$ × emergency stair capacity)

Concourse occupant load = 228 – 76 = 152 persons

Total concourse occupant load = Concourse load (inbound) + Concourse load (outbound)

Total concourse occupant load = 916 – 152 = 1068 persons

Concourse:

W_{fb} (waiting time at fare barriers)

[C.1.4c]

$$F_{fb} = \frac{\text{Concourse occupant load}}{\text{Fare barrier egress capacity}}$$

$$F_{fb} = \frac{1065}{360}$$

F_{fb} = 2.96 minutes

$W_{fb} = F_{fb}$ - max ($F_{p\text{-}i}$ or $F_{p\text{-}o}$)

W_{fb} = 2.96 – 3.38 = 0.00 minutes

W_c (waiting time at concourse egress elements)

[C.1.4d]

$$F_c\left(\text{concourse flow time}\right) = \frac{\text{Concourse occupant load}}{\text{Concourse egress capacity}}$$

$$F_c = \frac{1065}{272}$$

F_c = 3.92 minutes

$W_c = F_c - \max(F_{fb} \text{ or } F_{p\text{-}i} \text{ or } F_{p\text{-}o})$

W_c = 3.92 –3.38 = 0.54 minutes

[C.1.4e]

$$F_c = (\text{concourse flow time}) = \frac{\text{Concourse occupant load}}{\text{Concourse egress capacity}}$$

$$F_c = \frac{533}{156}$$

Total egress time = max ($T_{p\text{-}i} + W_{p-i}$ + *or* $T_{p-o} + W_{p-o}$) + $W_{fb} + W_c$

Total = 3.26 + 2.05 + 0.00 + 0.54

Total = 5.85 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 occupant load determinations for the two platform levels.

The step-by-step procedure relating to the occupant load calculations generally is recommended as follows:

(1) Calculate the occupant load for each platform level as in the appropriate examples in C.1.3 and C.1.4 for the same assumed time(s) of day. Refer also to 5.3.2.3(2) and A.5.3.2.3(2).
(2) If the fire is on the upper-level platform (for an underground station), an assumption can be made as to the percentage of occupants who might be expected to evacuate the lower level through the normal egress routes versus the percentage who might be expected to exit via emergency stairs. These assumptions will be unique for each system as a function of various parameters, including physical configuration of stations, means of egress, and location of emergency exits; communications facilities to advise passengers, both verbal and signing; level of transit personnel working in stations; and transit personnel emergency procedure responsibilities established for the transit operating authority.
(3) The upper-level occupant load is increased by the people evacuating from the lower level through the normal egress routes in accordance with C.1.5(2).
(4) For a fire on the lower level, appropriate assumptions relative to the distribution of the occupant loads to the available means of egress are calculated in a fashion similar to the procedures described above.

The remainder of the exiting calculations essentially are unchanged from the other sample calculations in C.1.3 and C.1.4.

C.2 Escalators. ANSI/ASME A17.1/CSA B44 is generally recognized as the standard governing the installation and maintenance of escalators.

However, considering the critical operational nature of the escalators in stations, specially designed units with additional safety features should be provided.

Table C.1.4 Sample Calculations — Side-Platform Station

Egress Element	**mm**	**in.**	**p/mm-min**	**pim**	**p/min**
Inbound platform to concourse (upward)					
Stairs (2)	3660	144	0.0555	1.41	203
Escalators (1*)	1220	48	0.0555	1.41	68
Emergency stairs (2)	2440	96	0.0555	1.41	135
					406
Walking Time for Longest Exit Route	**m**	**ft**	**m/min**	**fpm**	**min**
Inbound platform					
On platform, T_1	50.3	165	37.7	124	1.33
Platform to concourse, T_2	5.5	18	14.6	48	0.38
On concourse, T_3	35.1	115	37.7	124	0.94
Concourse to grade, T_4	7.9	26	14.6	48	0.54
On grade to safe area, T_5	3.05	10	37.7	124	0.08
Total walking time, $T = T_1 + T_2 + T_3 + T_4 + T_5$					3.26
Element	**mm**	**in.**	**p/mm-min**	**pim**	**p/min**
Outbound platform to concourse (upward)					
Stairs (2)	3660	144	0.0555	1.41	203
Escalators (1*)	1220	48	0.0555	1.41	68
Emergency stairs (2)	2440	96	0.0555	1.41	135
					406
Walking Time for Longest Exit Route	**m**	**ft**	**m/min**	**fpm**	**min**
Outbound platform					
On platform, T_1	18.2	60	37.7	124	0.49
Platform to concourse, T_2	5.5	18	14.6	48	0.38
On concourse, T_3	39.6	130	37.7	124	1.05
Concourse to grade, T_4	7.9	26	14.6	48	0.54
On grade to safe area, T_5	3.05	10	37.7	124	0.08
Total walking time, $T = T_1 + T_2 + T_3 + T_4 + T_5$					2.54
Concourse:					
Throughfare barriers					
Turnstiles (12) capacity = 25 p/min					300
Service gate (1)	1 gate	1 gate	60p/gate/min	60p/gate/min	60
					360
Fare barriers to safe areas					
Stairs (2)	3660	72	0.0555	1.41	204
Escalator (2*)	1220	48	0.0555	1.41	68
					272

*One escalator discounted (5.3.6).

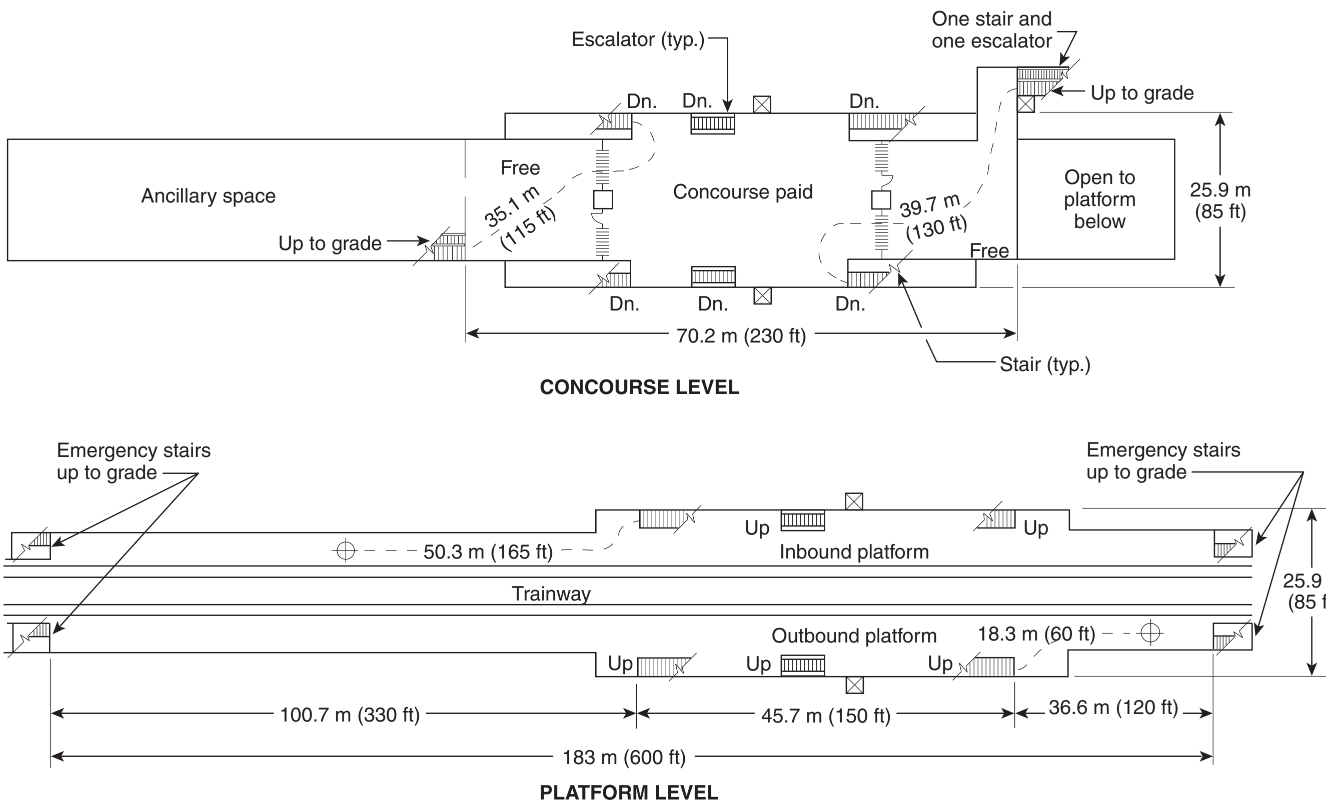


FIGURE C.1.4 Side-Platform Station.

The number of flat steps at the upper landings should be increased in proportion to the vertical rise of the escalator. For a rise up to 6.1 m (20 ft), there should be two flat steps, the ANSI/ASME A17.1/CSA B44 minimum number of flat steps; from 6.1 m (20 ft) to 18.3 m (60 ft) rise, three flat steps; and over 18.3 m (60 ft) rise, four flat steps.

A remote monitoring panel should be provided in the station that displays the following for each escalator:

(1) Direction of travel
(2) Operating speed (if more than one)
(3) Out-of-service status
(4) Flashing light that indicates the escalator is stopped because of activation of a safety device

Annex D Rail Vehicle Fires

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

D.1 Introduction. This annex provides additional information on the hazards associated with burning vehicles and the impact of a burning vehicle on the evacuation of passengers and crew to a point of safety. Emergency evacuation from a vehicle containing a fire could include exiting a vehicle containing the fire to an adjacent vehicle, exiting the train into the operating environment (station, tunnel, etc.) where the train is located, and moving through the operating environment to the point of safety. Chapter 8 contains minimum prescriptive requirements that are intended to provide sufficient time for passengers and crew to safely evacuate from a train containing a fire. This annex provides guidance for designing and evaluating train fire performance. A fire involving a train will have an impact on the conditions in the operating environment, and this type of fire is often used to design emergency systems in operating environments. Chapters 5 through 7 provide requirements on design of the operating environment to ensure that passengers can safely egress to a point of safety.

D.2 Initial Fire Development Inside Vehicles. The development of a fire inside a vehicle is dependent on the fire performance of interior finish materials, the size and location of the initiating fire, the size of the enclosure where the fire is located, and the ventilation into the enclosure.

D.2.1 Material fire performance is most often considered in the evaluation of fire performance of the vehicle. Material fire performance is measured in terms of ignitibility, heat release rate, and smoke and toxic gas production. Flame spread and fire development are dependent on the material's ignitibility and heat release rate as well as the severity of the initiating fire and surrounding environment.

D.2.1.1 The ignitibility, heat release rate, and smoke and toxic gas production can be measured in the ASTM E1354 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 E162 flame spread test. Though this downward flame spread test will screen out many poorly performing materials, the test does not provide a measure of wind-aided flame spread (i.e., upward flame spread or flame spread along a ceiling). Wind-aided flame spread is the fastest type of flame spread and is the type of flame spread that will cause the maximum surface area of material to become involved in the fire. The amount of upward flame spread is affected by the size of the initiating fire and the material fire performance. Some materials might not exhibit any flame spread when exposed to a small fire (e.g., a newspaper fire), but when exposed to something slightly larger (e.g., burning bag of trash with paper and plastic) will readily spread flame.

D.2.1.3 Smoke and toxic gas production can have an impact on the operating environment through which passengers will need to evacuate. Some materials naturally produce more smoke and toxic gases. Some fire-retardant additives can cause more smoke and toxic gases to be produced compared to untreated materials. The amount of smoke and toxic gas produced will be a function of the amount of material burning. Therefore, limiting fire propagation on materials will also help limit the amount of smoke and toxic gas production.

D.2.2 The size and location of the initiating fire will have a significant impact on whether materials become ignited and spread flame. Materials exposed to higher levels of heat (heat fluxes) 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 a vehicle, 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 vehicle body is being manufactured of fiber-reinforced resin composite materials. End caps have been made of composite materials for years, and other vehicle body components are being constructed of composite materials to make vehicles lighter in weight. Even if these materials meet the ASTM E162 requirement in Chapter 8, they can ignite and flames can spread up the height of the vehicle exterior.

D.3.2 Initiating fires on the exterior of the vehicle could range from a small trash fire to a vehicle fire. Although 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 vehicle. Some trains are operated in close proximity to automobiles. Automobile fires can become quite large (~5 MW) and can include fuel spills. If such a fire occurred close to a train, the fire could ignite nearby combustible exterior components on the vehicle.

D.3.3 Connections between vehicles can be particularly vulnerable to exterior fires. Some vehicles are connected by articulating bellows, which are constructed of relatively thin, flexible, combustible materials. The materials used for these components should be carefully screened 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 combustible components of the 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. Where the intended vehicle consist contains multiple units connected by articulating sections creating a single car volume (no separating walls or doors), consideration should be given to resulting effects such as heat release rate of the train fire, the fire profile, and impacts on vehicle and station egress.

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. 2003). 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 the vehicle. If the fuels inside the vehicle can produce a 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 also 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 undercar 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 E2061 [3] and APTA PR-PS-RP-005-00 [4]. On May 12, 1999, the Federal Railroad Administration (FRA) issued a rule containing passenger rail equipment fire safety regulations [5]. The FRA issued a clarification/revision of the fire safety regulations on June 25, 2002 [6]. 49 CFR 238.103 requires that materials used for passenger rail cars and locomotive cabs meet certain fire safety performance criteria and that fire safety (e.g., hazard) analysis be conducted for all new and existing rail passenger equipment.

In addition, scenarios are used to assess the adequacy of vehicle designs considered and ultimately selected. Accordingly, initiating events as referenced from the ASTM rail fire assessment guide [3] are specified for analysis. 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, the design 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 E2061 [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. The four steps are as follows:

(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, as follows:

(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 the process tailored for rail vehicle 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.

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.

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 [10, 11]. 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 (e.g., crumpled newspaper)
(2) Ignition source on top of a vandalized seat (e.g., crumpled newspaper)
(3) Overheated equipment (e.g., 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 is 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, 2012.
(2) *SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings*, Bethesda, MD: Society of Fire Protection Engineers, 2000.
(3) ASTM E2061, *Guide for Fire Hazard Assessment of Rail Transportation Vehicles*. West Conshohocken, PA: ASTM International, 2003.
(4) APTA PR-PS-RP-005-00, *Recommended Practice for Fire Safety Analysis of Existing Passenger Rail Equipment*, Washington, DC: American Public Transportation Association, Approved November 1, 2000, edited 3/22/2004.
(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 Exposed Environment		Highly Exposed (No External Protection)	
Application		Electronic and Protected Electronic Devices (½ Amp Where Max.)		Control and Power Devices Mounted in Control Group Enclosures (Short Circuit Limits)		Power Resistors Open Disconnect Devices Mounted Outside Protective Enclosures		Third Rail Shoe Beams and Current Collection Devices (Short Circuit Unlimited by Onboard Devices)	
Nominal Voltage	Surface	mm	in.	mm	in.	mm	in.	mm	in.
37.5	Horizontal	1.6	1⁄16	3.2	1⁄8	19.1	3⁄4	N/A	N/A
	Vertical	1.6	1⁄16	3.2	1⁄8	12.7	1⁄2	N/A	N/A
74	Horizontal	3.2	1⁄8	6.5	1⁄4	40	1 9⁄16	N/A	N/A
	Vertical	3.2	1⁄8	6.5	1⁄4	25	1	N/A	N/A
230	Horizontal	8.3	3⁄8	15.9	5⁄8	76.2	3	101.6	4
	Vertical	8.3	3⁄8	15.9	5⁄8	50.8	2	57.2	2 1⁄4
600	Horizontal	19.1	1⁄4	31.8	1 1⁄4	177.8	7	254	10
	Vertical	19.1	1⁄4	31.8	1 1⁄4	127	5	152.4	6
750	Horizontal	*	*	40	1 9⁄16	*	*	*	*

*Where no value is given or for nonstandard values, the creepage distance should be agreed upon between the supplier and the authority having jurisdiction. EN 50124-1, while not as conservative as the requirements of this standard, provides a basis for discussion of alternative requirements.

Annex G Onboard Fire Suppression System

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

G.1 Onboard fire suppression systems (e.g., mist systems), while relatively new in the passenger rail and fixed guideway industry, have been successfully used on a number of passenger rail and diesel powered light rail systems outside of the United States. The applications for this type of system can range from protection of diesel engine compartments to the interior of passenger rail vehicles. The use of a fire suppression system could save lives in the incident vehicle during a fire condition; minimize damage to the train, tunnel, and the station which it has entered; reduce or eliminate potential use of station sprinklers; reduce or eliminate the need for down-stands; significantly reduce the impact of designing for fire emergencies on station architecture; reduce tunnel ventilation capacities by approximately 40 percent; reduce the number and/or diameter of emergency ventilation fans at each end of each station and within the tunnels, thus reducing structure sizes; decrease shaft airflow cross section areas by approximately 40 percent; and decrease tunnel ventilation shaft portal areas that correspond to the required fans sizes/velocities. When considering the addition of a fire suppression system, several design challenges should be met by the rail vehicle manufacturer. These challenges include the type of extinguishing medium used, which all must be approved by the authority having jurisdiction, the size and number of medium canisters and where on the vehicle to place them for easy access for maintenance; the resultant increased energy consumption caused by the increase in weight of the suppression system; the maintenance intervals; the cost of the system; the testing and commissioning of the system; and the cost and difficulties associated with retrofitting vehicles.

Annex H Fire Scenarios and Fire Profiles

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

H.1 Introduction. This annex presents information on fire scenarios and methodologies used for predicting fire profiles. The engineering approach for predicting fire profiles has changed over time. Because this is a rapidly developing field, designers should be careful to justify the appropriateness of the methodology selected.

H.2 Fire Scenarios. Representative design fire scenarios include the following:

(1) A fire originates outside the vehicle interior, such as below the floor or rooftop. The fire causes the train to stop in a tunnel or station and could burn through the floor or rooftop into the vehicle's interior.
(2) A fire originates in a vehicle's interior. Some recent train fire studies suggest that an NFPA 130-compliant car will not flashover, unless the event is initiated with two or more liters of a flammable liquid or accelerant. The designer should verify this possibility, as ventilation requirements can vary greatly depending on flashover expectations.
(3) The fire spreads from car-to-car. The fire might spread from car-to-car. Parameters that affect this are the fire resistances of the car ends, whether the interior car doors are left open or closed, whether or not the cars have "bellows" connecting them, the tunnel ventilation moving the heat from the fire site downstream to the next car, whether the car exterior windows are glass or polycarbonate, and whether or not the station has sprinklers.
(4) A fire consumes trash, luggage, wayside electrical equipment, and so forth, in the stations or tunnels.
(5) A fire occurs in a nontransit occupancy that is not protected by sprinklers, such as a kiosk or small shop.
(6) A fire in a dual-powered vehicle (diesel and electric traction) results from the puncture of a fuel tank or rupture of a fuel line.
(7) A fire originates in a maintenance vehicle or work train. If maintenance vehicles are never in the stations or tunnels during periods of revenue operations, then maintenance vehicle or work train fire scenarios do not have to be considered as design fire scenarios.

H.3 Fire Profiles. As per 7.2.1(2), critical velocity is the criterion for determining the required tunnel airflow and hence the ventilation system fan capacities required for tunnel fire incidents. The most commonly used software is the Subway Environment Simulation (SES) computer program [1]. The peak fire heat release rate is the primary fire input.

Tenability in stations is usually predicted by computational fluid dynamics (CFD) programs. The design fire profile is an input to the CFD programs, which predict temperatures, visibilities, and carbon monoxide concentrations as a function of the three-dimensional location in the station and the time since the initiation of the fire. Any combustible materials that could contribute to the fire load at the incident site should also be evaluated.

Several references provided a reasonably good overview of a number of methodologies for predicting design fire profiles [2][3][4]. More recent methodologies include, but are not limited to, the following:

CFD Modeling of Fire Profiles with Cone Calorimeter Tests of Train Materials. This methodology includes cone-calorimeter tests of train materials and computer modeling of fire growth and decay for a fire that originated in a train's interior in the presence of accelerants. Several CFD programs have been used in predicting fire profiles for transit and rail projects in the United States since 2005. The CFD programs are validated for their intended use and predict pre- and post-flashover fire profiles. When selecting a computer program, it is important to select the program that best fits the need of the problem rather than to select the program based on availability. The following conditions should be considered when building a CFD model for predicting fire profiles: 1) quantity and properties of accelerants; 2) fire characteristic of car interior materials measured according to ASTM E1354; 3) layout of the car interiors, including seating layouts, orientations, and dimensions; 4) bags and luggage carried by passengers; 5) overall thermal transmission value for vehicle body; 6) openings, including windows and doors; 7) oxygen levels; and 8) mechanical and natural ventilation.

Full-Scale Fire Tests. A handful of full-scale train fire tests have yielded data to estimate the fire profiles. The 1995 EUREKA project [5] showed that an intercity train reached a peak fire heat release rate of 12 MW in 25 minutes, while a Metro train car reached a peak fire heat release rate of 35 MW in 5 minutes. A Baku Metro train fire (Azerbaijan, 1995) was estimated to reach 100 MW in about 30-45 minutes, and in 2002 a Frankfurt Metro fire model reached 5.6 MW in 30 minutes [3]. The fire profile studies focused on accidental fires such as debris or transient car loadings becoming ignited or mechanical failure causing the train car itself to ignite.

More recent full-scale fire tests have focused on fires where a deliberate attempt was made to ignite and flashover the train car. The full-scale fire tests in Sweden [6] used a commuter train and found that the maximum fire heat release rate of 76.7 MW was achieved in 12.7 minutes in one of the tests, and the corresponding value for another test with the train walls and ceiling covered by aluminum was 77.4 MW and occurred 117.9 minutes after ignition. The general shape of the two fire curves are almost the same. Other full-scale fire tests in Canada used a subway car, which reached a maximum FHRR of 52.5 MW in 2.3 minutes, and a railway car, which reached a peak FHRR of 32 MW in 18 minutes [7]. A fourth test was performed in Australia, where a passenger rail car reached a maximum FHRR of 13 MW in 2.3 minutes [8].

Modern trains that are fire hardened have not been readily tested. Research has been on older model trains where the degree of fire hardening has not been quantified. Initiating fires in order to combust the trains have been disproportionately large in consideration of the ignition source typically found on a train and have been conspicuously located in the worst-case location in order to combust the train. The above results in a premature growth to the combustible lining materials on the train than would ordinarily be present from ignition sources; this yields extremely large fires that overcome the fire hardening characteristics and result in very large peak heat release rates. Consideration should also be given to ventilation conditions, different types of lining materials, especially at the ceilings, and the interconnection of train cars.

H.4 Impacts on Ventilation System Design. The train fire profile has a major impact on the station and tunnel ventilation design. The design fire scenarios and fire profiles should be determined based on the perceived threats. In response to increased awareness that transit and passenger rail systems are potential terrorist targets, some systems are designed for significant incendiary fires and others are not. The decision could be based on cost, the inferred risk, or a formal threat and vulnerability assessment.

H.5 References. The following references are cited in this annex:

(1) Parsons, Brinckerhoff, Quade & Douglas, Inc., "Subway Environmental Design Handbook (SEDH), Volume II, Subway Environment Simulation Computer Program, SES Version 4.1, Part I User's Manual," 2nd edition, February 2002, U.S. Department of Transportation, Washington, DC.

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

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

(4) Kennedy, W.D., Ray, R.E., and Guinan, J.W., "A Short History of Train Fire Heat Release Calculations," presented at the 1998 ASHRAE Annual Meeting, Toronto, Ontario, Canada, June 1998.

(5) Sørlie, R. and Mathisen, H.M., EUREKA-EU 499 Firetun-Project: Fire Protection in Traffic Tunnels, SINTEF, Applied Thermodynamics, 1994.

(6) Lonnemark, A., et al., "Large-scale Commuter Train Fire Tests — Results from the METRO Project," presented at the Fifth International Symposium on Tunnel Safety and Security, New York, 14–16 March, 2012.

(7) Hadjisophcleous, G., Lee, D.H. and Park, W.H., "Full-scale Experiments for Heat Release Rate Measurements of Railcar Fires," presented at the Fifth International Symposium on Tunnel Safety and Security, New York, 14–16 March, 2012.

(8) White, N., Dowling, V,. and Barnett, J., "Full-scale Fire Experiment on a Typical Passenger Train, in Fire Safety Science," Proceedings of the Eighth International Symposium, Beijing, International Association for Fire Safety Science, Boston, MA, 2005.

Annex I Informational References

I.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.

I.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 72 ®, *National Fire Alarm and Signaling Code*, 2016 edition.

NFPA *101*®, *Life Safety Code*®, 2015 edition.

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

NFPA 1006, *Standard for Technical Rescuer Professional Qualifications*, 2013 edition.

NFPA 1670, *Standard on Operations and Training for Technical Search and Rescue Incidents*, 2014 edition.

I.1.2 Other Publications.

I.1.2.1 APTA Publications. American Public Transportation Association, 1666 K Street NW, Washington, DC 20006.

APTA PR-PS-RP-005-00, *Recommended Practice for Fire Safety Analysis of Existing Passenger Rail Equipment*, 2000, edited 3/22/2004.

APTA PR-E-S-013-99, Rev 1, *Standard for Emergency Lighting Design for Passenger Cars*, 1999, revised 2007.

I.1.2.2 ASHRAE Publications. ASHRAE Inc., 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.

ASHRAE Handbook – Fundamentals, 2013.

ASHRAE Handbook – Applications, 2015.

ASHRAE Handbook – Systems and Equipment, 2012.

I.1.2.3 ASME Publications. ASME Technical Publishing Office, Two Park Avenue, New York NY 10016-5990.

ANSI/ASME A17.1, *Safety Code for Elevators and Escalators*, 2013.

I.1.2.4 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM D3675, *Standard Test Method for Surface Flammability of Flexible Cellular Materials Using a Radiant Heat Energy Source*, 2014.

ASTM E162, *Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source*, 2013.

ASTM E662, *Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials*, 2015.

ASTM E1354, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*, 2015a.

ASTM E1537, *Standard Test Method for Fire Testing of Upholstered Furniture*, 2013.

ASTM E1590, *Standard Test Method for Fire Testing of Mattresses*, 2013.

ASTM E2061, *Standard Guide for Fire Hazard Assessment of Rail Transportation Vehicles*, 2012.

I.1.2.5 CENELEC Publications. CENELEC, 35, European Committee for Electrotechnical Standardization, CEN-CENELEC Management Centre, Avenue Marnix 17, 4th floor, B-1000 Brussels.

EN 50124-1, *Railway Applications — Insulation Coordination. Part 1: Basic Requirements — Clearances and Creepage Distances for All Electrical and Electronic Equipment*, 2001, revised 2010.

I.1.2.6 FAA Publications. U.S. Federal Aviation Administration, U.S. Government Publishing Office, Washington, DC 20402.

FAR 25.853(c), *Oil Burner Test for Seat Cushions*.

I.1.2.7 ISO Publications. International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland.

ISO/DIS 13571, *Life threat from fires — Guidance on the estimation of time available for escape using fire data*, 2006.

I.1.2.8 NIST Publications. National Institute of Standards and Technology, 100 Bureau Drive, Gaithersburg, MD 20899-1070.

NIST IR 4730, *Routine for Analysis of the People Movement Time for Elevator Evacuation*, Klote and Alvord, 1992.

I.1.2.9 OSHA Publications. Occupational Safety and Health Administration, 200 Constitution Avenue, NW, Washington, DC 20210.

Title 29, Code of Federal Regulations, Part 1910.95, "Occupational Noise Exposure," 2008.

I.1.2.10 SFPE Publications. Society of Fire Protection Engineers, 9711 Washingtonian Blvd, Suite 380, Gaithersburg, MD 20878.

SFPE Engineering Guide to Performance-Based Fire Protection Analysis and Design of Buildings, 2007.

I.1.2.11 TDC Publications. Transit Development Corporation, Inc., 1666 K St. NW, Washington, DC 20006.

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.

I.1.2.12 Other Publications.

"Acute Exposure Guideline Levels for Selected Airborne Chemicals," Vol. 8, Committee on Acute Exposure Guideline Levels, Committee on Toxicology, National Research Council. National Academies Press, Washington DC, 2010.

Ahrens, 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.

Bothe C., G. M. Wolinski, and A. J. Breunese, "Spalling of concrete tunnel linings in fire," *(Re)Claiming the Underground Space,* J. Saveur, ed., pp. 227–231, Swets & Zeitlinger Lisse, 2003.

Bukowski, R. W., et al. *Fire Hazard Assessment Method*, NIST Handbook 146, Gaithersburg, MD: NIST, 1989.

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

"Escalator Handling Capacity," *Elevator World*, December 1996.

Federal Railroad Administration, Title 49, Code of Federal Regulations, 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, Title 49, Code of Federal Regulations, Transportation, Part 238, "Passenger Equipment Safety Standards: Final Rules," *Federal Register*, Vol. 67, No. 122, June 25, 2014, 42892-42912. Washington, DC: National Archives and Records Administration.

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.

Fruin, J. J. *Pedestrian Planning and Design*. 1979 (revised ed.). Mobile, AL: Elevator World Inc., Educational Services Division, 354 Morgan Avenue, Mobile, AL, 36606.

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.

Hadjisophcleous, G., Lee, D.H. and Park, W.H., "Full-scale Experiments for Heat Release Rate Measurements of Railcar Fires," presented at the Fifth International Symposium on Tunnel Safety and Security, New York, 14–16 March, 2012.

Hirschler, M. M. "A New Mattress Fire Test for Use in Detention Environments," Business Communications Company Eighth Annual Conference on Recent Advances in Flame Retardancy of Polymeric Materials, Stamford, CT, June 2–4, 1997.

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.

Kennedy, W.D., Ray, R.E., and Guinan, J.W., "A Short History of Train Fire Heat Release Calculations," presented at the 1998 ASHRAE Annual Meeting, Toronto, Ontario, Canada, June 1998.

Khoury, G.A. "Passive Protection Against Fire," *Tunnels and Tunneling International*, pp. 40–42. November 2002.

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

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

London Underground Ltd., *LUL Station Planning Guidelines*, London, 2015.

Lonnemark, A., et al., "Large-scale Commuter Train Fire Tests — Results from the METRO Project," presented at the Fifth International Symposium on Tunnel Safety and Security, New York, 14–16 March 2012.

Ontario Building Code, "Rapid Transit Stations," Canada, 2012.

Parsons, Brinckerhoff, Quade & Douglas, Inc., "Subway Environmental Design Handbook (SEDH), Volume II, Subway Environment Simulation Computer Program, SES Version 4.1, Part I User's Manual," 2nd edition, February 2002, U.S. Department of Transportation, Washington, DC.

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 NISTR 6825, December 2002.

Schachenmayr, Martin P. *Application Guidelines for the Egress Element of the Fire Protection Standard for Fixed Guideway Transit Systems*, Parsons, Brinckerhoff, Quade & Douglas, 1998.

Sørlie, R. and Mathisen, H.M., EUREKA-EU 499 Firetun-Project: Fire Protection in Traffic Tunnels, SINTEF, Applied Thermodynamics, 1994.

Strege, S., B. Y. Lattimer, and C. Beyler. January 2003. "Fire Induced Failure of Polycarbonate Windows in Railcars," *Proceedings of Fire and Materials*. London, UK: Interscience Communications, Ltd., 269–278, January 2003.

Subway Environmental Design Handbook (SEDH), National Technical Information, December 1993.

Tatnall, P.C. "Shotcrete in Fires: Effects of Fibers on Explosive Spalling," American Shotcrete Association, Farmington Hills, Michigan, 2002.

White, N., Dowling, V., and Barnett, J., "Full-scale Fire Experiment on a Typical Passenger Train, in Fire Safety Science," Proceedings of the Eighth International Symposium, Beijing, International Association for Fire Safety Science, Boston, MA, 2005.

I.2 Informational References. The following documents or portions thereof are listed here as informational resources only. They are not a part of the requirements of this document.

ANSI/ASA S3.5, *American National Standard Methods for Calculation of the Speech Intelligibility Index*, 1997 (R2012).

ANSI/ASA S12.65, *American National Standard for Rating Noise with Respect to Speech Interference*, 2006 (R2011).

BS EN 50129, *Railway Applications. Communication, Signaling and Processing Systems. Safety-Related Electronic Systems for Signaling*, 2003, Corrigendum 2010.

Building Type Basics for Transit Facilities, K. W. Griffin, ed., John Wiley & Sons, 2004.

Friedman, R. "An International Survey of Computer Models for Fire and Smoke," *SFPE Journal of Fire Protection Engineering*, 4(3), 1992, pp. 81–92.

International Standards Organization Technical Committee 92/SC 3/WG5, "ISO 13571 — Life Threatening Components of Fire — Guidance on the Estimation of Time to Compromised Tenability in Fires." Document ISO/TC 92/SC 3/N203, 2012.

ISO 1999, *Acoustics — Estimation of noise-induced hearing loss*, 2013.

MIL-STD 882D, *Standard Practice for System Safety,* 2012.

NFPA *Fire Protection Handbook*, 20th edition, 2008.

Smith, Edwin E., Phase I Report, *Transit Vehicle Material Specification Using Release Rate Tests for Flammability and Smoke*, October 1976.

Society of Fire Protection Engineers. *SFPE Engineering Guide to Predicting 1st and 2nd Degree Skin Burns,* 1st Edition, Bethesda, MD, 2000.

I.3 References for Extracts in Informational Sections.

NFPA 921, *Guide for Fire and Explosion Investigations*, 2014 edition.

Index

Sequence of Events for the Standards Development Process

Once the current edition is published, a Standard is opened for Public Input.

Step 1 – Input Stage

- Input accepted from the public or other committees for consideration to develop the First Draft
- Technical Committee holds First Draft Meeting to revise Standard (23 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Technical Committee ballots on First Draft (12 weeks); Technical Committee(s) with Correlating Committee (11 weeks)
- Correlating Committee First Draft Meeting (9 weeks)
- Correlating Committee ballots on First Draft (5 weeks)
- First Draft Report posted on the document information page

Step 2 – Comment Stage

- Public Comments accepted on First Draft (10 weeks) following posting of First Draft Report
- If Standard does not receive Public Comments and the Technical Committee chooses not to hold a Second Draft meeting, the Standard becomes a Consent Standard and is sent directly to the Standards Council for issuance (see Step 4) or
- Technical Committee holds Second Draft Meeting (21 weeks); Technical Committee(s) with Correlating Committee (7 weeks)
- Technical Committee ballots on Second Draft (11 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Correlating Committee Second Draft Meeting (9 weeks)
- Correlating Committee ballots on Second Draft (8 weeks)
- Second Draft Report posted on the document information page

Step 3 – NFPA Technical Meeting

- Notice of Intent to Make a Motion (NITMAM) accepted (5 weeks) following the posting of Second Draft Report
- NITMAMs are reviewed and valid motions are certified by the Motions Committee for presentation at the NFPA Technical Meeting
- NFPA membership meets each June at the NFPA Technical Meeting to act on Standards with "Certified Amending Motions" (certified NITMAMs)
- Committee(s) vote on any successful amendments to the Technical Committee Reports made by the NFPA membership at the NFPA Technical Meeting

Step 4 – Council Appeals and Issuance of Standard

- Notification of intent to file an appeal to the Standards Council on Technical Meeting action must be filed within 20 days of the NFPA Technical Meeting
- Standards Council decides, based on all evidence, whether to issue the standard or to take other action

Notes:

1. Time periods are approximate; refer to published schedules for actual dates.
2. Annual revision cycle documents with certified amending motions take approximately 101 weeks to complete.
3. Fall revision cycle documents receiving certified amending motions take approximately 141 weeks to complete.

Committee Membership Classifications[1,2,3,4]

The following classifications apply to Committee members and represent their principal interest in the activity of the Committee.

1. M *Manufacturer:* A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.
2. U *User:* A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.
3. IM *Installer/Maintainer:* A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.
4. L *Labor:* A labor representative or employee concerned with safety in the workplace.
5. RT *Applied Research/Testing Laboratory:* A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.
6. E *Enforcing Authority:* A representative of an agency or an organization that promulgates and/or enforces standards.
7. I *Insurance:* A representative of an insurance company, broker, agent, bureau, or inspection agency.
8. C *Consumer:* A person who is or represents the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in (2).
9. SE *Special Expert:* A person not representing (1) through (8) and who has special expertise in the scope of the standard or portion thereof.

NOTE 1: "Standard" connotes code, standard, recommended practice, or guide.

NOTE 2: A representative includes an employee.

NOTE 3: While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of member or unique interests need representation in order to foster the best possible Committee deliberations on any project. In this connection, the Standards Council may make such appointments as it deems appropriate in the public interest, such as the classification of "Utilities" in the National Electrical Code Committee.

NOTE 4: Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.

Submitting Public Input / Public Comment Through the Online Submission System

Soon after the current edition is published, a Standard is open for Public Input.

Before accessing the Online Submission System, you must first sign in at www.nfpa.org. *Note: You will be asked to sign-in or create a free online account with NFPA before using this system:*

a. Click on Sign In at the upper right side of the page.
b. Under the Codes and Standards heading, click on the "List of NFPA Codes & Standards," and then select your document from the list or use one of the search features.

OR

a. Go directly to your specific document information page by typing the convenient shortcut link of www.nfpa.org/document# (Example: NFPA 921 would be www.nfpa.org/921). Sign in at the upper right side of the page.

To begin your Public Input, select the link "The next edition of this standard is now open for Public Input" located on the About tab, Current & Prior Editions tab, and the Next Edition tab. Alternatively, the Next Edition tab includes a link to Submit Public Input online.

At this point, the NFPA Standards Development Site will open showing details for the document you have selected. This "Document Home" page site includes an explanatory introduction, information on the current document phase and closing date, a left-hand navigation panel that includes useful links, a document Table of Contents, and icons at the top you can click for Help when using the site. The Help icons and navigation panel will be visible except when you are actually in the process of creating a Public Input.

Once the First Draft Report becomes available there is a Public Comment period during which anyone may submit a Public Comment on the First Draft. Any objections or further related changes to the content of the First Draft must be submitted at the Comment stage.

To submit a Public Comment you may access the online submission system utilizing the same steps as previously explained for the submission of Public Input.

For further information on submitting public input and public comments, go to: http://www.nfpa.org/publicinput.

Other Resources Available on the Document Information Pages

About tab: View general document and subject-related information.

Current & Prior Editions tab: Research current and previous edition information on a Standard.

Next Edition tab: Follow the committee's progress in the processing of a Standard in its next revision cycle.

Technical Committee tab: View current committee member rosters or apply to a committee.

Technical Questions tab: For members and Public Sector Officials/AHJs to submit questions about codes and standards to NFPA staff. Our Technical Questions Service provides a convenient way to receive timely and consistent technical assistance when you need to know more about NFPA codes and standards relevant to your work. Responses are provided by NFPA staff on an informal basis.

Products & Training tab: List of NFPA's publications and training available for purchase.

Information on the NFPA Standards Development Process

I. Applicable Regulations. The primary rules governing the processing of NFPA standards (codes, standards, recommended practices, and guides) are the NFPA *Regulations Governing the Development of NFPA Standards (Regs)*. Other applicable rules include NFPA *Bylaws*, NFPA *Technical Meeting Convention Rules*, NFPA *Guide for the Conduct of Participants in the NFPA Standards Development Process*, and the NFPA *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council*. Most of these rules and regulations are contained in the *NFPA Standards Directory*. For copies of the *Directory*, contact Codes and Standards Administration at NFPA Headquarters; all these documents are also available on the NFPA website at "www.nfpa.org."

The following is general information on the NFPA process. All participants, however, should refer to the actual rules and regulations for a full understanding of this process and for the criteria that govern participation.

II. Technical Committee Report. The Technical Committee Report is defined as "the Report of the responsible Committee(s), in accordance with the Regulations, in preparation of a new or revised NFPA Standard." The Technical Committee Report is in two parts and consists of the First Draft Report and the Second Draft Report. (See *Regs* at Section 1.4.)

III. Step 1: First Draft Report. The First Draft Report is defined as "Part one of the Technical Committee Report, which documents the Input Stage." The First Draft Report consists of the First Draft, Public Input, Committee Input, Committee and Correlating Committee Statements, Correlating Notes, and Ballot Statements. (See *Regs* at 4.2.5.2 and Section 4.3.) Any objection to an action in the First Draft Report must be raised through the filing of an appropriate Comment for consideration in the Second Draft Report or the objection will be considered resolved. [See *Regs* at 4.3.1(b).]

IV. Step 2: Second Draft Report. The Second Draft Report is defined as "Part two of the Technical Committee Report, which documents the Comment Stage." The Second Draft Report consists of the Second Draft, Public Comments with corresponding Committee Actions and Committee Statements, Correlating Notes and their respective Committee Statements, Committee Comments, Correlating Revisions, and Ballot Statements. (See *Regs* at 4.2.5.2 and Section 4.4.) The First Draft Report and the Second Draft Report together constitute the Technical Committee Report. Any outstanding objection following the Second Draft Report must be raised through an appropriate Amending Motion at the NFPA Technical Meeting or the objection will be considered resolved. [See *Regs* at 4.4.1(b).]

V. Step 3a: Action at NFPA Technical Meeting. Following the publication of the Second Draft Report, there is a period during which those wishing to make proper Amending Motions on the Technical Committee Reports must signal their intention by submitting a Notice of Intent to Make a Motion (NITMAM). (See *Regs* at 4.5.2.) Standards that receive notice of proper Amending Motions (Certified Amending Motions) will be presented for action at the annual June NFPA Technical Meeting. At the meeting, the NFPA membership can consider and act on these Certified Amending Motions as well as Follow-up Amending Motions, that is, motions that become necessary as a result of a previous successful Amending Motion. (See 4.5.3.2 through 4.5.3.6 and Table 1, Columns 1-3 of *Regs* for a summary of the available Amending Motions and who may make them.) Any outstanding objection following action at an NFPA Technical Meeting (and any further Technical Committee consideration following successful Amending Motions, see *Regs* at 4.5.3.7 through 4.6.5.3) must be raised through an appeal to the Standards Council or it will be considered to be resolved.

VI. Step 3b: Documents Forwarded Directly to the Council. Where no NITMAM is received and certified in accordance with the Technical Meeting Convention Rules, the standard is forwarded directly to the Standards Council for action on issuance. Objections are deemed to be resolved for these documents. (See *Regs* at 4.5.2.5.)

VII. Step 4a: Council Appeals. Anyone can appeal to the Standards Council concerning procedural or substantive matters related to the development, content, or issuance of any document of the NFPA or on matters within the purview of the authority of the Council, as established by the Bylaws and as determined by the Board of Directors. Such appeals must be in written form and filed with the Secretary of the Standards Council (see *Regs* at Section 1.6). Time constraints for filing an appeal must be in accordance with 1.6.2 of the *Regs*. Objections are deemed to be resolved if not pursued at this level.

VIII. Step 4b: Document Issuance. The Standards Council is the issuer of all documents (see Article 8 of *Bylaws*). The Council acts on the issuance of a document presented for action at an NFPA Technical Meeting within 75 days from the date of the recommendation from the NFPA Technical Meeting, unless this period is extended by the Council (see *Regs* at 4.7.2). For documents forwarded directly to the Standards Council, the Council acts on the issuance of the document at its next scheduled meeting, or at such other meeting as the Council may determine (see *Regs* at 4.5.2.5 and 4.7.4).

IX. Petitions to the Board of Directors. The Standards Council has been delegated the responsibility for the administration of the codes and standards development process and the issuance of documents. However, where extraordinary circumstances requiring the intervention of the Board of Directors exist, the Board of Directors may take any action necessary to fulfill its obligations to preserve the integrity of the codes and standards development process and to protect the interests of the NFPA. The rules for petitioning the Board of Directors can be found in the *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council* and in Section 1.7 of the *Regs*.

X. For More Information. The program for the NFPA Technical Meeting (as well as the NFPA website as information becomes available) should be consulted for the date on which each report scheduled for consideration at the meeting will be presented. To view the First Draft Report and Second Draft Report as well as information on NFPA rules and for up-to-date information on schedules and deadlines for processing NFPA documents, check the NFPA website (www.nfpa.org/docinfo) or contact NFPA Codes & Standards Administration at (617) 984-7246.

ANNEXE C

Portes, les fenêtres et les puits de lumière, résidentiels, vendus au Canada—critères d'admissibilité

Les spécifications techniques d'homologation ENERGY STAR®

ENERGY STAR HAUTE EFFICACITÉ HIGH EFFICIENCY

Téléchargez la version PDF (389ko)

Version 4 - 1er février 2015

Cette spécification technique déterminent la façon dont les fenêtres, les portes et les puits de lumière résidentiels vendus au Canada se qualifient dans le cadre du programme ENERGY STAR®. Cette spécification a été établies par Ressources naturelles Canada (RNCan). RNCan a été autorisée par la Environmental Protection Agency (EPA) des États-Unis à promouvoir et administrer le nom et le symbole ENERGY STAR au Canada. Un produit doit être conforme aux spécifications établies pour être présenté comme étant homologué ENERGY STAR au Canada par le fabricant ou son agent autorisé. Les fabricants doivent également signer une entente administrative avec RNCan.

1) Définitions

Types de produit

A. Fenêtre : Assemblage constitué d'un cadre ou d'un châssis et tenant un ou plusieurs morceaux de vitrage, conçu pour laisser entrer la lumière ou l'air dans une enceinte et pour être installé en position verticale dans l'un des murs extérieurs d'un bâtiment résidentiel. Cela inclut toutes les impostes de plus de 700 mm (27 po) de hauteur.

B. Porte : Système d'entrée coulissant ou battant conçu pour être installé dans un mur vertical séparant des espaces climatisés ou non climatisés dans un bâtiment résidentiel. La principale fonction d'une porte est de permettre d'entrer et de sortir. Toutes les impostes inférieures ou égales à 700 mm (27 po) de hauteur, de même que toutes les fenêtres latérales, sont considérées comme faisant partie intégrante de la porte.

C. Puits de lumière : Fenêtre conçue pour être installée en pente ou en position horizontale dans le toit d'un bâtiment résidentiel, et dont la fonction principale est de fournir un éclairage ou une ventilation naturelle.
D. Porte d'entrée coulissante : Porte contenant un ou plusieurs panneaux à commande manuelle coulissant horizontalement dans un cadre commun.
E. Porte d'entrée battante : Système de porte comportant, au minimum, un type quelconque de fixation à charnière entre le battant et le montant, le meneau ou le bord d'un autre battant, ou un seul axe vertical fixe autour duquel le battant pivote entre la position ouverte et la position fermée.
F. Fenêtre latérale : Type de fenêtre constitué d'une surface vitrée ou givrée, ou fenêtre à guillotine installée sur un côté ou les deux côtés d'une porte.
G. Imposte : Type de fenêtre constitué d'une surface vitrée ou givrée, ou fenêtre à guillotine installée au-dessus d'une porte ou d'une fenêtre.
H. Dispositif tubulaire d'éclairage naturel ou puits de lumière tubulaire : Dispositif fixe principalement conçu pour transmettre l'éclairage naturel de la toiture d'un bâtiment résidentiel à un plafond au moyen d'un conduit tubulaire. Le dispositif est constitué d'une surface vitrée extérieure résistante aux intempéries, d'un tube de transmission de lumière doté d'une surface intérieure réfléchissante et d'un dispositif d'étanchéité intérieur tel qu'un panneau de plafond translucide.
I. Vitrage dynamique : Tout produit de fenêtrage ayant la capacité entièrement réversible de modifier ses propriétés de performance, notamment le facteur U, le coefficient de gain de chaleur solaire (CGCS), la transmission visible et le rendement énergétique (RE). Cela inclut, sans en exclure d'autres, les systèmes d'ombrage entre les couches de vitrage et le vitrage chromogène.

i. Vitrage chromogène : Vaste catégorie de vitrages commutables ayant la propriété de modifier leurs qualités optiques avec effet réversible, y compris des matières actives (p. ex., le vitrage électrochromique et les matières particulaires (MP)) et des matières inertes (p. ex., photochromique, thermochromique, etc.).
ii. Système d'ombrage interne : Stores ou toiles mobiles intégrés entre les panneaux de vitre d'une fenêtre, d'une porte ou d'un puits de lumière.

Paramètres de rendement :

J. Facteur U : Transfert de chaleur par temps, par région et par degré de différence de température exprimé en W/m^2°K (Btu/h pi^2 °F). Le facteur U multiplié par la différence de température intérieure-extérieure et par la superficie projetée du produit de fenêtrage donne la quantité totale de chaleur transférée à travers le produit de fenêtrage par conduction, par convection ou par rayonnement de grandes longueurs d'onde. La multiplication par 5,678263 du facteur U exprimé en Btu/h pi2 ·°F convertit la valeur en W/m2·K. Le facteur U en Btu/h pi^2 ·°F doit être en conformité avec le tableau 1 avant la conversion en W/m^2·K.
K. Coefficient de gain de chaleur solaire (CGCS) : Rapport entre la chaleur solaire pénétrant un espace à travers un produit de fenêtrage et le rayonnement solaire incident.
L. Fuite d'air : débit d'air s'écoulant des produits de fenestration, exprimé en L/s/m2. L'infiltration d'air est le débit d'air vers l'intérieur de l'enveloppe du bâtiment et l'exfiltration est le débit d'air vers l'extérieur de l'enveloppe du bâtiment. La multiplication par 5,08 du débit d'air convertit la

valeur en L/s/m2. Le taux de fuite d'air en pi3/min/pi2 doit être en conformité avec le tableau 1 avant la conversion en L/s/m2.
M. Rendement énergétique (RE) : Valeur sans unité dérivée d'une formule qui équilibre les pertes thermiques (facteur U), les pertes par fuite d'air et les gains solaires passifs potentiels d'un produit de fenêtrage donné. Le RE s'applique aux systèmes de fenêtrage qu'on installe à la verticale dans les immeubles résidentiels bas. Voici l'équation simplifiée :

$$RE = (57{,}76 \times CGCS_w) - (21{,}90 \times U_w) - (1{,}97 \times L75) + 40$$

dans laquelle

i. $CGCS_w$ = coefficient de gain de chaleur solaire du fenêtrage
ii. U_w = facteur U du fenêtrage (W/m2)
iii. L_{75} = coefficient des fuites d'air du fenêtrage, à une différence de pression de 75 Pa, établi conformément à la norme 101/I.S.2/A440 (North American Fenestration Standard) de l'AAMA/WDMA/CSA, exprimé en L/s•m^2. Le L_{75} correspond à la moyenne des infiltrations et des exfiltrations d'air.

Des explications plus détaillées de l'équation RE se trouvent dans la norme CSA A440.2.

N. Précision décimale : Au besoin, les chiffres sont arrondis à l'aide de la méthode arithmétique, avant d'effectuer les calculs, à la décimale indiquée au Tableau 1.

Tableau 1 : Précision décimale

Valeur	Précision décimale
Fuite d'air (infiltration)	1
Fuite d'air (exfiltration)	1
L75	1
Facteur U et CGCS	2
Rendement énergétique	0

Autres définitions :

O. Résidentiel : Aux fins du programme ENERGY STAR, « résidentiel » désigne les produits conçus pour être installés dans les bâtiments d'occupant résidentielle répondant à la partie 9 du Code national du bâtiment du Canada. Ces bâtiments ont trois étages ou moins et leur superficie est inférieure à 600 mètres carrés.
P. Vitrage isolant : Assemblage composé de feuilles de verre scellées sur les bords et séparées par des espaces déshydratés.
Q. Titulaire de marque maison : Entreprise qui commercialise des modèles de fenêtre, de porte ou de puits de lumière fabriqués par une autre entreprise sous son propre nom.
R. Conseil canadien des normes (CCN) : Société d'État canadienne qui accrédite les organismes rédacteurs de normes, les laboratoires d'essais, les organismes d'homologation, les

organismes de gestion de la qualité et les organismes d'enregistrement des systèmes de gestion environnementale.
S. U.S. National Fenestration Rating Council (NFRC) : Organisme américain qui élabore des normes de rendement énergétique pour les produits de fenêtrage, et qui offre une vérification indépendante du rendement énergétique et d'autres valeurs connexes pour les produits de fenêtrage.

2) Portée

A. Produits inclus : Les produits qui répondent à la définition d'une porte, d'une fenêtre ou d'un puits de lumière résidentiels, selon ce qui est précisé aux présentes, sont admissibles à l'homologation ENERGY STAR, sauf les produits énumérés à la section 2.B.
B. Produits exclus : Les produits assemblés sur place, y compris, sans en exclure d'autres, les fenêtres à guillotine, les fenêtres, les portes et les puits de lumière installés dans les immeubles non résidentiels, et les pièces ou accessoires pour fenêtres, portes et puits de lumière dont on ne tient pas compte dans le calcul du rendement énergétique certifié d'un produit.

3) Critères d'admissibilité

Les zones climatiques canadiennes sont définies à l'Annexe A. Les critères d'admissibilité de chacune sont établis dans les tableaux qui suivent. Le cas échéant, la qualification peut être établie à l'aide des critères d'admissibilité ou autres critères applicables au même type ou sous-type de produit. La zone la plus élevée que l'on réussit à déterminer correspond à la qualification établie. La qualification est cumulative. Par exemple, un modèle qui se qualifie en zone 3 se qualifie également en zones 1 et 2. Les taux de fuite d'air indiqués dans les tableaux des critères d'admissibilité s'appliquent tant aux valeurs d'infiltration que d'exfiltration; il ne s'agit pas d'une moyenne de ces valeurs. Les vitrages dynamiques doivent être conformes aux critères d'admissibilité, à l'état teinté minimal pour les vitrages chromogènes ou à la position « ouverte » pour les systèmes d'ombrage interne.

A. Fenêtres

Tableau A1 : Critères d'admissibilité basés sur le rendement énergétique pour les fenêtres

Zone	Rendement énergétique minimum (sans unité)	Taux de fuite maximal $L/s/m^2$
1	25	1,5
2	29	1,5
3	34	1,5

Tableau A2 : Critères d'admissibilités basés sur le facteur U pour les fenêtres

Zone	Facteur U maximum W/m^2·K (Btu/h·ft.^{2}·°F)	Rendement énergétique minimum (sans unité)	Taux de fuite maximal L/s/m^2
1	1,60 (0,28)	16	1,5
2	1,40 (0,25)	20	1,5
3	1,20 (0,21)	24	1,5

B. Portes

Tableau B1 : Critères d'admissibilité basés sur le rendement énergétique pour les portes battantes, panneaux latéraux et fenêtres d'imposte

Zone	Rendement énergétique minimum (sans unité)	Taux de fuite maximal L/s/m^2
1	25	1,5
2	29	1,5
3	34	1,5

Tableau B2 : Critères d'admissibilité basés sur le facteur U pour les portes battantes, panneaux latéraux et fenêtres d'imposte

Zone	Facteur U maximum W/m^2·K (Btu/h·ft.^{2}·°F)	Taux de fuite maximal L/s/m^2
1	1,60 (0,28)	1,5
2	1,40 (0,25)	1,5
3	1,20 (0,21)	1,5

Tableau B3 : Critères d'admissibilité basés sur le rendement énergétique pour les

portes coulissantes en verre

Zone	Rendement énergétique minimum (sans unité)	Taux de fuite maximal L/s/m^2
1	25	1,5
2	29	1,5
3	34	1,5

Tableau B4 : Critères d'admissibilité basés sur le facteur U pour les portes coulissantes en verre

Zone	Facteur U maximum W/m^2·K (Btu/h·ft.^{2}·°F)	Rendement énergétique minimum (sans unité)	Taux de fuite maximal L/s/m^2
1	1,60 (0,28)	16	1,5
2	1,40 (0,25)	20	1,5
3	1,20 (0,21)	24	1,5

C. Puits de lumière

Tableau C1 : Critères d'admissibilité pour les puits de lumière à vitrage plat et en forme de dôme

Zone	Facteur U maximum W/m^2·K (Btu/h·ft.^{2}·°F)	Taux de fuite maximal L/s/m^2
1	2,60 (0,46)	1,5
2	2,40 (0,42)	1,5
3	2,10 (0,37)	1,5

Tableau C2 : Critères d'admissibilité pour les puits de lumière tubulaires

Zone	Facteur U maximum W/m²·K (Btu/h·ft.²·°F)	Taux de fuite maximal L/s/m²
Toutes	2,60 (0,46)	1,5

4) Exigences relatives aux essais et à l'homologation

A. Tous les modèles ENERGY STAR doivent être homologués, en ce qui a trait au rendement énergétique, conformément aux normes suivantes :

CSA A440.2-09 ou CSA A440.2-14 Rendement énergétique des systèmes de fenêtrage

et/ou

NFRC 100-10 Procedure For Determining Fenestration Product U-factors

et

NFRC 200-10 Procedure For Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence

B. Tous les modèles ENERGY STAR doivent être mis à l'essai et être conformes aux exigences minimales des normes suivantes :

AAMA/WDMA/CSA 101/I.S.2/A440-08 Norme nord-américaine sur les fenêtres (NAFS) Spécification relative aux fenêtres, aux portes et aux lanterneaux (NAFS)

et

Supplément canadien à l'AAMA/WDMA/CSA 101/I.S.2/A440-09 Spécification relative aux fenêtres, aux portes et aux lanterneaux

C. Tous les vitrages isolants des modèles homologués ENERGY STAR doivent être certifiés conformément aux normes suivantes :

ASTM E2190-10 Standard Specification for Insulating Glass Unit Performance and Evaluation

et/ou

CAN/CGSB 12.8-97 Norme sur les vitrages isolants

D. Le modèle sélectionné pour les essais doit être représentatif des produits qui seront commercialisés sous l'étiquette ENERGY STAR. Une famille de produits ne peut se qualifier selon cette spécification.
E. L'homologation doit être effectuée par un organisme accrédité par le CCN, selon le produit homologué, ou sous le programme NFRC.
F. Les essais NAFS et ceux du Supplément canadien doivent être effectués par un organisme accrédité par le CCN ou d'autres organismes signataires de l'accord de reconnaissance mutuelle de la Asia Pacific Laboratory Accreditation Cooperation (APLAC) ou de l'International Laboratory Accreditation Cooperation (ILAC), pour le produit mis à l'essai.

5) Inscription et étiquetage

A. Tous les modèles de produit doivent être dûment enregistrés auprès de RNCan à l'aide du formulaire d'inscription officiel pour que les produits puissent être étiquetés et homologués ENERGY STAR au Canada.
B. Les modèles de produits enregistrés auprès de RNCan, pour ENERGY STAR, doivent être étiquetés conformément aux *Directives liées à l'étiquetage et à la publicité concernant les portes, les fenêtres et les puits de lumière homologués ENERGY STAR® vendus au Canada* pour être homologués ENERGY STAR au Canada.

6) Instructions d'installation

Des instructions d'installation doivent être fournies en ligne ou avec le produit. Une version électronique des instructions peut également se trouver sur le site Web d'un détaillant, d'un fabricant ou d'une association industrielle. Un avis de non-responsabilité peut également être ajouté.

7) Date d'entrée en vigueur

La date d'entrée en vigueur de la version 4 est le 1er février 2015. Cette version remplace toutes les versions antérieures. Pour être admissible à l'homologation ENERGY STAR, un modèle de produit doit répondre à la spécification ENERGY STAR en vigueur à la date de fabrication du modèle. Chaque appareil possède une date de fabrication qui lui est propre, et cette date indique le moment où l'assemblage du produit a été terminé.

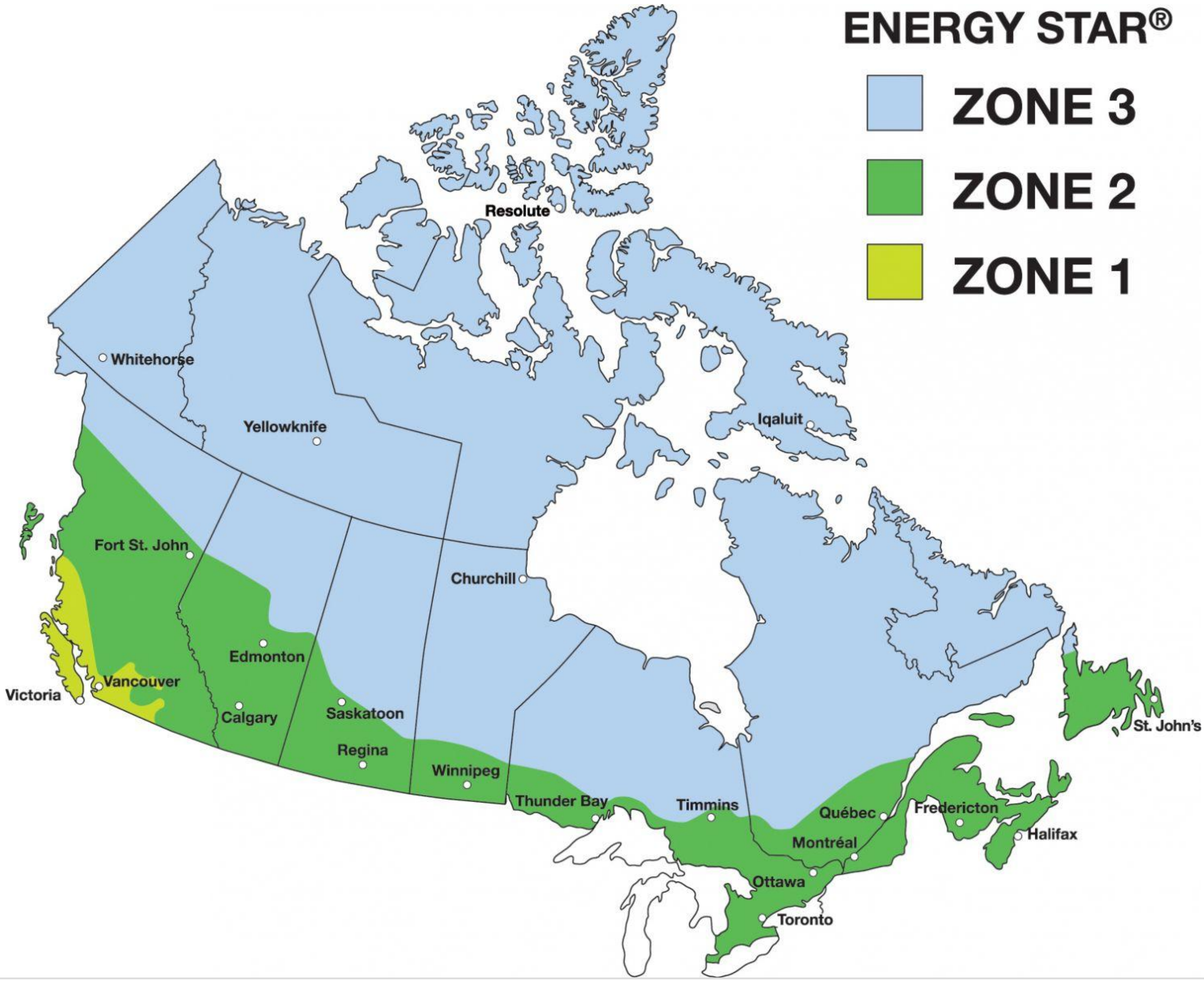
8) Prochaines révisions de la spécification

RNCan se réserve le droit de modifier la spécification si des changements technologiques ou liés au marché ont une incidence sur son utilité pour les consommateurs, l'industrie ou l'environnement. Afin d'être fidèle à la politique actuelle, la révision des spécifications sera effectuée au moyen de discussions entre les intervenants de l'industrie. Advenant la révision d'une spécification, veuillez prendre note que l'homologation ENERGY STAR n'est pas accordée automatiquement pour toute la durée de vie d'un modèle de produit.

Annexe A

Les zones climatiques sont établies en fonction des degrés-jours de chauffage (DJC) indiqués dans le Code national du bâtiment (2010). Des endroits précis, les valeurs DJC et la zone climatique sont indiqués sur la carte ci-dessous. Si l'endroit est accompagné d'un astérisque, cela signifie qu'on lui a attribué une zone plus froide afin de maintenir l'intégrité du marché.

Zone 3 : ≥6 000 DJC
Zone 2 : 3 500 to <6 000 DJC
Zone 1 : <3 500 DJC



▶ [Version textuelle - Carte des climats divisée en trois zones climatiques]

Code national du bâtiment (2010), degrés-jours de chauffage et zones climatiques d'endroits spécifiques au Canada

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Alberta	Athabasca	6000	3
Alberta	Banff	5500	2
Alberta	Barrhead	5740	2
Alberta	Beaverlodge	5700	2
Alberta	Brook	4880	2
Alberta	Calgary	5000	2
Alberta	Campsie	5750	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Alberta	Camrose	5500	2
Alberta	Canmore	5400	2
Alberta	Cardston	4700	2
Alberta	Claresholm	4680	2
Alberta	Cold Lake	5860	2
Alberta	Coleman	5210	2
Alberta	Coronation	5640	2
Alberta	Cowley	4810	2
Alberta	Drumheller	5050	2
Alberta	Edmonton	5120	2
Alberta	Edson	5750	2
Alberta	Embarras Portage	7100	3
Alberta	Fairview	5840	2
Alberta	Fort MacLeod	4600	2
Alberta	Fort McMurray	6250	3
Alberta	Fort Saskatchewan	5420	2
Alberta	Fort Vermilion	6700	3
Alberta	Grande Prairie	5790	2
Alberta	Habay	6750	3
Alberta	Hardisty	5640	2
Alberta	High River	4900	2
Alberta	Hinton	5500	2
Alberta	Jasper	5300	2
Alberta	Keg River	6520	3

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Alberta	Lac La Biche	6100	3
Alberta	Lacombe	5500	2
Alberta	Lethbridge	4500	2
Alberta	Manning	6300	3
Alberta	Medecine Hat	4540	2
Alberta	Peace River	6050	3
Alberta	Pincher Creek	4740	2
Alberta	Ranfurly	5700	2
Alberta	Red Deer	5550	2
Alberta	Rocky Mountain House	5640	2
Alberta	Slave Lake	5850	2
Alberta	Stettler	5300	2
Alberta	Stony Plain	5300	2
Alberta	Suffield	4770	2
Alberta	Taber	4580	2
Alberta	Turner Valley	5220	2
Alberta	Valleyview	5600	2
Alberta	Vegreville	5780	2
Alberta	Vermilion	5740	2
Alberta	Wagner	5850	2
Alberta	Wainwright	5700	2
Alberta	Wetaskiwin	5500	2
Alberta	Whitecourt	5650	2
Alberta	Wimborne	5310	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Colombie-Britannique	100 Mile House	5030	2
Colombie-Britannique	Abbotsford	2860	1
Colombie-Britannique	Agassiz	2750	1
Colombie-Britannique	Alberni	3100	1
Colombie-Britannique	Ashcroft	3700	2
Colombie-Britannique	Bamfield	3080	1
Colombie-Britannique	Beatton River	6300	3
Colombie-Britannique	Bella Bella	3180	1
Colombie-Britannique	Bella Coola	3560	2
Colombie-Britannique	Burns Lake	5450	2
Colombie-Britannique	Cache Creek	3700	2
Colombie-Britannique	Campbell River	3000	1
Colombie-Britannique	Carmi	4750	2
Colombie-Britannique	Castlegar	3580	2
Colombie-Britannique	Chetwynd	5500	2

Province/Territoire	**Endroit**	**Valeurs DJC du CMNB**	**Zone**
Colombie-Britannique	Chilliwack	2780	1
Colombie-Britannique	Cloverdale	2700	1
Colombie-Britannique	Comox	3100	1
Colombie-Britannique	Courtenay	3100	1
Colombie-Britannique	Cranbrook	4400	2
Colombie-Britannique	Crescent Valley	3650	2
Colombie-Britannique	Crofton	2880	1
Colombie-Britannique	Dawson Creek	5900	2
Colombie-Britannique	Dease Lake	6730	3
Colombie-Britannique	Dog Creek	4800	2
Colombie-Britannique	Duncan	2980	1
Colombie-Britannique	Elko	4600	2
Colombie-Britannique	Fernie	4750	2
Colombie-Britannique	Fort Nelson	6710	3
Colombie-Britannique	Fort St. John	5750	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Colombie-Britannique	Glacier	5800	2
Colombie-Britannique	Gold River	3230	1
Colombie-Britannique	Golden	4750	2
Colombie-Britannique	Grand Forks	3820	2
Colombie-Britannique	Greenwood	4100	2
Colombie-Britannique	Haney	2840	1
Colombie-Britannique	Hope	3000	1
Colombie-Britannique	Jordan River	2900	1
Colombie-Britannique	Kamloops	3450	1
Colombie-Britannique	Kaslo	3830	2
Colombie-Britannique	Kelowna	3400	1
Colombie-Britannique	Kimberley	4650	2
Colombie-Britannique	Kitimat Plant	3750	2
Colombie-Britannique	Kitimat Townsite	3900	2
Colombie-Britannique	Ladner	2600	1

Province/Territoire	**Endroit**	**Valeurs DJC du CMNB**	**Zone**
Colombie-Britannique	Ladysmith	3000	1
Colombie-Britannique	Langford	2750	1
Colombie-Britannique	Langley	2700	1
Colombie-Britannique	Lillooet	3400	1
Colombie-Britannique	Lytton	3300	1
Colombie-Britannique	Mackenzie	5550	2
Colombie-Britannique	Masset	3700	2
Colombie-Britannique	McBride	4980	2
Colombie-Britannique	McLeod Lake	5450	2
Colombie-Britannique	Merritt	3900	2
Colombie-Britannique	Mission City	2850	1
Colombie-Britannique	Montrose	3600	2
Colombie-Britannique	Nakups	3560	2
Colombie-Britannique	Nanaimo	3000	1
Colombie-Britannique	Nelson	3500	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Colombie-Britannique	New Westminster	2800	1
Colombie-Britannique	North Vancouver	2910	1
Colombie-Britannique	Ocean Falls	3400	1
Colombie-Britannique	Osoyoos	3100	1
Colombie-Britannique	Parksville	3200	1
Colombie-Britannique	Penticton	3350	1
Colombie-Britannique	Port Alberni	3100	1
Colombie-Britannique	Port Alice	3010	1
Colombie-Britannique	Port Hardy	3440	1
Colombie-Britannique	Port McNeill	3410	1
Colombie-Britannique	Port Renfrew	2900	1
Colombie-Britannique	Powell River	3100	1
Colombie-Britannique	Prince George	4720	2
Colombie-Britannique	Prince Rupert	3900	2
Colombie-Britannique	Princeton	4250	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Colombie-Britannique	Qualicum Beach	3200	1
Colombie-Britannique	Queen Charlotte City	3520	2
Colombie-Britannique	Quesnel	4650	2
Colombie-Britannique	Revelstoke	4000	2
Colombie-Britannique	Richmond	2800	1
Colombie-Britannique	Salmon Arm	3650	2
Colombie-Britannique	Sandspit	3450	2
Colombie-Britannique	Sechelt	2680	1
Colombie-Britannique	Sidney	2850	1
Colombie-Britannique	Smith River	7100	3
Colombie-Britannique	Smithers	5040	2
Colombie-Britannique	Sooke	2900	1
Colombie-Britannique	Squamish	2950	1
Colombie-Britannique	Stewart	4350	2
Colombie-Britannique	Surrey (88^{e} Av. et 156^{e} Rue)	2750	1

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Colombie-Britannique	Tahsis	3150	1
Colombie-Britannique	Taylor	5720	2
Colombie-Britannique	Terrace	4150	2
Colombie-Britannique	Tofino	3150	1
Colombie-Britannique	Trail	3600	2
Colombie-Britannique	Ucluelet	3120	1
Colombie-Britannique	Vancouver (hôtel de ville)	2825	1
Colombie-Britannique	Vancouver (Granville et 41^{e} Av.)	2925	1
Colombie-Britannique	Vancouver Region Burnaby (Univ. Simon Fraser)	3100	1
Colombie-Britannique	Vernon	3600	2
Colombie-Britannique	Victoria	2650	1
Colombie-Britannique	Victoria (Gonzales Heights)	2700	1
Colombie-Britannique	Victoria (Mount Tolmie)	2700	1
Colombie-Britannique	West Vancouver	2950	1
Colombie-Britannique	Whistler	4180	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Colombie-Britannique	White Rock	2620	1
Colombie-Britannique	Williams Lake	4400	2
Colombie-Britannique	Youbou	3050	1
Manitoba	Beausejour	5680	2
Manitoba	Boissevain	5500	2
Manitoba	Brandon	5760	2
Manitoba	Churchill	8950	3
Manitoba	Dauphin	5900	2
Manitoba	Flin Flon	6440	3
Manitoba	Gimli	5800	2
Manitoba	Island Lake	6900	3
Manitoba	Lac du Bonnet	5730	2
Manitoba	Lynn Lake	7770	3
Manitoba	Morden	5400	2
Manitoba	Neepawa	5760	2
Manitoba	Pine Falls	5900	2
Manitoba	Portage la Prairie	5600	2
Manitoba	Rivers	5840	2
Manitoba	Sandilands	5650	2
Manitoba	Selkirk	5700	2
Manitoba	Split Lake	7900	3
Manitoba	Steinbach	5700	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Manitoba	Swan River	6100	3
Manitoba	The Pas	6480	3
Manitoba	Thompson	7600	3
Manitoba	Virden	5620	2
Manitoba	Winnipeg	5670	2
Nouveau-Brunswick	Alma	4500	2
Nouveau-Brunswick	Bathurst	5020	2
Nouveau-Brunswick	Campbellton	5500	2
Nouveau-Brunswick	Edmundston	5320	2
Nouveau-Brunswick	Fredericton	4670	2
Nouveau-Brunswick	Gagetown	4460	2
Nouveau-Brunswick	Grand Falls	5300	2
Nouveau-Brunswick	Miramichi	4950	2
Nouveau-Brunswick	Moncton	4680	2
Nouveau-Brunswick	Oromocto	4650	2
Nouveau-Brunswick	Sackville	4590	2
Nouveau-Brunswick	Saint Andrews	4680	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Nouveau-Brunswick	Saint-George	4680	2
Nouveau-Brunswick	Saint John	4570	2
Nouveau-Brunswick	Shippagan	4930	2
Nouveau-Brunswick	St. Stephen	4700	2
Nouveau-Brunswick	Woodstock	4910	2
Terre-Neuve-et-Labrador	Argentia	4600	2
Terre-Neuve-et-Labrador	Bonavista	5000	2
Terre-Neuve-et-Labrador	Buchans	5250	2
Terre-Neuve-et-Labrador	Cape Harrison	6900	3
Terre-Neuve-et-Labrador	Cape Race	4900	2
Terre-Neuve-et-Labrador	Channel-Port-aux-Basques	5000	2
Terre-Neuve-et-Labrador	Corner Brook	4760	2
Terre-Neuve-et-Labrador	Gander	5110	2
Terre-Neuve-et-Labrador	Grand Bank	4550	2
Terre-Neuve-et-Labrador	Grand Falls	5020	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Terre-Neuve-et-Labrador	Happy Valley/Goose Bay	6670	3
Terre-Neuve-et-Labrador	Labrador City	7710	3
Terre-Neuve-et-Labrador	St. Anthony	6440	3
Terre-Neuve-et-Labrador	Stephenville	4850	2
Terre-Neuve-et-Labrador	St. John's	4800	2
Terre-Neuve-et-Labrador	Twin Falls	7790	3
Terre-Neuve-et-Labrador	Wabana	4750	2
Terre-Neuve-et-Labrador	Wabush	7710	3
Nouvelle-Écosse	Amherst	4500	2
Nouvelle-Écosse	Antigonish	4510	2
Nouvelle-Écosse	Bridgewater	4140	2
Nouvelle-Écosse	Canso	4400	2
Nouvelle-Écosse	Debert	4500	2
Nouvelle-Écosse	Digby	4020	2
Nouvelle-Écosse	Greenwood (BFC)	4140	2
Nouvelle-Écosse	Halifax (Dartmouth)	4100	2
Nouvelle-Écosse	Halifax (Halifax)	4000	2
Nouvelle-Écosse	Kentville	4130	2
Nouvelle-Écosse	Liverpool	3990	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Nouvelle-Écosse	Lockeport	4000	2
Nouvelle-Écosse	Louisbourg	4530	2
Nouvelle-Écosse	Lunenburg	4140	2
Nouvelle-Écosse	New Glasgow	4320	2
Nouvelle-Écosse	North Sydney	4500	2
Nouvelle-Écosse	Pictou	4310	2
Nouvelle-Écosse	Port Hawkesbury	4500	2
Nouvelle-Écosse	Springhill	4540	2
Nouvelle-Écosse	Stewiacke	4400	2
Nouvelle-Écosse	Sydney	4530	2
Nouvelle-Écosse	Tatamagouche	4380	2
Nouvelle-Écosse	Truro	4500	2
Nouvelle-Écosse	Wolfville	4140	2
Nouvelle-Écosse	Yarmouth	3990	2
Territoires du Nord-Ouest	Aklavik	9600	3
Territoires du Nord-Ouest	Echo Bay / Port Radium	9300	3
Territoires du Nord-Ouest	Fort Good Hope	8700	3
Territoires du Nord-Ouest	Fort McPherson	9150	3
Territoires du Nord-Ouest	Fort Providence	7620	3
Territoires du Nord-Ouest	Fort Resolution	7750	3

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Territoires du Nord-Ouest	Fort Simpson	7660	3
Territoires du Nord-Ouest	Fort Smith	7300	3
Territoires du Nord-Ouest	Hay River	7550	3
Territoires du Nord-Ouest	Holman / Ulukhaqtuuq	10700	3
Territoires du Nord-Ouest	Inuvik	9600	3
Territoires du Nord-Ouest	Mould Bay	12900	3
Territoires du Nord-Ouest	Norman Wells	8510	3
Territoires du Nord-Ouest	Rae-Edzo (Behchoko)	8300	3
Territoires du Nord-Ouest	Tungsten	7700	3
Territoires du Nord-Ouest	Wrigley	8050	3
Territoires du Nord-Ouest	Yellowknife	8170	3
Nunavut	Alert	13030	3
Nunavut	Arctic Bay	11900	3
Nunavut	Arviat / Eskimo Point	9850	3
Nunavut	Baker Lake	10700	3
Nunavut	Cambridge Bay / Iqaluktuuttiaq	11670	3
Nunavut	Chesterfield Inlet / Igluligaarjuk	10500	3
Nunavut	Clyde River / Kanngiqtugaapik	11300	3

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Nunavut	Coppermine (Kugluktuk)	10300	3
Nunavut	Coral Harbour / Salliq	10720	3
Nunavut	Eureka	13500	3
Nunavut	Iqaluit	9980	3
Nunavut	Isachsen	13600	3
Nunavut	Nottingham Island	10000	3
Nunavut	Rankin Inlet (Kangiqiniq)	10500	3
Nunavut	Resolute	12360	3
Nunavut	Resolute Island	9000	3
Ontario	Ailsa Craig	3840	2
Ontario	Ajax	3820	2
Ontario	Alexandria	4600	2
Ontario	Alliston	4200	2
Ontario	Almonte	4620	2
Ontario	Armstrong	6500	3
Ontario	Arnprior	4680	2
Ontario	Atikokan	5750	2
Ontario	Attawapiskat	7100	3
Ontario	Aurora	4210	2
Ontario	Bancroft	4740	2
Ontario	Barrie	4380	2
Ontario	Barriefield	3990	2
Ontario	Beaverton	4300	2
Ontario	Belleville	3910	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Belmont	3840	2
Ontario	Bracebridge	4800	2
Ontario	Bradford	4280	2
Ontario	Brampton	4100	2
Ontario	Brantford	3900	2
Ontario	Brighton	4000	2
Ontario	Brockville	4060	2
Ontario	Burk's Falls	5020	2
Ontario	Burlington	3740	2
Ontario	Cambridge	4100	2
Ontario	Campbellford	4280	2
Ontario	Cannington	4310	2
Ontario	Carleton Place	4600	2
Ontario	Cavan	4400	2
Ontario	Centralia	3800	2
Ontario	CFB Borden	4300	2
Ontario	Chapleau	5900	2
Ontario	Chatham*	3470	2
Ontario	Chesley	4320	2
Ontario	Clinton	4150	2
Ontario	Coboconk	4500	2
Ontario	Cobourg	3980	2
Ontario	Cochrane	6200	3
Ontario	Colborne	3980	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Collingwood	4180	2
Ontario	Cornwall	4250	2
Ontario	Corunna	3600	2
Ontario	Deep River	4900	2
Ontario	Deseronto	4070	2
Ontario	Dorchester	3900	2
Ontario	Dorion	5950	2
Ontario	Dresden	3750	2
Ontario	Dryden	5850	2
Ontario	Dundalk	4700	2
Ontario	Dunnville	3660	2
Ontario	Durham	4340	2
Ontario	Dutton	3700	2
Ontario	Earlton	5730	2
Ontario	Edison	5740	2
Ontario	Elliot Lake	4950	2
Ontario	Elmvale	4200	2
Ontario	Embro	3950	2
Ontario	Englehart	5800	2
Ontario	Espanola	4920	2
Ontario	Exeter	3900	2
Ontario	Fenelon Falls	4440	2
Ontario	Fergus	4300	2
Ontario	Forest	3740	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Fort Erie	3650	2
Ontario	Fort Erie (Ridgeway)	3600	2
Ontario	Fort Frances	5440	2
Ontario	Ganagoque	4010	2
Ontario	Geraldton	6450	3
Ontario	Glencoe	3680	2
Ontario	Goderich	4000	2
Ontario	Gore Bay	4700	2
Ontario	Graham	5940	2
Ontario	Gravenhurst (aéroport Muskoka)	4760	2
Ontario	Grimsby	3520	2
Ontario	Guelph	4270	2
Ontario	Guthrie	4300	2
Ontario	Haileybury	5600	2
Ontario	Haldimand (Caledonia)	3750	2
Ontario	Haldimand (Hagersville)	3760	2
Ontario	Haliburton	4840	2
Ontario	Halton Hills (Georgetown)	4200	2
Ontario	Hamilton*	3460	2
Ontario	Hanover	4300	2
Ontario	Hastings	4280	2
Ontario	Hawkesbury	4610	2
Ontario	Hearst	6450	3
Ontario	Honey Harbour	4300	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Hornepayne	6340	3
Ontario	Huntsville	4850	2
Ontario	Ingersoll	3920	2
Ontario	Iroquois Falls	6100	3
Ontario	Jellicoe	6400	3
Ontario	Kapuskasing	6250	3
Ontario	Kemptville	4540	2
Ontario	Kenora	5630	2
Ontario	Killaloe	4960	2
Ontario	Kincardine	3890	2
Ontario	Kingston	4000	2
Ontario	Kinmount	4600	2
Ontario	Kirkland Lake	6000	3
Ontario	Kitchener	4200	2
Ontario	Kitchenuhmaykoosib (Big Trout Lake)	7450	3
Ontario	Lakefield	4330	2
Ontario	Lansdowne House	7150	3
Ontario	Leamington*	3400	2
Ontario	Lindsay	4320	2
Ontario	Lion's Head	4300	2
Ontario	Listowel	4300	2
Ontario	London	3900	2
Ontario	Lucan	3900	2
Ontario	Maitland	4080	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Markdale	4500	2
Ontario	Markham	4000	2
Ontario	Martin	5900	2
Ontario	Matheson	6080	3
Ontario	Mattawa	5050	2
Ontario	Midland	4200	2
Ontario	Milton	3920	2
Ontario	Milverton	4200	2
Ontario	Minden	4640	2
Ontario	Mississauga	3880	2
Ontario	Mississauga (Aéroport international Lester B. Pearson)	3890	2
Ontario	Mississauga (Port Credit)	3780	2
Ontario	Mitchell	4100	2
Ontario	Moosonee	6800	3
Ontario	Morrisburg	4370	2
Ontario	Mount Forest	4700	2
Ontario	Nakina	6500	3
Ontario	Nanticoke (Jarvis)	3700	2
Ontario	Nanticoke (Port Dover)	3600	2
Ontario	Napanee	4140	2
Ontario	New Liskeard	5570	2
Ontario	Newcastle	3990	2
Ontario	Newcastle (Bowmanville)	4000	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Newmarket	4260	2
Ontario	Niagara Falls	3600	2
Ontario	North Bay	5150	2
Ontario	Norwood	4320	2
Ontario	Oakville	3760	2
Ontario	Orangeville	4450	2
Ontario	Orillia	4260	2
Ontario	Oshawa	3860	2
Ontario	Ottawa (Barrhaven)	4500	2
Ontario	Ottawa (hôtel de ville)	4440	2
Ontario	Ottawa (Kanata)	4520	2
Ontario	Ottawa (aéroport international Macdonald-Cartier)	4500	2
Ontario	Ottawa (Orléans)	4500	2
Ontario	Owen Sound	4030	2
Ontario	Pagwa River	6500	3
Ontario	Paris	4000	2
Ontario	Parkhill	3800	2
Ontario	Parry Sound	4640	2
Ontario	Pelham (Fonthill)	3690	2
Ontario	Pembroke	4980	2
Ontario	Penetanguishene	4200	2
Ontario	Perth	4540	2
Ontario	Petawawa	4980	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Peterborough	4400	2
Ontario	Petrolia	3640	2
Ontario	Pickering (Dunbarton)	3800	2
Ontario	Picton	3980	2
Ontario	Plattsville	4150	2
Ontario	Point Alexander	4960	2
Ontario	Port Burwell	3800	2
Ontario	Port Colborne	3600	2
Ontario	Port Elgin	4100	2
Ontario	Port Hope	3970	2
Ontario	Port Perry	4260	2
Ontario	Port Stanley	3850	2
Ontario	Prescott	4120	2
Ontario	Princeton	4000	2
Ontario	Raith	5900	2
Ontario	Rayside-Balfour (Chelmsford)	5200	2
Ontario	Red Lake	6220	3
Ontario	Renfrew	4900	2
Ontario	Richmond Hill	4000	2
Ontario	Rockland	4600	2
Ontario	Sarnia	3750	2
Ontario	Sault Ste. Marie	4960	2
Ontario	Schreiber	5960	2
Ontario	Seafort	4100	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Shelburne	4700	2
Ontario	Simcoe	3700	2
Ontario	Sioux Lookout	5950	2
Ontario	Smiths Falls	4540	2
Ontario	Smithville	3650	2
Ontario	Smooth Rock Falls	6250	3
Ontario	South River	5090	2
Ontario	Southampton	4100	2
Ontario	St. Catharines	3540	2
Ontario	St. Mary's	4000	2
Ontario	St. Thomas	3780	2
Ontario	Stirling	4220	2
Ontario	Stratford	4050	2
Ontario	Strathroy	3780	2
Ontario	Sturgeon Falls	5200	2
Ontario	Sudbury	5180	2
Ontario	Sundridge	5080	2
Ontario	Tavistock	4100	2
Ontario	Temagami	5420	2
Ontario	Thamesford	3950	2
Ontario	Thedford	3710	2
Ontario	Thunder Bay	5650	2
Ontario	Tillsonburg	3840	2
Ontario	Timmins	5940	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Timmins (Porcupine)	6000	3
Ontario	Toronto (hôtel de ville)	3520	2
Ontario	Toronto (Etobicoke)	3800	2
Ontario	Toronto (North York)	3760	2
Ontario	Toronto (Scarborough)	3800	2
Ontario	Trenton	4110	2
Ontario	Trout Creek	5100	2
Ontario	Uxbridge	4240	2
Ontario	Vaughan (Woodbridge)	4100	2
Ontario	Vittoria	3680	2
Ontario	Walkerton	4300	2
Ontario	Wallaceburg	3600	2
Ontario	Waterloo	4200	2
Ontario	Watford	3740	2
Ontario	Wawa	5840	2
Ontario	Welland	3670	2
Ontario	West Lorne	3700	2
Ontario	Whitby	3820	2
Ontario	Whitby (Brooklin)	4010	2
Ontario	White River	6150	3
Ontario	Wiarton	4300	2
Ontario	Windsor*	3400	2
Ontario	Wingham	4220	2
Ontario	Woodstock	3910	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Ontario	Wyoming	3700	2
Île-du-Prince-Édouard	Charlottetown	4460	2
Île-du-Prince-Édouard	Souris	4550	2
Île-du-Prince-Édouard	Summerside	4600	2
Île-du-Prince-Édouard	Tignish	4770	2
Québec	Acton Vale	4620	2
Québec	Alma	5800	2
Québec	Amos	6160	3
Québec	Asbestos	4800	2
Québec	Aylmer	4520	2
Québec	Baie-Comeau	6020	3
Québec	Baie-Saint-Paul	5280	2
Québec	Beauport	5100	2
Québec	Bedford	4420	2
Québec	Beloeil	4500	2
Québec	Brome	4730	2
Québec	Brossard	4420	2
Québec	Buckingham	4880	2
Québec	Campbell's Bay	4900	2
Québec	Chambly	4450	2
Québec	Coaticook	4750	2
Québec	Contrecoeur	4500	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Québec	Cowansville	4540	2
Québec	Deux-Montagnes	4440	2
Québec	Dolbeau	6250	3
Québec	Drummondville	4700	2
Québec	Farnham	4500	2
Québec	Fort-Coulonge	4950	2
Québec	Gagnon	7600	3
Québec	Gaspé	5500	2
Québec	Gatineau	4600	2
Québec	Gracefield	5080	2
Québec	Granby	4500	2
Québec	Harrington Harbour	6150	3
Québec	Havre-St-Pierre	6100	3
Québec	Hemmingford	4380	2
Québec	Hull	4550	2
Québec	Iberville	4450	2
Québec	Inukjuak	9150	3
Québec	Joliette	4720	2
Québec	Kuujjuaq	8550	3
Québec	Kuujjuarapik	7990	3
Québec	La Pocatière	5160	2
Québec	Lachute	4640	2
Québec	Lac-Mégantic	5180	2
Québec	La Malbaie	5400	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Québec	La Tuque	5500	2
Québec	Lennoxville	4700	2
Québec	Léry	4420	2
Québec	Loretteville	5200	2
Québec	Louiseville	4900	2
Québec	Magog	4730	2
Québec	Malartic	6200	3
Québec	Maniwaki	5280	2
Québec	Masson	4610	2
Québec	Matane	5510	2
Québec	Mont-Joli	5370	2
Québec	Mont-Laurier	5320	2
Québec	Montmagny	5090	2
Québec	Montréal (Beaconsfield)	4440	2
Québec	Montréal (hôtel de ville)	4200	2
Québec	Montréal (Dorval)	4400	2
Québec	Montréal (Laval)	4500	2
Québec	Montréal (Outremont)	4300	2
Québec	Montréal (Pierrefonds)	4430	2
Québec	Montréal (Ste-Anne-de-Bellevue)	4460	2
Québec	Montréal (St-Lambert)	4400	2
Québec	Montréal (St-Laurent)	4270	2
Québec	Montréal (Verdun)	4200	2
Québec	Montréal-Est	4470	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Québec	Montréal-Nord	4470	2
Québec	Nicolet (Gentilly)	4900	2
Québec	Nitchequon	8100	3
Québec	Noranda	6050	3
Québec	Percé	5400	2
Québec	Pincourt	4480	2
Québec	Plessisville	5100	2
Québec	Port-Cartier	6060	3
Québec	Puvirnituq	9200	3
Québec	Québec (Ancienne-Lorette)	5130	2
Québec	Québec (Lévis)	5050	2
Québec	Québec (Québec)	5080	2
Québec	Québec (Sillery)	5070	2
Québec	Québec (Ste-Foy)	5100	2
Québec	Richmond	4700	2
Québec	Rimouski	5300	2
Québec	Rivière-du-Loup	5380	2
Québec	Roberval	5750	2
Québec	Rock Island	4850	2
Québec	Rosemère	4550	2
Québec	Rouyn	6050	3
Québec	Saguenay	5700	2
Québec	Saguenay (Bagotville)	5700	2
Québec	Saguenay (Jonquière)	5650	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Québec	Saguenay (Kenogami)	5650	2
Québec	Saint-Eustache	4500	2
Québec	Saint-Hubert-de-Rivière-du-Loup	5520	2
Québec	Saint-Jean-sur-le-Richelieu	4450	2
Québec	Salaberry-de-Valleyfield	4400	2
Québec	Schefferville	8550	3
Québec	Senneterre	6180	3
Québec	Sept-Îles	6200	3
Québec	Shawinigan	5050	2
Québec	Shawville	4880	2
Québec	Sherbrooke	4700	2
Québec	Sorel	4550	2
Québec	Ste-Agathe-des-Monts	5390	2
Québec	St-Félicien	5850	2
Québec	St-Georges-de-Cacouna	5400	2
Québec	St-Hubert	4490	2
Québec	St-Hyacinthe	4500	2
Québec	St-Jérôme	4820	2
Québec	St-Jovite	5250	2
Québec	St-Lazare et Hudson	4520	2
Québec	St-Nicolas	4990	2
Québec	Sutton	4600	2
Québec	Tadoussac	5450	2
Québec	Témiscaming	5020	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Québec	Terrebonne	4500	2
Québec	Thetford Mines	5120	2
Québec	Thurso	4820	2
Québec	Trois-Rivières	4900	2
Québec	Val-d'Or	6180	3
Québec	Varennes	4500	2
Québec	Verchères	4450	2
Québec	Victoriaville	4900	2
Québec	Ville-Marie	5550	2
Québec	Wakefield	4820	2
Québec	Waterloo	4650	2
Québec	Windsor	4700	2
Saskatchewan	Assiniboia	5180	2
Saskatchewan	Battrum	5080	2
Saskatchewan	Biggar	5720	2
Saskatchewan	Broadview	5760	2
Saskatchewan	Dafoe	5860	2
Saskatchewan	Dundurn	5600	2
Saskatchewan	Estevan	5340	2
Saskatchewan	Hudson Bay	6280	3
Saskatchewan	Humboldt	6000	3
Saskatchewan	Island Falls	7100	3
Saskatchewan	Kamsack	6040	3
Saskatchewan	Kindersley	5550	2

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Saskatchewan	Lloydminster	5880	2
Saskatchewan	Maple Creek	4780	2
Saskatchewan	Meadow Lake	6280	3
Saskatchewan	Melfort	6050	3
Saskatchewan	Melville	5880	2
Saskatchewan	Moose Jaw	5270	2
Saskatchewan	Nipawin	6300	3
Saskatchewan	North Battleford	5900	2
Saskatchewan	Prince Albert	6100	3
Saskatchewan	Qu'Appelle	5620	2
Saskatchewan	Regina	5600	2
Saskatchewan	Rosetown	5620	2
Saskatchewan	Saskatoon	5700	2
Saskatchewan	Scott	5960	2
Saskatchewan	Strasbourg	5600	2
Saskatchewan	Swift Current	5150	2
Saskatchewan	Uranium City	7500	3
Saskatchewan	Weyburn	5400	2
Saskatchewan	Yorkton	6000	3
Yukon	Aishihik	7500	3
Yukon	Dawson	8120	3
Yukon	Destruction Bay	7800	3
Yukon	Faro	7300	3
Yukon	Haines Junction	7100	3

Province/Territoire	Endroit	Valeurs DJC du CMNB	Zone
Yukon	Snag	8300	3
Yukon	Teslin	6770	3
Yukon	Watson Lake	7470	3
Yukon	Whitehorse	6580	3

Ressources naturelles Canada promeut et administre le nom et le symbole ENERGY STAR, enregistrés au Canada par la Environmental Protection Agency des États-Unis.

Date de modification :
2017-01-31

ANSI/GRHC/SPRI VR-1 2011
Procedure for Investigating Resistance to Root Penetration on Vegetative Roofs

Approved February 24, 2011

Table of Contents

Disclaimer

This standard is for use by architects, engineers, roofing contractors and owners of low slope roofing systems. SPRI, its members and employees do not warrant that this standard is proper and applicable under all conditions.

411 Waverley Oaks Road
Suite 331
Waltham, MA 02452

www.spri.org

1.0 Purpose of this Standard

This standard is intended for testing the resistance of vegetative roof coverings to normal **root** and **rhizome** penetration.

2.0 Scope

The test described in this standard has been developed to evaluate the ability of a roofing material to resist normal **root** or **rhizome** penetration through a **root protection barrier**, or waterproofing layer. This test is based on the FLL "Procedure for Investigating Resistance to **Root** Penetration at Green Roof Sites." The FLL procedure was developed in Germany and is based on findings and testing experience of evaluations of various materials over a number of years. This test is intended to build on this experience and provide an equivalent evaluation protocol for North American test sites.

This procedure includes testing of vegetative roof **root** penetration barriers including all seams, edges and methods of attachment. This test standard excludes any lamination, i.e., a separate layer installed over the penetration barrier. The penetration barrier may be, but is not limited to, the waterproofing layer itself.

The test procedure only evaluates the top surface layer of the material to be tested where the membrane is composed of multiple layers of different materials. Materials included in the membrane system that are not exposed to **roots** are not evaluated by the test.

The test is intended to evaluate **root** resistance of environmentally stable physical barriers. Barriers based on chemical **root** inhibitors may be evaluated using this procedure; however, it should be noted that the procedure is not suitable for evaluating long-term chemical stability or long-term performance of these barriers.

The findings for any membrane or coating which has been tested shall not apply to plants with strong **rhizome** growth (e.g., bamboo or Chinese reeds varieties). When using such plants on top of a regular **root** penetration barrier, additional measures shall to be taken and special care shall be specified by the designer of record.

The test procedure does not evaluate waterproofing suitability, environmental compatibility of, or long term stability of, any products tested (i.e., resistance to temperature, UV light, microbial decomposition, etc.). (See C2.0)

3.0 Definitions

The following definitions are used in this document:

3.1 Root Protection Barrier

Any membrane or coating intended to prevent penetration of **root** growth. It may also be a waterproofing layer.

3.2 Trial Container

A container to be used for the examination having certain minimum dimensions and equipped with the membrane or coating to be tested. (See 5.4).

3.3 Growth Media

An engineered formulation of inorganic and organic materials, including but not limited to, heat-expanded clays, slates, shales, aggregate, sand, perlite, vermiculite and organic material including, but not limited to, compost worm castings, coir, peat, and other organic material. The structure of this course shall offer good water and air management properties. It shall be given light basic fertilization for optimum **root** development of the test plants. (See 5.8) The **growth media** shall be in direct contact with the material to be tested.

3.4 Rhizomes and Roots

- Since the evaluation differentiates between **roots** and **rhizomes**, a reliable determination of these subterranean plant organs is indispensable. The following indications serve as a basis for the evaluation:

- **Rhizomes** expanding in the **growth media** show a regular thickness of approximately 079 in (2 mm) and few branches. They are divided into different sections with knots forming the boundaries between the sections. Around the knots inconspicuous small leaves surrounding the stem as well as thin **roots** have formed. In between the knots the couch grass **rhizomes** are hollow. (See 4.1 **Elymus repens** "Couch Grass" or "Quack Grass" and Figure 1)
- **Roots** vary in thickness and show several branches. Leaves never form, and **roots** are not hollow. (See 4.1 **Pyracantha coccinea**—"Orange Charmer" or Scarlet Firethorn" and Figure 1.)

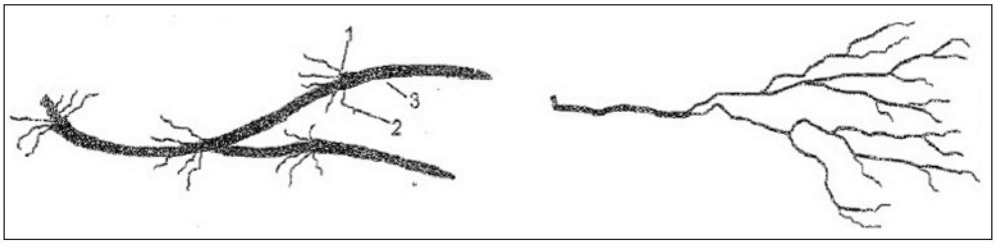


Figure 1: Schematic Representation Of Couch Grass **Rhizome** (Left) With Knots (1), **Roots** (2) And Leaves (3). "Orange Charmer" **Root** (Right).

4.0 Test Plants

4.1 Varieties (See C4.1)

Plants to be used shall be:

- **Pyracantha coccinea**, "Orange Charmer" or "scarlet firethorn"—a woody species capable of year round growth in a controlled environment greenhouse.
- **Elymus repens (AKA Agropyron repens)**, "Quack grass" or "couch grass"—a common weed species found on many roofs with a moderately aggressive rhizomatous growth habit.

4.2 Sufficient Growth Performance of the Test Plants

The plants in the **trial containers** shall show an average growth performance of at least 80% (above ground biomass, i.e., height, diameter of the stem, leaf area, etc.) of the plants in the control containers during the investigation.

4.3 Classification of Plant Growth

Plant growth shall be visually evaluated monthly with the following scale: Inadequate = <50% surface coverage, Adequate = 50–75% surface coverage, Good = >75% surface coverage. Within 3 months of the onset of the test, plant coverage of the medium surface shall be in excess of 60% of the surface, and there shall be evidence of new growth and plant **roots** shall be visible at the bottom of the control containers. Plant coverage shall remain dense (80% surface coverage and a dense mat of **roots** at the bottom of the control containers) throughout the remainder of the test procedure (Figure 2).

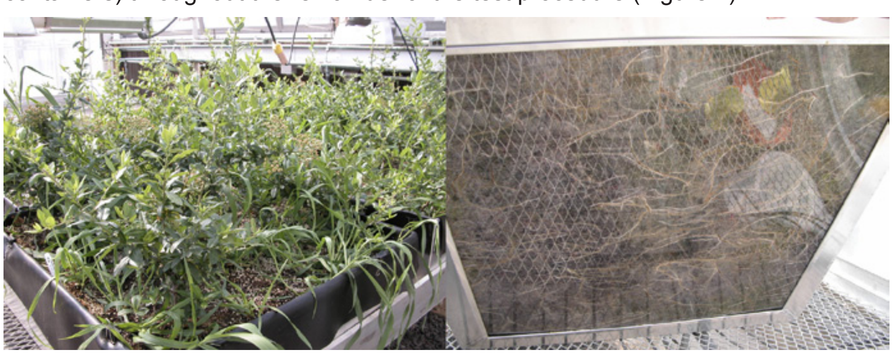


Figure 2: Healthy (good>75% coverage) plant growth in a **trial container** and dense **root** mat visible at the bottom of a control container.

4.4 Root Penetration

Roots have penetrated through the barrier or seams in the barrier material and are visible at the bottom of the **trial container** (Figure 3).

4.5 Rhizome Penetration

Rhizomes have penetrated through the barrier or seams in the barrier material and are visible at the bottom of the **trial container** (Figure 3).

4.6 Root Ingress and Surface Damage

Roots have grown into the surface or in the seam of the barrier and actively created cavities and have damaged the membrane or coating or seaming material. Not to be identified as **root** penetration but to be noted in the test documentation are:

Figure 3: **Root** penetration on backside of Membrane

- **Roots** that have grown into the surface or seam < 0.2 in (5 mm) on membranes or coatings, which contain radicide substances (**root** protecting agents), since here any **root** banning effect can only act upon the **root** in the membrane or coating. To ensure a clear valuation, such membrane or coating shall be clearly coded as "radicide-containing" by the manufacturer before the investigation is carried out and limitations to the testing procedure based on environmental stability of the radicide will be noted in the report.
- **Roots** that have grown into the surface made of products composed of several layers (e.g., bituminous membrane with copper band inlays or single ply membranes with fabric inlays) provided that the layer taking over the function of an ingress and penetration barrier has not been damaged. To ensure a clear valuation this layer shall be clearly defined by the manufacturer before the investigation is carried out.
- **Roots** that have penetrated seam sealing compounds (without damaging the welded or otherwise sealed seam).

See Commentary C4.6 for definition of **root** adhesion.

5.0 Testing Procedure

5.1 Description of the Procedure

The test shall be conducted in a climate-controlled greenhouse with environmental conditions maintained to promote continuous year-round growth of "Orange Charmer" and quack grass. The standard procedure is 2 years to ensure 24 months of active plant growth. Test periods longer than 24 months may be warranted to evaluate long-term stability of radicide materials. Plant growth procedures at individual test sites shall be modified based on local environmental conditions to ensure aggressive plant growth. Any modification from the standard procedure and the reason for the modification shall be noted in the test report.

Plants are installed in a commercial greenhouse or nursery **growth media** in the **trial containers**. (See 5.4) With dense planting and vigorous growth, moderate fertilization (see 5.8) and modest watering (see 5.9) the desired high **root** pressure will be obtained. At the Evaluation Stage, the **growth media** shall be removed from the container and the membrane or coating shall be examined to detect **root** or **rhizome** penetration or adhesion. (See 6.0) Control samples of any membrane or coating tested shall be saved and stored in a dark location at an average temperature of 77°F ± 5°F (25°C ± 3°C) for comparative examination at the end of the trial.

5.2 Testing Location

A greenhouse equipped with heating and ventilation facilities shall be provided. The heating system shall be set to 65 ± 5°F (18 ± 3°C) during the daylight hours and 60 ± 5°F (15 ± 3°C) at night. Ventilation set points shall be 75 ± 5°F (24 ± 3°C) during the daylight hours and 70 ± 5°F (21 ± 3°C) at night. Maximum daylight or night temperature shall not exceed 122 ± 5°F (50 ± 3°C) or be above 104 ± 5°F (40 ± 3°C) for more than 1 hour. Minimum daylight or night temperature shall not be less than 45 ± 5°F (7 ± 3°C). Adequate space shall be provided to ensure that all containers can be accessed to be evaluated and maintained.

Supplemental lighting shall be used to augment natural light where winter day length or light intensity results in less than 6 moles per square meter per day monthly average irradiance between 400 and 700nm. Sufficient supplemental light shall be applied to bring the daily total irradiance to a minimum of 6 moles per square meter per day. This shall be accomplished by using indoor plant grow lights. Lights should use a minimum 7200**°K** full spectrum bulb which promotes overall plant growth. This can be obtained by high CRI fluorescent lamps or Metal Halide to better stimulate average North Sky. Lights shall be placed no more than 2–3 ft (0.6–0.9 m) from the plant material in the trail containers Lights shall operate on 12 hour cycles until natural lighting conditions improve.

5.3 Test Duration

Following setup, the test shall run for a minimum of 24 months of equivalent plant growth.

5.4 Trial Containers

The internal dimensions of the containers used in the trial shall not be less than 32 in x 32 in x 10 in (800 mm x 800 mm x 250 mm). (See C5.4) **Trial containers** shall provide adequate space for membrane seaming to be used.

Trial containers shall be fitted with transparent bases (e.g., acrylic glass) so that **root** penetration can be detected even during the test phase without interfering with the **growth media**. (Figure 4).

Figure 4: Sample **trial container**. Note the interior metal fold to support the clear Plexiglas base.

For each **root** barrier to be tested, six **trial containers** shall be used. In addition, per experimental run—regardless of the number of membranes or coatings to be tested—three control containers (without any membrane or coating) shall be provided.

5.5 Protective Nonwoven Fabric

A nonwoven fabric made of synthetic fibers with a weight of approximately 200 g/m^2 shall be used in the bottom of the control containers. (See C5.5)

5.6 Membrane or Coating to be Tested

Test roof membranes **root** barriers, or waterproofing materials shall be supplied and installed in the **trial containers** per the manufacturer's specifications and shall contain several seams or joints as shown in Figure 6. Membrane shall be laid according to Section 5.12. Coatings shall be applied according to Section 5.13. The surface to be treated equals about 14 ft^2 (1.3 m^2) per container, presenting the indicated minimum dimension 32 in x 32 in x 10 in (800 mm x 800 mm x 250 mm).

5.7 Growth Media

Growth Media shall be a greenhouse or nursery **growth media** composed onsite or a commercially available product. (See C5.7) When a commercial product is used the manufacturer and lot number shall be recorded. If composed onsite, the media formulation shall be recorded. EC and pH will be measured using a standard saturated paste method.

5.8 Fertilizer

Fertilization by liquid feed or slow release fertilizer with complete macro and micro-nutrients shall be used to encourage plant and **root** growth. (See C5.8) Fertilizer shall be applied at the low or moderate rate recommended by the fertilizer manufacturer for containers of the size used to maximize plant growth. Formulations and quantities of fertilizer applied will be recorded and included in the final report. (See C5.8)

5.9 Irrigation

Plants shall be watered with good quality water suitable for greenhouse or nursery crop production. Plants shall be watered as needed based on local environmental conditions to maximize plant growth. Irrigation may be done by hand or by an automated system. In either case plants shall be allowed to dry between irrigation applications, and the media shall be thoroughly wetted with each irrigation application.

A tensiometer with a measuring range of 0–100 kilopascals (kPa) or centibars (cb) shall be used to monitor watering of the growing media per container.

5.10 Samples and Information Provided by the Manufacturer

To ensure a clear identification of the tested product, the following information shall be provided by the manufacturer before the test is started: product name, area of application, material description, material standards, thickness (without lamination), finish or structure, test certificates, year of manufacture, mounting or laying technique at the location of the investigation (overlapping, jointing techniques, jointing agents, type of seam sealing, covering strips over seams, special corner and angle joints), and admixture of biocides (e.g., **root** inhibitors) with details regarding the concentration of the substances.

For products consisting of several layers (e.g., bituminous membrane with copper band inlays or PVC membrane with polyester nonwoven fabric inlays), the manufacturer shall identify before the start of the investigation which layer is meant to take over the function of an ingress and penetration barrier.

5.11 Preparation and Installation of the Trial Container

Trial containers shall be prepared with the following layered superstructure (from bottom to top), Plexiglass **trial container** base, membrane or coating to be tested, **growth media**, planting.

After the installation of the membrane or coating (see 5.13) to be tested, the **trial containers** shall be flood tested for 12–24 hours to ensure that the waterproofing materials were installed properly.

The **growth media** shall be added to the **trial container** and compacted to a course depth of 5.9 ± .39 in (150 ± 10 mm). (See C5.11)

Four pieces of Pyracantha coccinea (“Orange Charmer”) per **trial container** of 32 in x 32 in (800 mm x 800 mm) shall be planted equally spread over the entire surface (Figure 5). Also, .07 oz (2 g) of seeds of Elymus repens (quack grass) or 8–10 **rhizome** plugs shall be equally sown or planted uniformly in the growing media in each container.

If larger **trial containers** are used, the number of plants and the quantity of seeds shall be increased so that at least the same plant density is reached.

The tensiometer ceramic cell shall be placed into the **growth media** directly on top of the membrane or coating. Thus, measurements can be carried out in the lowest part of the **root** area. The tensiometer shall be placed in the center of the test box (Figure 5).

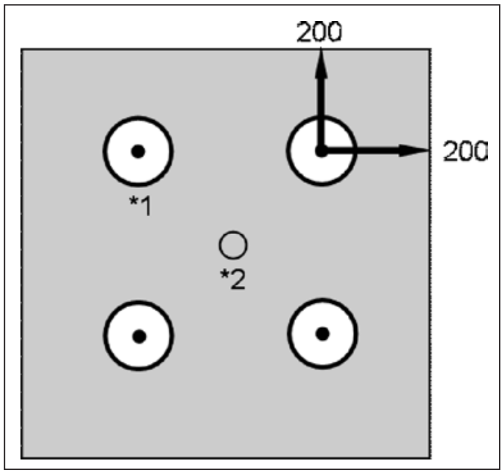


Figure 5: Arrangement of Plants (*1) And Tensiometer (*2) In the **Growth Media** in a Receptacle of 800 X 800 mm (Dimensions in mm)

5.12 Laying of Root Protection Membrane, Roof, and Damp-proof Lining

Cut out parts of the membrane or lining to be tested and lay them as required into the **trial containers**. Execute four seams at the corners where the walls meet, two seams along the base at the corners and one T-seam running along the middle. All membranes must be installed per manufacturer's published requirements. The membrane shall be brought up to the upper rim of the container walls (Figure 6).

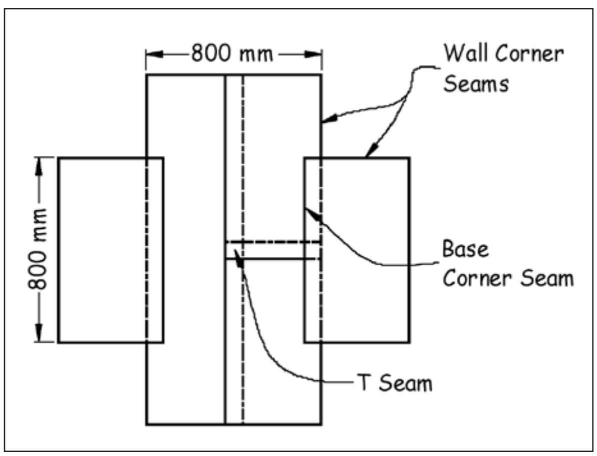


Figure 6: Layout of the Seams in the Membrane to Be Tested (Dimensions in mm)

5.13 Installation of Surface Coating under Investigation: Liquid Surface Treatment

The coating shall be brought up to the upper rims of the container walls. Seams or overlaps shall be included in the **trial container** installation for liquid applied materials equivalent to those described for sheet materials (5.12). If the material being tested has minimum and maximum recoat windows, seams shall be created both within and outside the recoat window following the manufacturers recommended procedures for each (Figure 7).

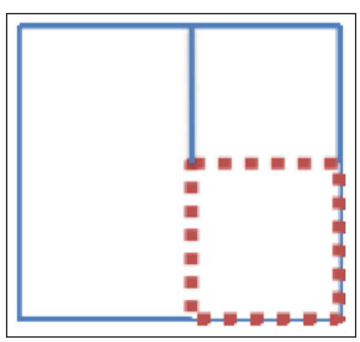


Figure 7: Seam or overlap pattern for liquid applied materials. Solid lines indicate seams and corners created within the recoat window. Dashed line indicates seams created outside the manufacturer's recommended recoat window.

5.14 Preparation and Installation of the Three Control Receptacles

Control receptacles shall be prepared and installed as described in Sections 5.4 and 5.5.

5.15 Care of the Plants During the Growth Period

The substrate moisture content shall be set according to the needs of the plants by means of top watering onto the **growth media**. The grower at the test site shall visually evaluate water requirements every 1–3 days and irrigate as needed. Sufficient water shall be applied at each irrigation to thoroughly wet the media. A tensiometer shall be used to assist in determining the requirements for irrigation.

To ensure a good germination and rooting of the plants in the first eight weeks after the greening process, irrigation shall commence as soon as the soil moisture tension drops below a value of 10 kPa (10 cb). Subsequent watering is applied only when the soil moisture tension falls below values between 30 and 40 kPa (cb).

Plant species other than those being evaluated should be removed.

Dead plants shall be replaced during the first 3 months of the investigation. If during the course of the investigation the losses in terms of plants account for more than 25% of the total plant number installed in more than 2 of the 6 replications the test shall be repeated.

Plants shall be pruned to aid in management or maintenance. Pruning shall be kept to a minimum because excessive pruning will limit **root** growth. Pruning shall be done equally to both test and control plants. (C5.15)

Insufficient quack grass coverage (< 40% of the surface is covered) shall be improved by up to two units of repeat seeding or by dividing existing plants or adding additional **rhizome** plugs in the first three months of the test.

In case of pest attacks or plant diseases threatening the survival of the plants under testing appropriate plant protection measures shall be carried out. Pesticide applications if necessary shall be kept to a minimum and the chemical class of the pesticides shall be carefully considered with the membrane manufacturer to avoid the use of materials that might interact with the roofing materials.

6.0 Evaluations

6.1 Evaluation During Testing

In addition to observations of plant condition every 1–3 days for the purpose of irrigation management, a closer inspection of each **trial container** shall be made once a month. This observation shall include visual evaluation of plant cover, plant appearance, new growth, and **root** density at the bottom of the control containers. (See 4.2)

A formal evaluation of the transparent base of all 6 **trial containers** shall be conducted in intervals of 6 months to detect visible **roots** and **rhizomes** (i.e., successful **root** penetration). A digital photograph of each **trial container** (base and plants) and each control shall be taken during this evaluation.

If visible **root** penetration is discovered in any one of the **trial containers**, the trial shall be discontinued at the discretion of the manufacturer. (See 4.6)

Plant damage, such as deformations of the leaves or changes of leave color, shall be noted.

6.2 Evaluation at the End of the Trial

Evaluation commences with a final monitoring of the growth performance of the plants. Plant above ground biomass for test and control plants shall be compared.

After the above ground biomass has been removed and evaluated the containers shall be turned upside down and the media and **root** mass removed. In a successful test the entire media mass will be completely bound together by **roots** and will come out of the test box as a single mass. **Root** density at the bottom of the containers shall be evaluated when the boxes are dissembled. **Root** density at the bottom of the **trial containers** shall be comparable to **root** density of the control containers as determined by visual inspection. Successful plant growth is indicated by a solid mat of **roots** at the bottom of the **trial containers**. **Root** density at the bottom of the **trial containers** of less than 80% observed in control containers indicates poor test conditions and the test should be repeated at the discretion of the manufacturer.

After plant and **root** evaluations, examine the membrane or surface coating for **root** and **rhizome** adhesion or penetration. Wash with garden hose using gentle pressure, any loose material should wash off. Evaluate any adhered material under a microscope for possible penetration. Examine remaining material to determine if **roots** have adhered to the surface. Any **roots** remaining after washing shall be examined with a microscope to determine if they are surface attached or have penetrated into the membrane. **Roots** or **rhizome** ingress and penetration into the membrane or coating shall be recorded.

6.2.1 Test Field Evaluation

If more than 50 **roots** or **rhizomes** per container are found to have penetrated into but not through the membrane or coating, the evaluation on penetration shall be performed only on a section of the tested material. In this case, the evaluation shall cover at least 2 ft^2 (0.2 m^2) equivalent to about 20% of the membrane or coating covered with the substrate, and shall be performed in the area indicated in Figure 8. The penetration of **roots** or **rhizomes** into the field of the evaluation area shall be recorded.

6.2.2 Test Seam Evaluation

The penetration of **roots** or **rhizomes** into the overlap area of seams shall be recorded. Samples of the membrane or coating for retention purposes shall be taken to mirror the result of the investigation. The samples shall be compared to the control samples stored at the initial stage of the testing. (See 5.1)

6.2.3 Failure Criteria

A membrane or coating is deemed to have failed if a **root** or **rhizome** completely penetrates through the tested material.

6.3 Premature Test Termination

If in the course of the test evaluations visible penetrations of **roots** or **rhizomes** into the membrane or coating to be tested is identified the test shall be terminated. (See 4.6)

If during the test phase more than 25 % of the plants are lost, the investigation shall be started anew, i.e., new planting shall be carried out. At the same time, the growing media shall be replaced by a new mixture.

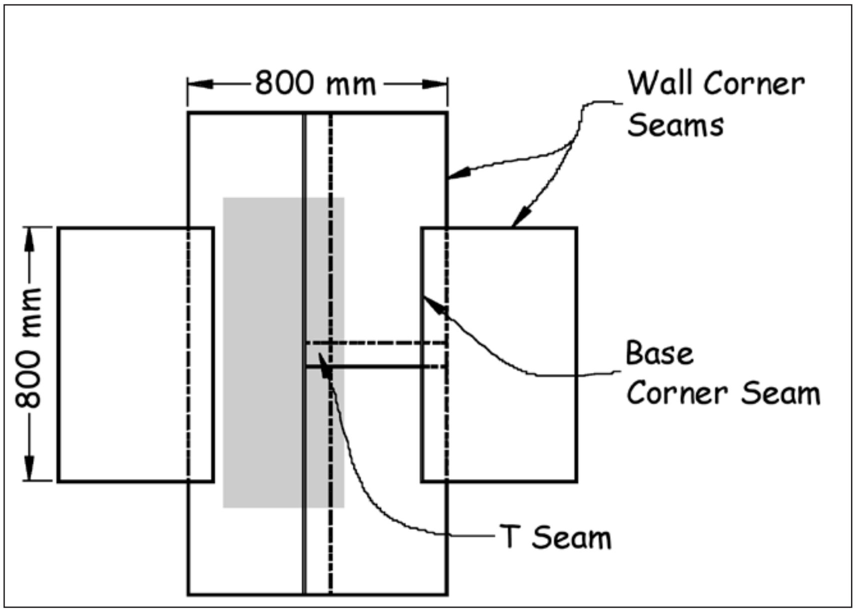


Figure 8: Evaluation Section of Penetrations into the Surface of a Membrane or Coating with > 50 Penetrations or Receptacle (Dimensions in mm)

6.4 Test Report

Upon termination of the trial a complete test report about the test shall be prepared.

The report shall contain the following information:

- Details provided by the manufacturer in relation to the membrane under testing
- (See 5.10):
- Description of the preparation of the **trial containers**: and
- All evaluation results in accordance with Section 6.1, 6.2 and 6.5.

Commentary

This Commentary is not a part of ANSI/SPRI VR-1 Investigating Resistance to **Root** Penetration on Vegetative Roofs. It is included as supplemental information.

This Commentary consists of explanatory and supplementary material designed to assist users in applying the recommended requirements. It is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at these requirements. The following wording shall be included in introduction to the Commentary: "The information contained in this Commentary is not part of this American National Standard (ANS) and has not been processed in accordance with ANSI's requirements for an ANS. As such, Commentary may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard."

The sections of the Commentary are numbered to correspond to the sections of the standard to which they refer. Since it is not necessary to have supplementary material for every section in the standard itself, there may be gaps in the numbering in the Commentary.

C2.0 The goal of this test procedure is to maximize **root** and **rhizome** growth in contact with the **root** resistant barrier or waterproofing membrane. The two moderately aggressive and vigorous plant species chosen represent a realistic threat to waterproofing integrity when well grown. Plant growth procedures described in this test are intended to maximize **root** and **rhizome** growth.

C4.1 "Orange Charmer" is an ornamental plant which under greenhouse conditions shows an all year round **root** growth suitable for the test.

Quack grass (Elymus repens) is an indigenous grass with slow-growing **rhizomes**, the settling of which can hardly be avoided on vegetative roofs, and which also grows sufficiently all year under the given testing conditions.

C4.6 **Root** adhesion is defined as **roots** that stick to the surface of the material or imperfections in the surface of the material that are not easily washed off with a low pressure water stream. This may include **roots** that have entered surface air bubbles or craters in the surface of the material but not progressed beyond the limits of the surface imperfection. **Root** adhesion does not include **roots** that stick to the material because of surface erosion or other degradation of the material.

C5.4 Larger containers may be used if the circumstances under which they are to be installed so require. For example, a larger **trial container** would be needed to evaluate seaming details as they would be installed in the field.

C5.5 The material compatibility of the nonwoven fabric with the membrane or coating to be tested shall be ensured. The material demand comes to 7 ft 2 in (0.65 m^2) per 32 in x 32 in (800 mm x 800 mm) **trial container**.

C5.7 Examples of commercially available **growth media** are Premier Horticulture Pro-Mix BX, Quebec, or other equivalent media. The substrate will require about 88 L per receptacle (taking into account a substrate supply via plant earth-clumps).

C5.8 An example of commercially available fertilizer is Osmacote Plus 15-9-12 with a release over 6 months.

C5.11 This corresponds to a substrate volume of 88 L. for a receptacle of 32 in x 32 in (800 mm x 800 mm). It is advisable to place the receptacles on stands to facilitate **root** penetration checks in regular intervals. Keep a minimum distance of 0.4 m between and around the different receptacles.

C5.15 Pruning is limited to side shoots if they are an obstacle to using walkways. Excessive pruning will limit **root** growth.

Designation: E2397 – 11

ANNEXE E

Standard Practice for Determination of Dead Loads and Live Loads Associated with Vegetative (Green) Roof Systems[1]

This standard is issued under the fixed designation E2397; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers a standardized procedure for predicting the system weight of a vegetative (green) roof system.

1.2 The practice addresses the loads associated with vegetative (green) roof systems. Components that are typically encountered in vegetative (green) roof systems include: membranes, non-absorptive plastic sheet components, metallic layers, fabrics, geocomposite drain layers, synthetic reinforcing layers, cover/recover boards, insulation materials, growth media, granular drainage media, and plant materials.

1.3 This practice also addresses the weight of the vegetative (green) roof system under two conditions: *(1)* weight under drained conditions after new water additions by rainfall or irrigation have ceased (this includes the weight of retained water and captured water), and *(2)* weight when rainfall or irrigation is actively occurring and the drain layer is completely filled with water. The first condition is considered the dead load of the vegetative (green) roof system. The difference in weight between the first and second conditions, approximated by the weight of transient water in the drain layer, is considered a live load.

1.4 This practice does not address point or line loads associated with architectural elements that are not essential components of a particular vegetative (green) roof system. These architectural elements may include pavement, walls, and masonry, and so forth.

1.5 This practice does not address live loads associated with construction activities.

1.6 This practice does not address loads associated with snow or wind.

1.7 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
E631 Terminology of Building Constructions
E2114 Terminology for Sustainability Relative to the Performance of Buildings
E2396 Test Method for Saturated Water Permeability of Granular Drainage Media [Falling-Head Method] for Vegetative (Green) Roof Systems
E2398 Test Method for Water Capture and Media Retention of Geocomposite Drain Layers for Vegetative (Green) Roof Systems
E2399 Test Method for Maximum Media Density for Dead Load Analysis of Vegetative (Green) Roof Systems

3. Terminology

3.1 *Definitions:*

3.1.1 For terms related to building construction, refer to Terminology E631.

3.1.2 For terms related to sustainability relative to the performance of buildings, refer to Terminology E2114.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *captured water, n*—the quantity of water that is retained in the drain layer of a vegetative (green) roof system after new water additions have ceased and that cannot escape the roof except through evaporation or plant transpiration.

3.2.1.1 *Discussion*—Water capture is a design technique for enhancing the water holding properties of a vegetative (green) roof system. Water may be captured using a number of techniques, including reservoirs built into a geocomposite drain layer, trays, and restricting drainage in order to hold

[1] This Practice is under the jurisdiction of ASTM Committee D08 on Roofing and Waterproofing and is the direct responsibility of Subcommittee D08.24 on Sustainability.

Current edition approved Feb. 15, 2011. Published March 2011. Originally approved in 2005. Last published in 2005 as E2397 – 05. DOI: 10.1520/E2397-11.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

water within the drain layer. In some vegetative (green) roof systems a granular course at the bottom of the vegetative (green) roof system provides both drainage and water capture functions. In this case the captured water applies only to the thickness of the granular course for which drainage is restricted. A method for determining the captured water associated with geocomposites based on the unit water capture volume is provided in Test Method E2398. The quantity of captured water will depend on whether or not the upper surface of the geocomposite drain layer is in-filled with granular media.

3.2.2 *geocomposite drain layer, n*—a synthetic sheet, mat, or panel that is specifically designed to convey water horizontally toward the roof deck drains, gutters, or scuppers.

3.2.2.1 *Discussion*—Geocomposite drain layers include absorptive drain mats whose principle function is drainage, but which will also contribute to water retention (see *retained water*). Some geocomposite drain layers may incorporate reservoirs on their upper surfaces that will capture water (see *captured water*).

3.2.3 *maximum media density, n*—the density of a mixed media material determined after it has been subjected to a specific amount of compaction and hydrated by immersion to simulate prolonged exposure to both foot traffic and rainfall.

3.2.3.1 *Discussion*—The maximum media density applies to media in a drained condition. The measurement of the maximum media density is provided in Test Method E2399.

3.2.4 *maximum media water retention*—the quantity of water held in a media layer at the maximum media density, measured in volume percent.

3.2.4.1 *Discussion*—A procedure for measuring the maximum media water retention is provided in Test Method E2399.

3.2.5 *module, n*—modular vegetative (green) roof systems combine many functional elements of vegetative (green) roof systems in a pre-manufactured module.

3.2.5.1 *Discussion*—Independent modules are designed to be placed adjacent to one another and linked in order to tile larger surfaces.

3.2.6 *retained water, n*—water which is held for a period of hours or days but would eventually drain out given enough time in the absence of evaporation or plant transpiration.

3.2.6.1 *Discussion*—Retained water is the quantity of water that is held for a prolonged period against gravity drainage in a vegetative (green) roof system, or in one of its components, after new additions by rainfall or artificial irrigation have ceased. Neglecting the effects of capillary rise, evaporation, and plant transpiration all of this water would eventually produce runoff. However, in practice most of this water will not become runoff but will be lost to evaporation and the plant-mediated processes of transpiration. This procedure describes standardized methods for estimating the quantity of water retained in a vegetative (green) roof system.

3.2.7 *roof system, n*—see *roofing system.*

3.2.8 *roofing system, n*—assembly of interacting components designed to weatherproof, and sometimes to insulate, the roof surface of a building. **E631**

3.2.8.1 *Discussion*—This term includes all components above the roof deck that are not part of the overlying vegetative (green) roof system. In practice this usually means the waterproofing membrane and all materials below the waterproofing membrane, down to the structural deck. It may include structural materials such as cover/recover board, insulation, protective layers, fire-suppressing materials, and waterproofing materials. The weight of these components (assumed dry) must be obtained from the manufacturer of the roofing system.

3.2.9 *transient water, n*—the quantity of water that is required to completely fill the drain layer of a vegetative (green) roof system, less the quantity of captured water.

3.2.9.1 *Discussion*—Transient water fills the open space, including pore spaces. This water can only be held for a period of minutes and drains immediately when rainfall additions end. This moisture contributes to the live load of the vegetative (green) roof system.

4. Summary of Practice

4.1 This practice describes a systematic procedure for estimating the dead load and transient water live load of vegetative (green) roof systems using information about the vegetative (green) roof components that are available from laboratory analysis.

5. Significance and Use

5.1 This practice addresses performance characteristics for vegetative (green) roof systems with respect to the dead load and transient water load of the entire vegetative (green) roof system.

5.2 Determining these performance characteristics of vegetative (green) roof systems provides information to facilitate the assessment of related engineering aspects of the facility. Such aspects may include structural design requirements, mechanical engineering and thermal design requirements, and fire and life safety requirements.

5.3 Determining these performance characteristics of vegetative (green) roof systems provides information to facilitate assessment of the performance of one vegetative (green) roof system relative to another.

6. Apparatus

6.1 *Apparatus:*

6.1.1 Scale, accurate to 0.005 oz (0.14 g);

6.1.2 Metal mesh with sieve opening size of U.S. #30 (0.6 mm), or larger, suspended from a drain stand;

6.1.3 Pan; and

6.1.4 Water bath.

6.2 Units of measure: lb/ft^2 (kg/m^2).

7. Procedure

7.1 *Weight of All Non-Absorptive Sheet Component*—These materials include plastic or rubber membranes, closed-cell foam layers, and the rigid or semi-rigid plastic cores of geocomposite drain layers. Also included is insulation provided as part of protected membrane roofing (PMR) installation. Absorptive drainage mats and fabrics, including fabrics integrated with geocomposite drain layers, are excluded (see

7.2 and 7.3). As needed, remove fabrics bonded to geocomposite drain layers for separate measurement according to 7.2. Weigh a 4-in. by 4-in. (10-cm by 10-cm) piece. Multiply this weight by 9 (100) to convert to unit weight in lb/ft^2 (kg/m^2), and record.

7.2 *Weight of All Fabrics*—4-in. by 4-in. (10-cm by 10-cm) sample in the dry condition. Multiply this weight by 9 (100) to convert to unit weight in lb/ft^2 (kg/m^2), and record. This is the dry unit weight of the fabric. Immerse the sample in a water bath for 15 min. Withdraw from the bath and drain for 15 min by laying the fabric flat on a suspended U.S. #30 (0.6 mm) wire cloth or sieve. Weigh the sample, convert to unit weight in lb/ft^2, and record. This is the unit weight of the fabric. The difference between the two measurements is the unit weight of the retained water associated with the fabric, *Wr*.

7.3 *Weight of Absorptive Drain Mats Used as Drain Layer Components*—These materials include open-cell foam layers, porous mats fabricated from particles of plastic or rubber, and mats manufactured from coir or other organic fibers. Weigh the pan using the scale. Weigh a 4-in. by 4-in. (10-cm by 10-cm) sample in the dry condition. Multiply this weight by 9 (100) to convert to unit weight in lb/ft^2 (kg/m^2), and record as the dry unit weight of the sample. Immerse the mat in the water bath for 24 hours. Withdraw the mat from the water bath and without delay place the mat into the pan. Weigh the pan and its contents. Subtract the weight of the pan and the dry weight of the mat. Multiply this weight by 9 (100) to convert to unit weight in lb/ft^2, and record as the unit weight of the water contained in the mat when filled to capacity. Dry the pan. Allow the mat to drain for an additional two hours by laying the mat flat on a suspended U.S. #30 (0.6 mm) wire cloth or sieve. Return the mat to the pan. Weigh the pan and its contents. Subtract the weight of the pan. Convert to unit weight in lb/ft^2, and record. This is the unit weight of the sample. Subtract the dry unit weight of the sample, and record. This is the unit weight of the retained water, *Wr*, in the mat. Subtract the unit weight of the retained water from the unit weight of the water when the mat was filled to capacity. This is the unit weight of the transient water associated with the absorptive drain mat, *Wt*.

7.4 *Weight of Growth Media*—Use Test Method E2399 to determine the maximum media density (MMD) and dry media density, D_{dry}, both measured in lb/ft^3 (kg/m^3), and the maximum media water retention (MMWR), measured in volume percent. Multiply the maximum media density times the thickness of the media layer in feet (metres) to convert to unit weight in lb/ft^2 (kg/m^2), and record. This is the unit weight of the growth media. Multiply the dry media density times the thickness of the media layer in feet to convert to unit weight in lb/ft^2, and record. This is the dry unit weight of the growth media. To determine the unit weight of the retained water, *Wr*, multiply the MMWR by the thickness of the media layer in feet and by 0.624 (10) and record this unit weight in lb/ft^2.

7.5 *Weight of Granular Drainage Media:*

7.5.1 *Drain Layers Consisting Entirely of Granular Drainage Media*—Use Test Method E2399 to determine the MMD and dry media density, D_{dry}, both measured in lb/ft^3 (kg/m^3), and the MMWR of the granular material, measured in volume percent. Multiply the MMD times the thickness of the granular drainage media in feet (metres). Record the unit weight of the granular drainage media in lb/ft^2 (kg/m^2). Multiply the dry media density times the thickness of the media layer in feet to convert to unit weight in lb/ft^2, and record. This is the dry unit weight of the granular drainage media. To determine the unit weight of the retained water, *Wr*, multiply the MMWR by the thickness of the layer in feet and by 0.624 (10). Record this unit weight in lb/ft^2.

7.5.2 *Drain Layers Incorporating Geocomposite Drain Layers*—In many vegetative (green) roof systems, granular drainage media is in-filled on the upper surface of a geocomposite drain layer. In these instances, the effective thickness of the granular drainage media, *ET*, is the unit media retention volume, *Rm*, measured in ft^3/ft^2 (cm^3/cm^2), as determined using Test Method E2398, plus any supplemental thickness of granular drainage media above the geocomposite drain layer, measured in feet (metres). Use Test Method E2399 to determine the MMD and dry media density, D_{dry}, both measured in lb/ft^3 (kg/m^3), and the MMWR of the granular material, measured in volume percent. Multiply the MMD times the effective thickness of the granular drainage media in feet and by 0.624 (10). Record the unit weight of the granular drainage media in lb/ft^2 (kg/m^2). Multiply the dry media density times the effective thickness of the granular drainage layer in feet to convert to unit weight in lb/ft^2, and record. This is the dry unit weight of the granular drainage media. To determine the weight of the retained water, *Wr*, multiply the MMWR by the effective thickness of the granular drainage media layer in feet and by 0.624 (98.1). Record this unit weight in lb/ft^2.

7.6 *Unit Weight of Captured Water:*

7.6.1 *Drain Layers Consisting Entirely of Granular Drainage Media*—One strategy for capturing water in vegetative (green) roof systems is to impound water in the drain layer by restricting drainage. In these cases water will accumulate in the granular drainage media layer at the base of the vegetative (green) roof system. Use Test Method E2399 to determine the air-filled porosity (AFP) of the granular drainage media, reported in percent. Multiply AFP times the average depth of impounded water layer in feet (metres) and by 0.624 (10). Record the unit weight of captured water, *Wc*, in lb/ft^2 (kg/m^2).

7.6.2 *Geocomposite Drain Layers, Without Granular Drainage Media*—For vegetative (green) roof systems that incorporate geocomposite drain layers with water capture, use Test Method E2398 to determine the weight of captured water based on the unit water capture volume (*Rw*). Multiply the unit water capture volume, stated in ft^3/ft^2 (cm ^{3}/cm^2), by 62.4 (10). Record the unit weight of captured water, *Wc*, in lb/ft^2 (kg/m^2).

7.6.3 *Drain Layers That Incorporate In-Filling of Granular Media on the Upper Surface of a Geocomposite Drain Layer*—Use Test Method E2399 to determine the AFP of the granular drainage media, reported in percent. To determine the weight of captured water, multiply AFP times *Rw* and by 62.4 (10). Record the unit weight of captured water, *Wc*, in lb/ft^2 (kg/m^2).

7.7 *Unit Weight of Transient Water:*

7.7.1 *Drain Layers Consisting Entirely of Granular Drainage Media*—Use Test Method E2399 to determine the AFP of the granular drainage media, reported in percent. Multiply AFP times the thickness of the drain layer in feet (metres) and by 0.624 (10). Subtract the unit weight of captured water, determined in 7.6.1. Record the unit weight of transient water, *Wt*, in lb/ft^2 (kg/m^2).

7.7.2 *Drain Layers Incorporating Geocomposite Drain Layers*—For vegetative (green) roof systems using absorptive drain mats, the method for determining the weight of transient water is described in 7.3. For other geocomposite drain layers, measure the thickness of the geocomposite drain layer in feet (centimetres). Add any supplemental thickness associated with the granular drainage media above the geocomposite drain layer. Record as the unit volume, *UV*, in ft^3/ft^2 (cm^3/cm^2).

7.7.2.1 *Drain Layers Without Granular Drainage Media*—Multiply the unit volume by 62.4 (10). Subtract the unit weight of captured water, determined in 7.6.2. Record the unit weight of transient water, *Wt*, in lb/ft^2 (kg/m^2).

7.7.2.2 *Drain Layers Incorporating Granular Drainage Media*—Use Test Method E2399 to determine the AFP for the granular drainage media, reported in percent. Multiply AFP times the effective thickness of the granular drainage media layer, determined in 7.5.2. Add this result to the unit volume. Subtract the effective thickness. Multiply this result by 62.4 (10). Subtract the unit weight of captured water, determined in 7.6.3. Record the resulting unit weight of transient water, *Wt*, in lb/ft^2 (kg/m^2).

$$Wt = (UV - ET(1 - AFP))*62.4 - Wc \text{ (in. - lb)} \quad (1)$$

$$Wt = (UV - ET(1 - AFP))*10 - Wc \text{ (SI)}$$

where:

Wt = unit weight of transient water, lb/ft^3 (kg/m^3),
UV = unit volume of geocomposite, ft^3/ft^2 (cm^3/cm^2),
ET = effective thickness of granular drainage media, ft^3/ft^2 (cm^3/cm^2),
AFP = air filled porosity, volume percent, and
Wc = unit weight of captured water, lb/ft^3 (kg/m^3).

NOTE 1—A method for measuring the effective unit volume of a geocomposite drain layer has not been introduced at this time. In the absence of a standard test method, use the full thickness of the geocomposite drain layer, measured in feet (centimetres) and reported as unit volume in units of ft^3/ft^2 (cm^3/cm^2). If a geocomposite drain layer has been manufactured from a non-absorbent close-cell plastic foam, or similar, deduct the average thickness of the foam material from the unit volume.

NOTE 2—When evaluating modules, set the module on a horizontal surface and measure the distance from the surface to the uppermost asperities on the textured bottom surface of the module.

7.8 *Weight of Retained Water in a Vegetative (Green) Roof System*—For purposes of comparison between vegetative (green) roof systems, the weight of the retained water in a vegetative (green) roof system shall be determined as the sum of the following unit weights:

7.8.1 Retained water in fabrics (see 7.2),

7.8.2 Retained water in absorptive drain mats (see 7.3),

7.8.3 Retained water in the growth media layer (see 7.4),

7.8.4 Retained water in the granular drainage media layer (see 7.5), and

7.8.5 Captured water (see 7.6).

7.9 *Volume of Retained Water,* reported in inches (centimetres), associated with a vegetative (green) roof system shall be the total weight of retained water, reported in lb/ft^2 (kg/m^2), divided by 62.4 (1000), and multiplied by 12 (100).

7.10 *Weight of Transient Water Associated with a Vegetative (Green) Roof System, Wt*—For purposes of comparison between vegetative (green) roof systems, the weight of the transient water in a vegetative (green) roof system shall be determined as the sum of the following unit weights:

7.10.1 Transient water in absorptive drain mats (see 7.3), and

7.10.2 Transient water in the drain layer (see 7.7)

7.11 *Volume of Transient Water,* reported in inches (centimetres), associated with a vegetative (green) roof system shall be the total weight of transient water, reported in lb/ft^2 (kg/m^2), divided by 62.4 (1000), and multiplied by 12 (100).

8. Report

8.1 Use the Report Format (Annex A1) to record the unit weights determined for each vegetative (green) roof component.

9. Keywords

9.1 dead load; live load; sustainability; vegetative (green) roof; vegetative (green) roof system; vegetative (green) roofing system; water retention

ANNEX

(Mandatory Information)

A1. REPORT FORMAT

SYSTEM DESIGNATION:_________
TOTAL SYSTEM THICKNESS, IN. (CM):_________
VOLUME OF RETAINED WATER, IN. (CM):_________
VOLUME OF CAPTURED WATER, IN. (CM):_________

Component	Thickness, in. (cm)	Comment	Dry Unit Weight, lb/ft^2 (kg/m^2)	Unit Weight, lb/ft^2 (kg/m^2)[A]
		DEAD LOAD SUMMATION		
A. Roofing System[B]	NA	Obtain from roofing manufacturer		
B. Non-Absorptive Components		Unit weight equals dry unit weight		
• Insulation		Protected membrane roofing (PMR) installations		
• Root-Barrier				
• Protection Layer				
• Geocomposite Drain Layer				
• Other (Describe)				
C. Fabrics				
• Protection				
• Moisture Retention				
• Separation				
• Other (Describe)				
D. Absorptive Drainage Mats				
E. Growth Media				
F. Drainage Media				
G. Captured Water	NA			
H. Extensive Plant Material	NA	Use 2 lb/ft^2 (96 kg/m^2)		
I. Intensive Plant Material (excluding large perennials and trees)	NA	Use 3 lb/ft^2 (144 kg/m^2)		
J. Other (Describe)				
		Total Dead Load		
		Total Transient Water Live Load	NA	

[A] Includes weight of retained water.
[B] For purposes of this worksheet, waterproofing membrane and all materials below this membrane.

ANNEXE F

ANSI/SPRI RP-14 2016

Wind Design Standard For Vegetative Roofing Systems

Approved September 9, 2016

Approved American National Standard ANSI

SPRI Single Ply Roofing Industry

Table of Contents

465 Waverley Oaks Road
Suite 421
Waltham, MA 02452

www.spri.org.

Disclaimer
This standard is for use by architects, engineers, roofing contractors, and owners of low slope roofing systems. SPRI, its members and employees do not warrant that this standards is proper and applicable under all conditions.

1.0 Introduction

This standard provides a method of designing wind uplift resistance of *vegetative roofing systems* utilizing adhered roofing membranes. It is intended to provide a minimum design and installation reference for those individuals who design, specify, and install *vegetative roofing systems*. It shall be used in conjunction with, or enhanced by, the installation specifications and requirements of the manufacturer of the specific products used in the *vegetative roofing system*. See Commentary C1.0.

2.0 Definitions

All words defined within this section are italicized throughout the standard.

The following definitions shall apply when designing a *Vegetative Roofing System*.

2.1 Vegetative Roofing System

An assembly of interacting components designed to waterproof a building's top surface that includes, by design, vegetation and related landscaping elements.

2.2 Ballast

The weight provided by stones, pavers or light-weight interlocking paver systems to provide uplift resistance for roofing systems that are not adhered or mechanically attached to the roof deck. The inorganic portion of *growth media* can be considered *ballast* if vegetation nominally covers the visible surface of the *growth media* or the *growth media* is protected by a system to prevent wind erosion. See Commentary 2.2.

2.3 Vegetation Coverage

2.3.1 Nominal Vegetation Coverage

No exposed *growth media* greater than a 4 in (102 mm) in diameter.

2.3.2 Unprotected Growth Media or Unprotected Modular Vegetative Roof Trays

Systems that do not have *nominal vegetation coverage*.

2.3.3 Protected Growth Media or Protected Modular Vegetative Roof Trays

Systems that have *nominal vegetation coverage* or a system to prevent *growth media* blow off.

2.4 Growth Media

An engineered formulation of inorganic and organic materials including but not limited to heat-expanded clays, slates, shales, aggregate, sand, perlite, vermiculite and organic material including but not limited to compost worm castings, coir and peat.

2.5 Basic Wind Speed

The *Basic Wind Speed* is the 3-second gust speed at 33 ft (10 m) above the ground in *Exposure C* as follows:

2.5.1 Risk Category II

Wind speeds correspond to approximately a 7% probability of exceedance in 50 years. See Attachment I-A.

2.5.2 Risk Category III and IV

Wind speeds correspond to approximately a 3% probability of exceedance in 50 years. See Attachment I-B.

2.5.3 Risk Category I

Wind speeds correspond to approximately a 15% probability of exceedance in 50 years. See Attachment I-C.

2.5.4 Risk Category IV

Wind speeds correspond to approximately a 1.6% probability of exceedance in 50 years. See Attachment I-C.

Approved
September 9, 2016

2.5.5 Wind speed conversion

The ultimate design *wind speeds* of Attachment I A, B, C, and D shall be converted to nominal design *wind speeds* V_{asd}, using the following equation:

$$V_{asd} = V_{ult}\sqrt{0.6}$$

where:

V_{asd} = nominal design *wind speed*

V_{ult} = ultimate design *wind speeds* determined from Attachment I A, B, C, and D

2.6 Roof Areas See Figure 1.

2.6.1 Corner

The space between intersecting walls forming an angle greater than 45 degrees but less than 135 degrees. See Commentary 2.6.1.

2.6.2 Corner Area

For roofs having height, h ≤ 60 ft (18 m), the *corner area* is defined as the *corner* roof section with sides equal to α (see below). See Commentary 2.6.2. For roofs having height, h > 60 ft (18 m), the *corner* zone is defined as the *corner* roof section with sides equal to 2 x **α** (see below).

α = 0.4h, but not less than either 4% of least horizontal dimension or 8.5 ft (2.9 m)

See Commentary 2.6.2.

2.6.3 Perimeter Area

Perimeter area is defined as the rectangular roof section parallel to the roof edge and connecting the *corner areas* with a width measurement equal to **α** (see above).

2.6.4 Field

The *field* of the roof is defined as that portion of the roof surface which is not included in the *corner* or the *perimeter area* as defined above.

2.7 Surface Roughness/Exposure Categories

A ground *surface roughness* within each 45-degree sector shall be determined for a distance upwind of the site as defined in Section 2.7.1, 2.72 or 2.7.3 for the purpose of assigning an exposure category.

2.7.1 Surface Roughness/Exposure B

Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.

*Exposure B***:** For buildings with a mean roof height of less than or equal to 30 ft (9.1 m), *Exposure B* shall apply where the ground *surface roughness*, as defined by *Surface Roughness B*, prevails in the upwind direction for a distance greater than 1,500 ft (457 m). For buildings with a mean roof height greater than 30 ft (9.1 m), *Exposure B* shall apply where *Surface Roughness B* prevails in the upwind direction for a distance greater than 2,600 ft (792 m) or 20 times the height of the building, whichever is greater.

2.7.2 Surface Roughness/Exposure C

Open terrain with scattered obstructions having heights generally less than 30 ft (9.1 m). This category includes flat open country and grasslands. *Exposure C* shall apply for all cases where *Exposures B* or *D* do not apply. See Commentary C2.7.

2.7.3 Surface Roughness/Exposure D

Flat, unobstructed areas and water surfaces. This category includes smooth mud flats, salt flats, and unbroken ice. *Exposure D* shall apply where the ground *surface roughness*, as defined by *Surface Roughness D*, prevails in the upwind direction for a distance greater than 5,000 ft (1,524 m) or 20 times the building height, whichever is greater. *Exposure D* shall also apply where the ground *surface roughness* immediately upwind of the site is B or C, and the site is within a distance of 600 ft (183 m) or 20 times the building height, whichever is greater, from an *Exposure D* condition as defined in the previous sentence. For a site located in the transition zone between *exposure categories*, the category resulting in the largest wind forces shall be used. See Section 5.3.

2.7.4 Exception

An intermediate exposure between the preceding categories is permitted in a transition zone provided that it is determined by a rational analysis method defined in the recognized literature.

2.8 Impervious Decks

A roof deck that will not allow air to pass through it. Some examples are poured in-place concrete, gypsum, and poured-in-place lightweight concrete. See Commentary C2.8.

2.9 Pervious Decks

A roof deck that allows air to move through it. Some examples are metal, cementitious wood fiber, oriented strand board, plywood and wood plank.

2.10 Occupancy Category

Occupancy category accounts for the degree of hazard to human life and damage to property. See Table 1.

2.11 Wind Borne Debris Regions

Areas within hurricane prone areas where impact protection is required for glazed openings.

2.12 Registered Design Professional

An individual who is registered or licensed to practice their respective design profession as defined by the statutory requirements of the professional registration laws of the state or jurisdiction in which the project is to be constructed.

Table 1

Classification of Buildings and Other Structures for Wind, Snow, and Earthquake Loads[1]

Nature of Occupancy	Category
Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to: ▶ Agricultural facilities ▶ Certain temporary facilities ▶ Minor storage facilities	I
All buildings and other structures except those listed in Categories I, III, IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to: ▶ Buildings and other structures where more than 300 people congregate in one area ▶ Buildings and other structures with elementary school, secondary school, or day care facilities with capacity greater than 150 ▶ Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities ▶ Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities ▶ Jails and detention facilities ▶ Power generating stations and other public utility facilities not included in Category IV ▶ Buildings and other structures containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released including, but not limited to: A. Petrochemical facilities B. Fuel storage facilities C. Manufacturing or storage facilities for hazardous chemicals D. Manufacturing or storage facilities for explosives	III
Buildings and other structures designated as essential facilities including, but not limited to: ▶ Hospitals and other health care facilities having surgery or emergency treatment facilities ▶ Fire, rescue and police stations and emergency vehicle garages ▶ Designated earthquake, hurricane, or other emergency shelters ▶ Communications centers and other facilities required for emergency response ▶ Power generating stations and other public utility facilities required in an emergency ▶ Ancillary structures (including, but not limited to communications towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water or other fire suppression material or equipment) required for operation of Category IV structures during an emergency ▶ Aviation control towers, air traffic control centers and emergency aircraft hangers ▶ Water storage facilities and pump structures required to maintain water pressure for fire suppression ▶ Buildings and other structures having critical national defense functions	IV

[1] The definitions above are based on those of ANSI/ASCE 7-2010. Examples of building types are retained from previous version of ASCE 7 for clarification.

3.0 General Design Considerations and System Requirements

All *vegetative roofing systems* shall comply with the following:

3.1 Roof Structure

The building owner shall consult with a *registered design professional* such as an architect, architectural engineer, civil engineer, or structural engineer to verify that the structure and deck will support the *vegetative roofing system* loads including the *ballast* load in combination with all other design loads.

3.2 Building Height

The building height shall be measured from ground level to the roof system surface at the roof edge. When more than one roof level is involved, each shall have its own design per Sections 4.0 and 5.0; or be designed to the criteria required for the most exposed or highest roof level. When building height exceeds 150 ft (46 m), the roof design shall be designed by a *registered design professional* using current wind engineering practices consistent with ASCE 7 and the design shall be approved by the authority having jurisdiction. See Commentary C3.2.

3.3 Slope

The Wind Design Standard for *Vegetative Roofing Systems* is limited to roof slope designs up to 1.5 in 12 (7 degrees) as measured at the top side of the roof membrane. For slopes greater than 1.5 in 12, a *registered design professional* experienced in vegetative roof wind design shall provide design requirements and the design shall be approved by the authority having jurisdiction.

3.4 Positive Pressure Building Systems

When HVAC equipment generates a positive pressure inside a building greater than 0.5 in (13 mm) of water the roof system shall be designed to resist the pressure by increasing the wind load requirements in accordance with Section 5.2.

3.5 Rooftop Projections

The *roof area* at the base of any rooftop projection that extends more than 2 ft (0.6 m) above the top of the parapet and has one side longer than 4 ft (1.2 m) shall be designed in accordance with Section 5.3.

3.6 Overhanging Eaves and Canopies

By their design, overhanging eaves and canopies are subject to greater uplift forces than the roof surface because of the impact of the air flow up the wall. Such conditions shall be designed in accordance with Section 5.4. See Figures 2 and 3.

3.7 Membrane Requirements

The membrane specified for use in the vegetative system shall meet the recognized industry minimum material requirements for the generic membrane type, and shall meet the specific requirements of its manufacturer. Membranes not having a consensus product standard shall meet the specific requirements of their manufacturer. Where the membrane is not impervious to root penetration, root barriers shall be necessary. See Commentary C3.7.

3.8 Membrane Perimeter and Angle Change Attachment

See Commentary C3.8.

3.8.1 At Roof Edge and Top of Parapet Wall

When the roofing system is terminated using a metal edge or coping flashing, the metal flashing shall be designed and installed in accordance with ANSI/SPRI/FM 4435/ES-1 *Wind Design Standard for Edge Systems Used With Low Slope Roofing Systems* except gutters. When the membrane or roof flashing is terminated on a parapet wall below the coping, the perimeter attachment used to terminate a roofing system shall be capable of withstanding the calculated load. For asphaltic and fully adhered single ply membranes, it is permitted to use alternative attachments that comply with manufacturer's drawings and specifications. Roofs terminated at gutters shall meet manufactures requirement for gutter edge securement.

3.8.2 For Angle Changes
All attachments of membranes at angle changes or system type changes in a roofing system shall be capable of withstanding the calculated load.

3.8.3 Parapet Height
The parapet height for *vegetative roofing systems* is the distance from the top of the *growth media* to the top of the parapet. When the lowest parapet height is outside of the defined *corner area* of the roof and is less than 70% of the height of the parapet within the defined *corner area*, then this lower parapet height shall be used for the design. When the lowest parapet is located outside the defined *corner area* of the roof and is equal to or greater than 70% of the height of the parapet within the defined *corner area*, then the minimum parapet height within the *corner* segment shall be used for the design. See example in Figure 4.

3.8.4 Metal Edge Flashing (Gravel Stop)
When an edge flashing is used at the building perimeter, the top edge of the flashing shall be higher than the top surface of the *ballast*, but not less than 2 in (50 mm) above the top surface of the *growth media*. Metal edge flashing shall be designed and installed in accordance with ANSI/SPRI/FM 4435/ES-1.

3.8.5 Transition
At the junction of loose-laid roof membranes with the adhered or mechanically attached membrane areas, a mechanical termination shall be provided. The termination shall resist the forces as calculated using ANSI/SPRI/FM 4435/ES-1.

3.9 Wind Erosion
When the *growth media* is not nominally covered with vegetation, provision for preventing wind erosion shall be installed in the *corner* and perimeter to prevent *growth media* from being wind-blown. See Commentary C3.9.

3.10 High Winds
When the *wind speed* exceeds 140 miles per hour (63 m/s) 3-second gust *wind speed* after all adjustments are applied, the roof design shall be designed by a *registered design professional* using current wind engineering practices consistent with ASCE 7 and the design shall be approved by the authority having jurisdiction.

3.11 Wind Borne Debris
Roofs installed in regions designated by ASCE 7, or the authority having jurisdiction, as *wind borne debris regions* shall be designed by a *registered design professional* using current wind engineering practices consistent with ASCE 7. The design shall be approved by the authority having jurisdiction. See Commentary C3.11.

3.12 Ballast Requirements
See Commentary C3.12. *Ballast* shall be in accordance with the manufacturer's specification and not less than the following:

3.12.1 #4 Ballast
For vegetative roofs when vegetation nominally covers the visible surface of the *growth media* or provisions have been made to prevent wind erosion from the surface, #4 *ballast* can consist of any of the following used independently or in combinations:

- *Growth media* spread at a minimum dry weight of 10 psf (49 kg/m^2) of inorganic material plus organic material;

  Interlocking contoured fit or strapped together trays containing *growth media* spread at minimum dry weight of 10 psf (49 kg/m^2) of inorganic material plus organic material;

- Independently set modular pre-planted or pre-grown vegetative roof trays containing 18 psf (88 kg/m^2) dry weight inorganic material plus organic material.

  Vegetation coverage or erosion protection is not required when the #4 *ballast* below is used.

- River bottom or coarse stone nominal 1-1/2 in (38 mm) of *ballast* gradation size #4, or alternatively, #3, #24, #2, or #1 as specified in ASTM D7655, *Standard Classification for Size of Aggregate Used as Ballast for Membrane Roof Systems* spread at a minimum weight of 10 psf (49 kg/m^2);
- Concrete pavers independently set (minimum 18 psf (88 kg/m^2));
- Interlocking, beveled, doweled, or contour-fit lightweight concrete pavers (minimum 10 psf (49 kg/m^2)).

3.12.2 #2 Ballast

For vegetative roofs when vegetation nominally covers the visible surface of the *growth media* or provisions have been made to prevent wind erosion from the surface, #2 *ballast* can consist of any of the following used independently or in combinations:

- *Growth media* spread at a minimum dry weight of 13 psf (64 kg/m^2) of inorganic material plus organic material;
- Interlocking contoured fit or strapped together trays containing *growth media* spread at minimum dry weight of 13 psf (64 kg/m^2) of inorganic material plus organic material;
- Independently set modular pre-planted or pre-grown vegetative roof trays containing 22 psf (104 kg/m^2) dry weight inorganic material plus organic material.

  Vegetation coverage or erosion protection is not required when the #2 *ballast* below is used:

- River bottom or course stone nominal 2-1/2 in (64 mm) of *ballast* gradation size #2, or alternatively, #1 as specified in ASTM D7655 *Standard Classification for Size of Aggregate Used as Ballast for Membrane Roof Systems* spread at a minimum weight of 13 psf; (64 kg/m^2);
- Concrete pavers independently set (minimum 22 psf (104 kg/m^2));
- Interlocking, beveled, doweled, or contour-fit lightweight concrete pavers (minimum 10 psf ;(49 kg/m^2)).

4.0 Design Options

The vegetative roof wind designs include, but are not limited to, the generic systems shown below. Other systems, when documented or demonstrated as equivalent with the provisions of this standard, shall be used when approved by the authority having jurisdiction. The designs listed in Sections 4.2 and 4.3 are the minimum specifications. See Commentary C4.0.

4.1 Roof Membrane Attachment

All roof membrane shall be fully adhered. The fully adhered roofing membrane shall withstand the uplift design pressure without the *ballast* in accordance with requirements of the authority having jurisdiction. See Commentary C4.1.

4.2 Ballasted Design Systems for Vegetative Roofing Systems

See Section 2.2 for definition of *Ballast*. The design systems listed below are based on Table 2. Any building not fitting the Table 2 Design Tables shall be treated as a Special Design Consideration and shall be reviewed by a *registered design professional* and approved by the authority having jurisdiction.

4.2.1 System 1

The installed membrane shall be ballasted with #4 *ballast*. See Section 3.12.1.

4.2.2 System 2

The installed membrane shall be ballasted as follows:

4.2.2.1 Corner Area

The installed membrane in the *corner area* shall be ballasted with #2 *ballast*. See Section 3.12.2 and Figure 1.

4.2.2.2 Perimeter

The installed membrane in the *perimeter area* shall be ballasted with #2 *ballast*. See Section 3.12.2 and Figure 1.

4.2.2.3 Field

In the *field* of the roof, the installed membrane shall be ballasted with #4 *ballast*. See Section 3.12.1. For areas designated as wind debris areas, #2 *ballast* shall be the minimum size-weight *ballast* used.

4.2.3 System 3

Install the system as follows:

4.2.3.1 Corner Area

In each *corner area*, the adhered roof system designed to withstand the uplift force in accordance with ASCE 7 or the local building code, shall be installed in accordance with the provisions for the *corner* location with no loose stone, *unprotected growth media or unprotected modular vegetative roof trays* placed on the membrane. See Figure 1 and Commentary C4.0.

When a protective covering is required in the *corner area*, install minimum 22 psf (104 kg/m^2) pavers, or other material approved by the authority having jurisdiction.

4.2.3.2 Perimeter

In the *perimeter area*, the adhered roof system designed to withstand the uplift force in accordance with ASCE 7 or the local building code, shall be installed in accordance with the provisions for the perimeter location with no loose stone, *growth media* or modular vegetative roof trays placed on the membrane.

When a protective covering is required in a perimeter area, install minimum 22 psf (104 kg/m^2) pavers or other material approved by the authority having jurisdiction.

4.2.3.3 Field

In the *field* of the roof, install #2 *ballast*. See Section 3.12.2.

4.3 Protected Vegetative Roofing Systems

(Systems where the insulation is installed over the waterproofing membrane) See Commentary C4.3 for description.

The protected membrane roof wind designs include, but are not limited to, the generic systems shown below. Other systems, which comply with the provision of this specification, shall be permitted when approved by the authority having jurisdiction.

4.3.1 System 1 and System 2

When the design criteria based on *wind speed*, building height, and parapet height and exposure, require a System 1 or System 2 design, the ballasting procedures for that respective system shall be according to Sections 4.2.1 and 4.2.2, respectively.

4.3.2 System 3

When the design criteria, based on *wind speed* and building height, parapet height and exposure require a System 3 design, a minimum 2 ft (0.6 m) parapet height See Section 3.8.3 for determining parapet height) is required and the installation procedures for System 3 as defined in Section 4.2.3 above shall be followed. In addition, the insulation that is installed over the fully adhered perimeter and *corner areas* shall be ballasted with 22 psf (104 kg/m^2) pavers (minimum) or other material approved by the authority having jurisdiction.

5.0 Design Provisions

5.1 Rooftop Projections

See Section 3.5 for description.

When rooftop projections rise 2 ft (0.6 m) or more above the parapet height and have at least one side greater than 4 ft (1.2 m) in length, the *roof area* shall be protected from wind erosion. See Commentary C3.9.

5.2 Overhangs, Eaves and Canopies

5.2.1 Impervious Decks

When a deck is *impervious*, overhang, eaves and canopy shall be defined as the following: Eaves and overhangs: The overhang or eave shall be considered the perimeter of the applicable design. See Figure 2. Canopies: The entire canopy area shall be designed as a *corner* section of the applicable design.

5.2.2 Pervious Decks

Because a fully adhered membrane roof system is used, the design shall follow the *impervious* deck design.

5.3 Exposure D

For buildings located in *Exposure D*, the roof design as identified in the Design Tables (See Table 2) shall be upgraded to a higher level of resistance to wind. Under *Exposure C* the roof top *wind speed* shall be increased by 20 mph (9 m/s) from the *basic wind speed* from the wind map. See section 2.7.3. Under these conditions a building roof located in a 90 mph (40 m/s) wind zone would be upgraded to 110 mph (49 m/s). Installation shall follow all of the requirements for the higher design wind.

5.4 Occupancy Category

ASCE 7 provides *wind speed* maps based on the *occupancy category* for the buildings being roofed. Find the *wind speed* from the appropriate map (Attachment I A-D) and install the appropriate system using the Design Table II A-G.

Approved
September 9, 2016

6.0 Determination of Vegetative System Roof Design

To determine the vegetative design for a given building, the following process shall be followed. See Commentary C6.0.

6.1 Based on the building location, the nominal design *wind speed* shall be determined following Section 2.5.4 and *Surface Roughness/Exposure* from Section 2.7.

6.1.1 The building height shall be determined by following Section 3.2 and the parapet height from Section 3.8.3.

6.1.2 Knowing the *wind speed*, building height, parapet height, *Risk Category* and *Surface Roughness/Exposure*, determine the System Design (1, 2 or 3) using the appropriate Design Table contained in Table 2.

6.1.3 Having determined the System from the Design Tables (Table 2), use Section 4.0, Design Options, to determine the ballasting requirements based on the type of roof system as described in Sections 4.1, 4.2 and 4.3.

6.1.4 Section 5.0, Design Provisions shall be reviewed to determine the necessary enhancements to the system's ballasting requirements. These provisions are the accumulative addition to the base design from the Design Table 2A-G.

7.0 Maintenance

Vegetative roof systems shall be maintained to provide vegetation that nominally covers the visible surface of the *growth media*. When wind scour occurs to an existing *vegetative roof system* and the scour is less than 50 ft^2 (4.6 m^2), the *growth media* and plants shall be replaced. For scour areas greater than 50 ft^2 (4.6 m^2), the vegetative roof design shall be upgraded a minimum of one system design level per Section 4.0. The requirement for maintenance shall be conveyed by the designer to the building owner, and it shall be the building owner's responsibility to maintain the *vegetative roofing system*.

Table 2

Design Tables[3]

A. From 2 inch high to less than 6.0 inch high parapet

Maximum Wind Speed (MPH)

Roof height feet	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–15	110	115	125	125	140	140
15–30	110	115	120	125	140	140
30–45	100	110	110	125	140	140
45–60	No	No	105	125	130	140
60–75	No	No	100	120	130	130
75–90	No	No	No	No	No	No
90–105	No	No	No	No	No	No
105–120	No	No	No	No	No	No
120–135	No	No	No	No	No	No
135–150	No	No	No	No	No	No

B. For parapet heights from 6.0 to less than 12.0 inches

Maximum Wind Speed (MPH)

Roof height feet	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–15	110	115	125	125	140	140
15–30	110	115	120	125	140	140
30–45	100	110	110	125	140	140
45–60	No	No	105	125	130	140
60–75	No	No	100	120	130	140
75–90	No	No	No	No	No	No
90–105	No	No	No	No	No	No
105–120	No	No	No	No	No	No
120–135	No	No	No	No	No	No
135–150	No	No	No	No	No	No

C. For parapet heights from 12.0 to less than 18.0 inches

Maximum Wind Speed (MPH)

Roof height feet	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–15	110	115	125	125	140	140
15–30	110	115	120	125	140	140
30–45	100	115	115	125	140	140
45–60	No	100	105	125	140	140
60–75	No	100	100	120	130	140
75–90	No	No	100	120	120	130
90–105	No	No	100	110	120	120
105–120	No	No	95	110	110	120
120–135	No	No	No	110	110	120
135–150	No	No	No	105	110	120

[3] Wind speed reference see Section 2.5
Wind speeds in above tables are "3 second gust" measured at 10 meters (33 feet).

Table 2

Design Tables[3]

D. For parapet heights from 18.0 to less than 24.0 inches

Maximum Wind Speed (MPH)

Roof height feet	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–15	120	120	130	130	140	140
15–30	120	120	120	130	140	140
30–45	105	120	120	130	140	140
45–60	95	120	105	130	140	140
60–75	No	100	100	120	140	140
75–90	No	100	100	120	130	140
90–105	No	No	100	110	120	130
105–120	No	No	100	110	120	120
120–135	No	No	100	110	120	120
135–150	No	No	No	110	110	120

E. For parapet heights from 24.0 to less than 36.0 inches

Maximum Wind Speed (MPH)

Roof height feet	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–15	120	120	130	130	140	140
15–30	120	120	130	130	140	140
30–45	105	120	120	130	140	140
45–60	95	120	110	130	140	140
60–75	No	100	100	130	140	140
75–90	No	100	100	120	140	140
90–105	No	No	100	110	130	140
105–120	No	No	100	110	130	140
120–135	No	No	100	110	130	140
135–150	No	No	100	110	120	140

F. For parapet heights from 36.0 to less than 72 inches

Maximum Wind Speed (MPH)

Roof height feet	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–15	120	120	130	130	140	140
15–30	120	120	130	130	140	140
30–45	110	120	130	130	140	140
45–60	105	120	115	130	140	140
60–75	100	110	110	130	140	140
75–90	100	110	110	130	140	140
90–105	100	100	110	120	140	140
105–120	95	100	110	120	140	140
120–135	95	100	110	120	140	140
135–150	No	95	110	120	140	140

[3] Wind speed reference see Section 2.5
Wind speeds in above tables are “3 second gust” measured at 10 meters (33 feet).

Table 2

Design Tables[3]

G. For parapet heights from 72 inches and above

Maximum Wind Speed (MPH)

Roof height feet	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–15	120	120	130	130	140	140
15–30	120	120	130	130	140	140
30–45	120	120	130	130	140	140
45–60	110	120	130	130	140	140
60–75	105	120	125	130	140	140
75–90	100	110	120	130	140	140
90–105	100	110	120	130	140	140
105–120	100	110	120	130	140	140
120–135	100	110	120	130	140	140
135–150	95	110	120	120	140	140

[3] Wind speed reference see Section 2.5
Wind speeds in above tables are “3 second gust” measured at 10 meters (33 feet).

Table 2

Design Tables[3]

Metric

A. From 50 mm height to less than 150mm parapet height

Maximum Allowable Wind Speed m/s

Roof height meters	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–5	50	52	56	56	63	68
5–9	50	52	54	56	63	68
9–14	45	50	50	56	63	68
14–18	No	No	52	56	59	68
18–23	No	No	45	54	59	68
23–27	No	No	No	No	No	59
27–32	No	No	No	No	No	No
32–37	No	No	No	No	No	No
37–41	No	No	No	No	No	No
41–46	No	No	No	No	No	No

B. For parapet heights from 150 mm to less than 300 mm

Maximum Allowable Wind Speed m/s

Roof height meters	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–5	53	55	59	59	66	71
5–9	53	55	57	59	66	71
9–14	48	53	53	59	66	71
14–18	No	No	55	59	62	71
18–23	No	No	48	57	62	66
23–27	No	No	No	No	No	66
27–32	No	No	No	No	No	No
32–37	No	No	No	No	No	No
37–41	No	No	No	No	No	No
41–46	No	No	No	No	No	No

C. For parapet heights from 0.3 m to less than 0.45 m

Maximum Allowable Wind Speed m/s

Roof height meters	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–5	50	52	56	56	68	68
5–9	50	52	54	56	68	68
9–14	45	52	52	56	68	68
14–18	No	No	47	56	63	68
18–23	No	No	45	54	59	63
23–27	No	No	45	54	54	59
27–32	No	No	45	50	54	54
32–37	No	No	43	50	50	54
37–41	No	No	No	50	50	54
41–46	No	No	No	47	50	54

[3] Wind speed reference see Section 2.5
Wind speeds in above tables are “3 second gust” measured at 10 meters (33 feet).

Table 2

Design Tables[3]

D. For parapet heights from 0.45 m to less than 0.60 m

Maximum Allowable Wind Speed m/s

Roof height meters	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–5	54	54	59	59	68	68
5–9	54	54	54	59	68	68
9–14	47	54	54	59	68	68
14–18	43	54	47	59	63	68
18–23	No	40	45	54	59	63
23–27	No	40	45	54	54	59
27–32	No	No	45	50	54	54
32–37	No	No	45	50	50	54
37–41	No	No	45	50	50	54
41–46	No	No	No	50	50	54

E. For parapet heights from 0.60 m to less than 1 m

Maximum Allowable Wind Speed m/s

Roof height meters	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–5	54	54	59	59	68	68
5–9	54	54	59	59	68	68
9–14	47	54	54	59	68	68
14–18	43	54	50	59	68	68
18–23	No	45	45	59	63	68
23–27	No	45	45	54	63	68
27–32	No	No	45	50	59	68
32–37	No	No	45	50	59	68
37–41	No	No	45	50	59	68
41–46	No	No	45	50	54	63

F. For parapet heights from 1 m to less than 2 m

Maximum Allowable Wind Speed m/s

Roof height meters	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–5	54	54	59	59	68	68
5–9	54	54	59	59	68	68
9–14	50	54	59	59	68	68
14–18	47	54	52	59	68	68
18–23	45	50	50	59	68	68
23–27	45	50	50	59	68	68
27–32	45	45	50	54	63	68
32–37	43	45	50	54	63	68
37–41	43	45	50	54	63	68
41–46	No	43	50	54	63	68

[3] Wind speed reference see Section 2.5
Wind speeds in above tables are “3 second gust” measured at 10 meters (33 feet).

Table 2

Design Tables[3]

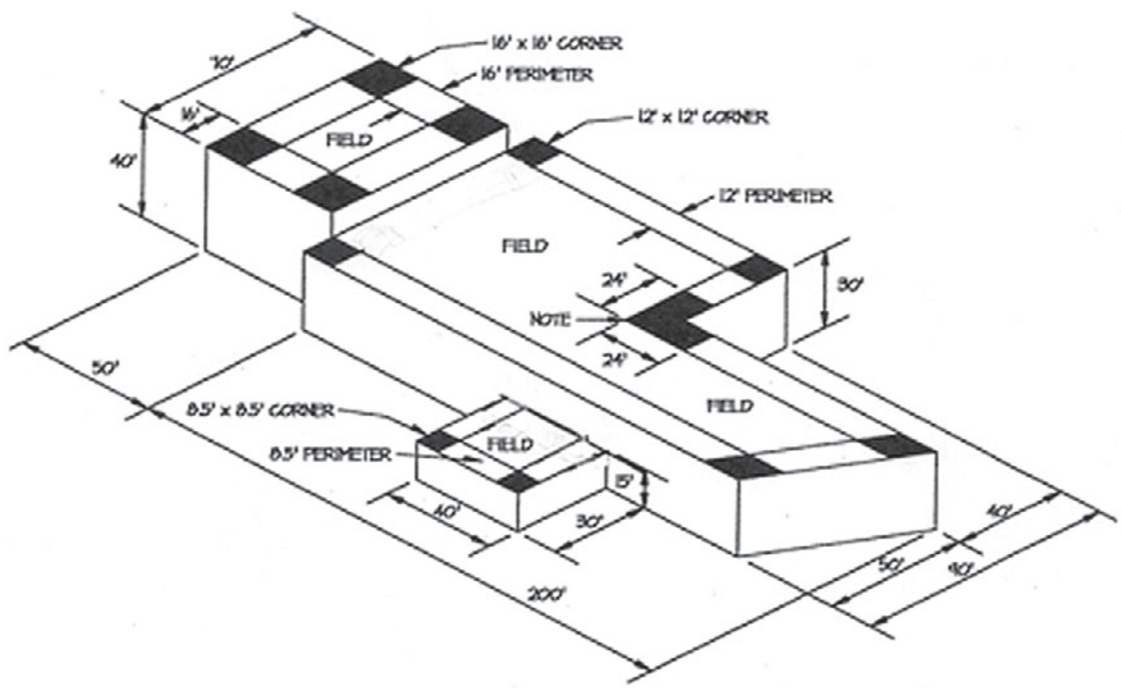
G. For parapet heights from 2 m and above

Maximum Allowable Wind Speed m/s

Roof height meters	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–5	54	54	59	59	68	68
5–9	54	54	59	59	68	68
9–14	54	54	59	59	68	68
14–18	50	54	59	59	68	68
18–23	47	54	56	59	68	68
23–27	45	50	54	59	68	68
27–32	45	50	54	59	68	68
32–37	45	50	54	59	63	68
37–41	45	50	54	59	63	68
41–46	43	50	54	54	63	68

[3] Wind speed reference see Section 2.5
Wind speeds in above tables are “3 second gust” measured at 10 meters (33 feet).

Figure 1
Roof Areas
Systems 2 and 3



Note: Reentrant corners are larger than other corners.

	Low Roof	Main Roof	High roof
Roof Height	15 ft	30 ft	40 ft
40% of Building Height	6.0 ft	12 ft	16 ft
Corner Length	8.5 ft (a)	12 ft	16 ft
Perimeter Width	8.5 ft (a)	12 ft	16 ft

(a) 8.5 ft minimum controls

Figure 1
Roof Layout
Systems 2 and 3

Metric Dimensions

	Low Roof	Main Roof	High Roof
Roof height	4.6 m	9.0 m	12 m
40% of building height	2.0 m	3.6 m	5 m
Corner length	2.6 m (a)	3.6 m	5 m
Perimeter width	2.6 m (a)	3.6 m	5 m

(a) 2.6 m minimum controls

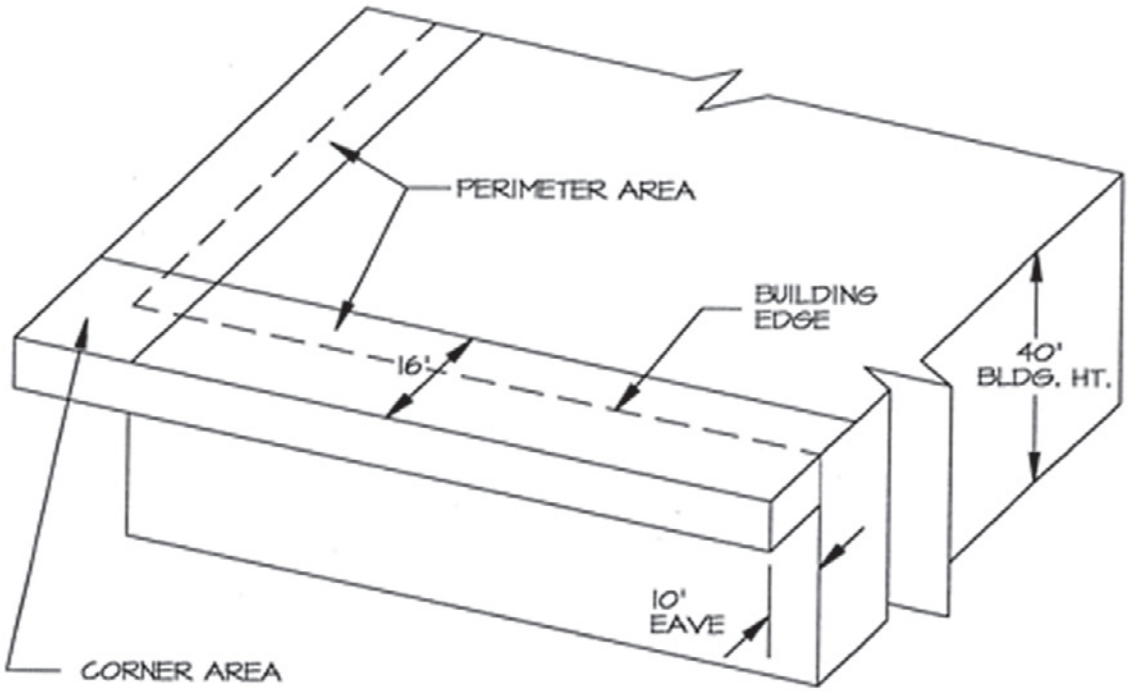
Other Dimensions

Description	IP	Metric
High Roof		
Corner	16 ft x 16 ft	5 m x 5 m
Perimeter	16 ft	5 m
Width	70 ft	21.3 m
Height	40 ft	12 m
Main Roof		
Corner	12 ft x 12 ft	3.6 m x 3.6 m
Perimeter	12 ft	3.6 m
Height	30 ft	9 m
Re-entrant Corner	24 ft x 24 ft	7.3 m x 7.3 m
Off set	40 ft	12 m
Width	90 ft	27.4 m
Length	200 ft	61 m
Low Roof		
Corner	8.5 ft x 8.5 ft	2.6 m
Perimeter	8.5 ft	2.6 m
Width	30 ft	9 m
Height	15 ft	4.6 m

Figure 2

Canopies and Overhanging Eaves
Impervious Decks

For Systems 2 and 3



Eave = 10 ft

Corner area = .4 × the building height
(or 8.5 ft (2.6 m) minimum)
16 ft for this example

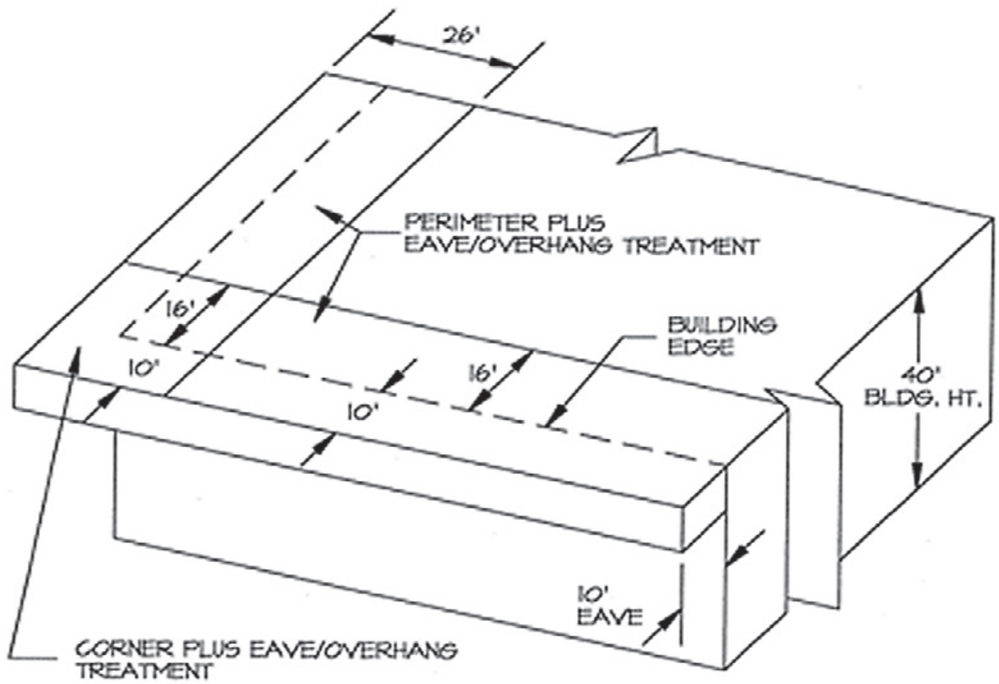
Perimeter area = .4 × the building height
(or 8.5 ft (2.6 m) minimum)
16 ft for this example

Description	IP	Metric
Building Height	40 ft	12 m
Eave	10 ft	3 m
Corner and Perimeter area	8.5 ft minimum	2.6 m
Corner and Perimeter area	16 ft for this example	5 m

Figure 3

Canopies and Overhanging Eaves
Pervious Decks

For Systems 1, 2 and 3



Eave = 10 ft

Corner area = .4 × the building height plus the overhang area
(or 8.5 ft (2.6 m) minimum)
26 ft for this example

Perimeter area = .4 × the building height plus the overhand are
(or 8.5 ft (2.6 m) minimum)
26 ft for this example

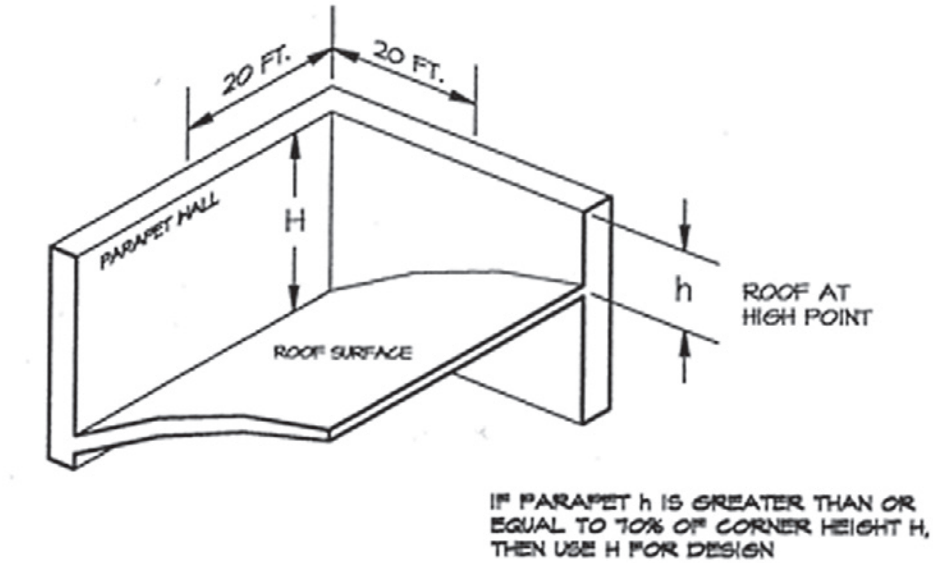
Description	IP	Metric
Building Height	40 ft	12 m
Eave	10 ft	3 m
Perimeter	16 ft	5 m
Corner and Perimeter area	8.5 ft minimum	2.6 m
Corner and Perimeter area	26 ft for this example	8 m

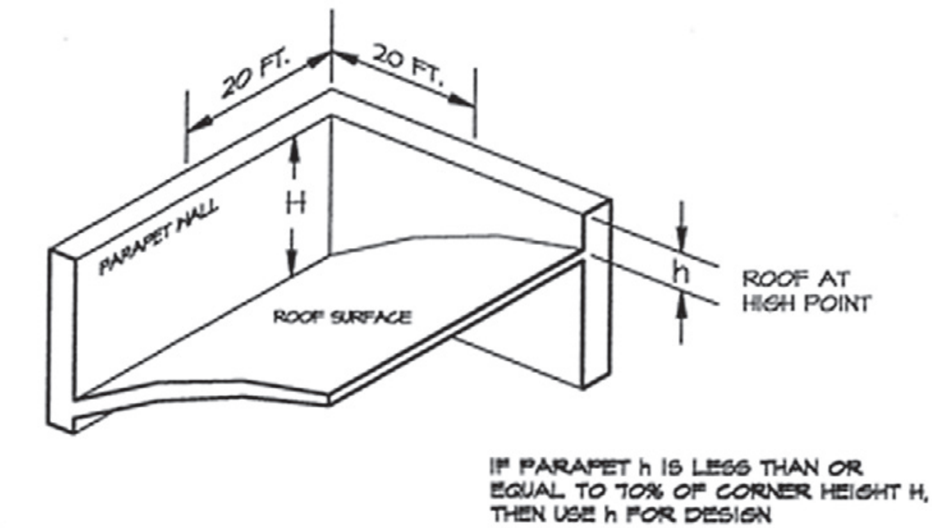
ANSI/SPRI RP-14 2016
Wind Design Standard For Vegetative Roofing Systems

Approved
September 9, 2016

Figure 4

Parapet Height
Design Considerations

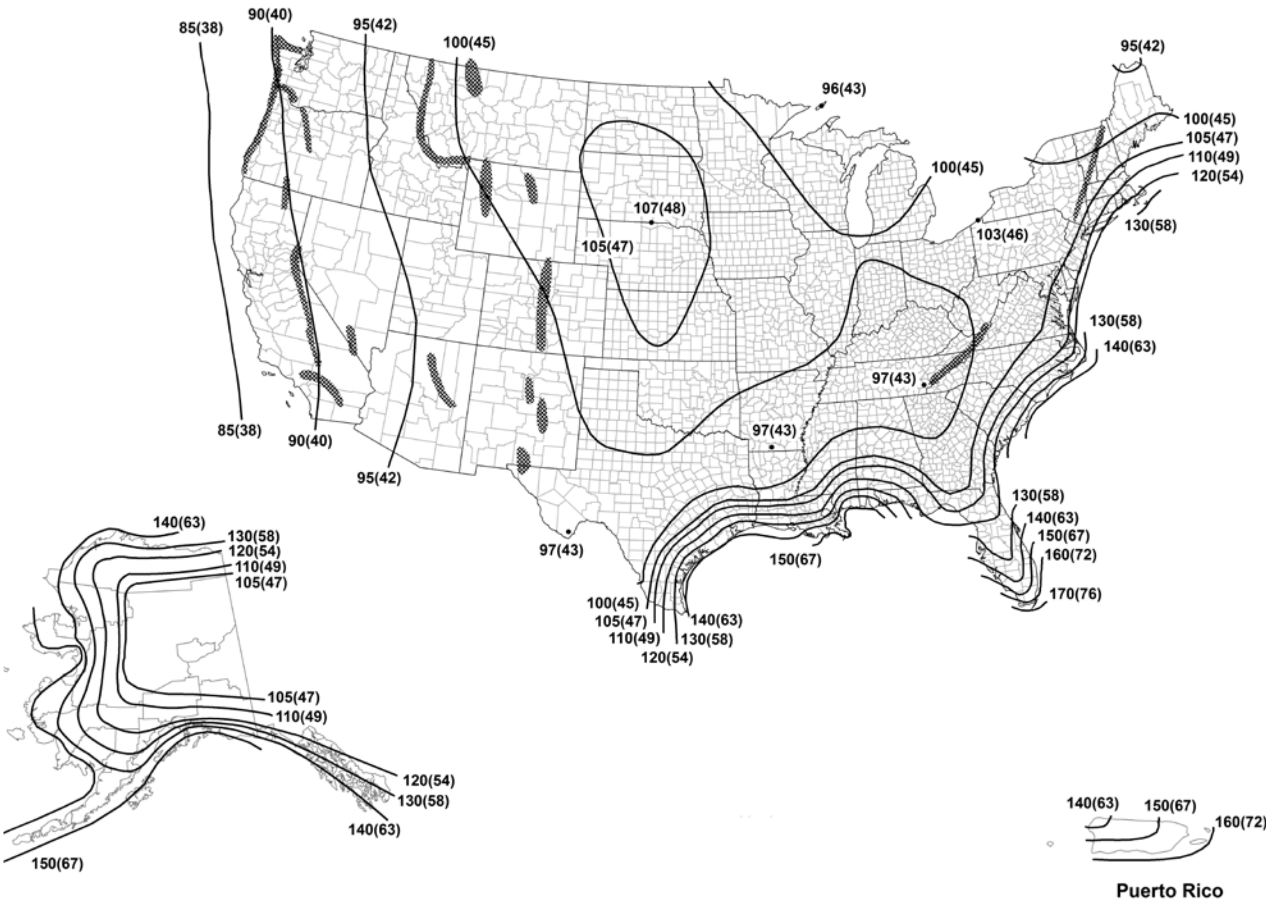




Metric Dimensions

Description	IP	Metric
Corner	20 ft	6 m

Attachment I
ASCE7-16 Figure 26.5-1A
Basic Wind Speeds for Risk Category I Buildings and Other Structures



Location	V (mph)	V (m/s)
Guam	180	(80)
Virgin Islands	150	(67)
American Samoa	150	(67)
Hawaii	See Figure 26.5-2A	

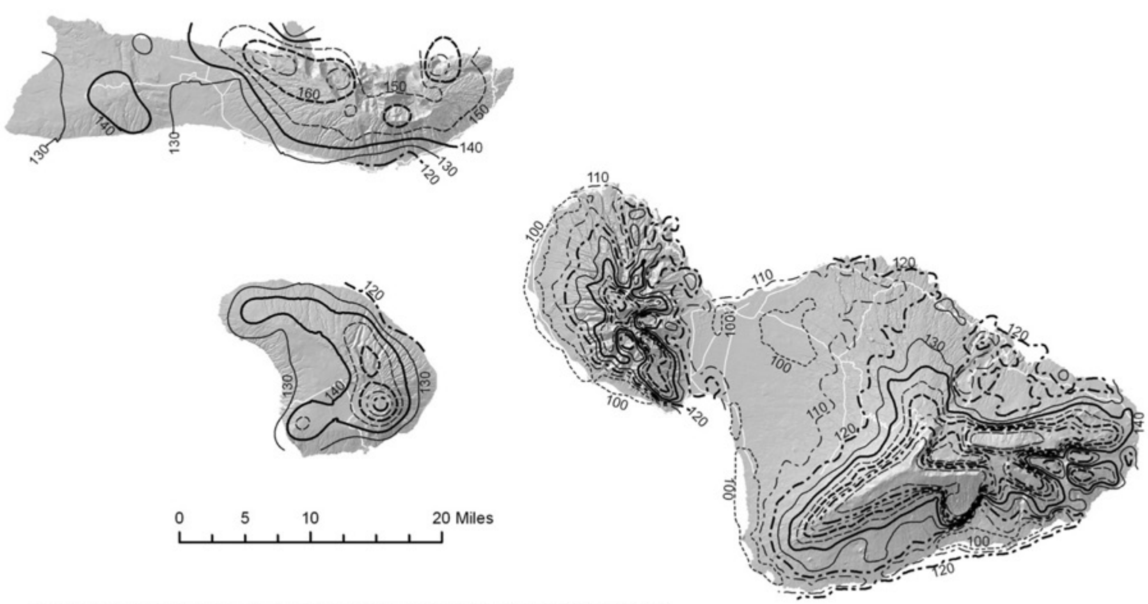
ANSI/SPRI RP-14 2016
Wind Design Standard For Vegetative Roofing Systems

Approved
September 9, 2016

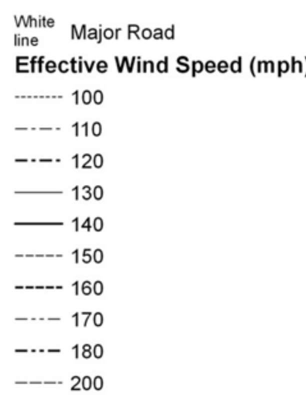
Notes: Dark shading indicates a Special Wind Region.

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C.
2. Linear interpolation is permitted between contours. Point values are provided to aid with interpolation.
3. Islands, coastal areas, and land boundaries outside the last contour shall use the last wind speed contour.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 15% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00333, MRI = 300 years).
6. Location-specific basic wind speeds shall be permitted to be determined using www.atcouncil.org/windspeed.

Attachment I
ASCE7-16 Figure 26.5-2A
Basic Wind Speeds for Risk Category I Buildings and Other Structures: Hawaii



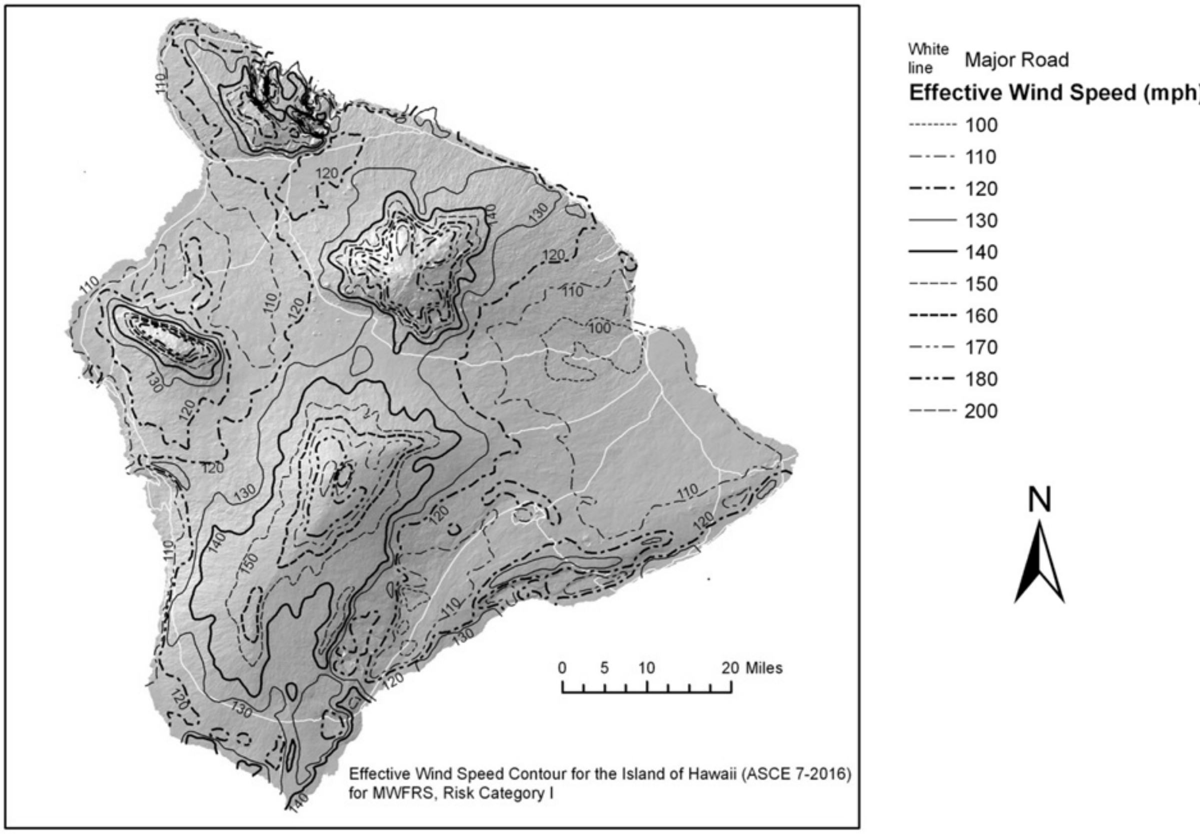
Effective Wind Speed Contour for the Islands of Maui, Molokai and Lanai (ASCE 7-2016) for MWFRS, Risk Category I



Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 15% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00333, MRI = 300 years)

Attachment I
ASCE7-16 Figure 26.5-2A (continued)
Basic Wind Speeds for Risk Category I Buildings and Other Structures: Hawaii



ANSI/SPRI RP-14 2016
Wind Design Standard For Vegetative Roofing Systems

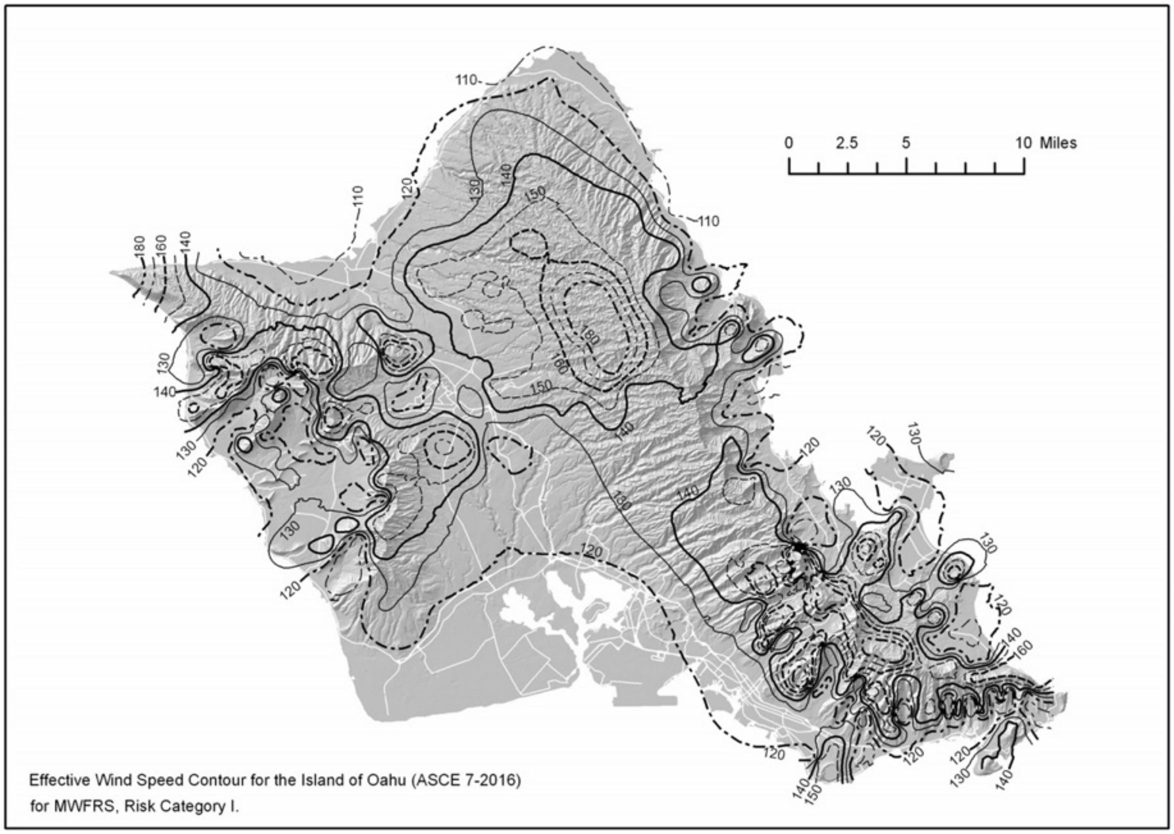
Approved
September 9, 2016

Notes:
1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 15% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00333, MRI = 300 years)

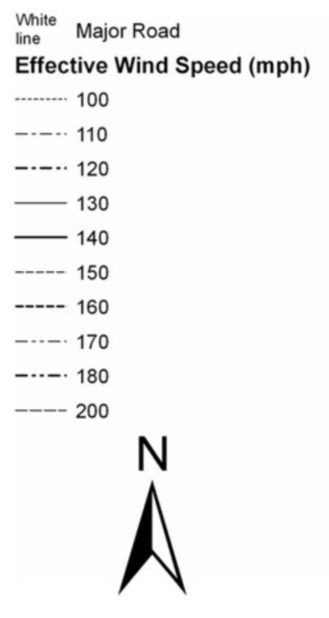
Attachment I

ASCE7-16 Figure 26.5-2A (continued)

Basic Wind Speeds for Risk Category I Buildings and Other Structures: Hawaii



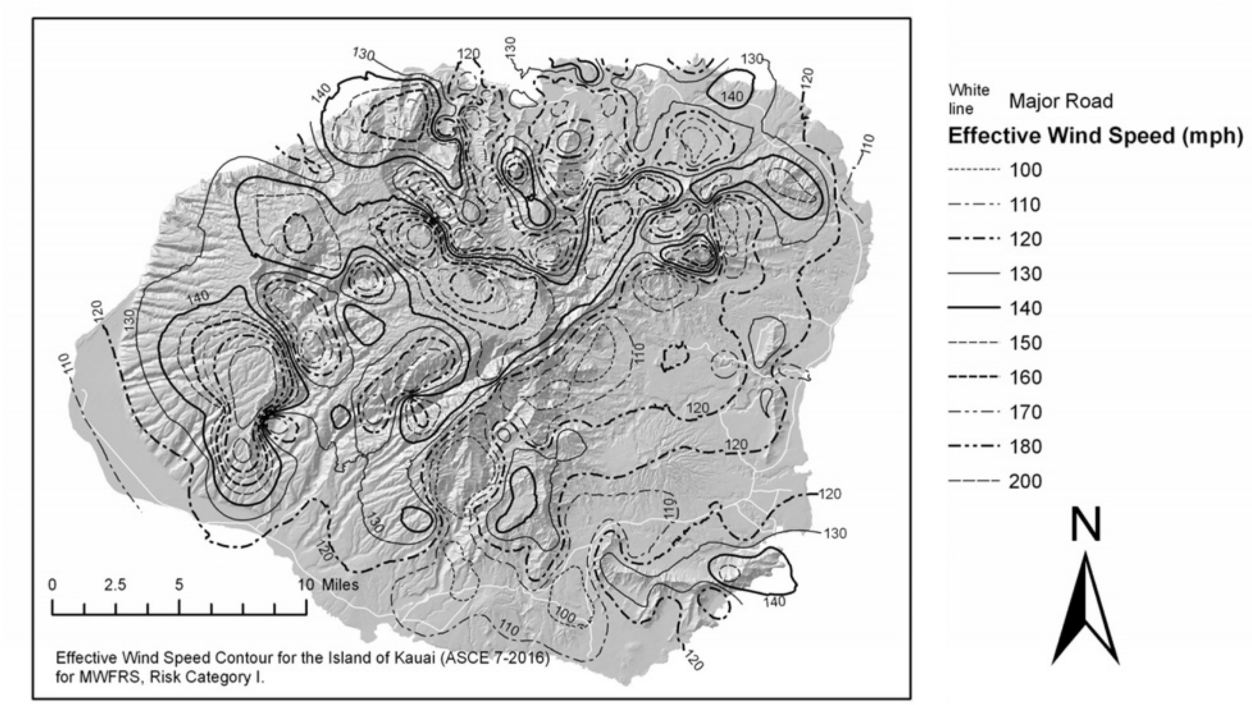
Effective Wind Speed Contour for the Island of Oahu (ASCE 7-2016) for MWFRS, Risk Category I.



Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 15% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00333, MRI = 300 years)

Attachment I
ASCE7-16 Figure 26.5-2A (continued)
Basic Wind Speeds for Risk Category I Buildings and Other Structures: Hawaii



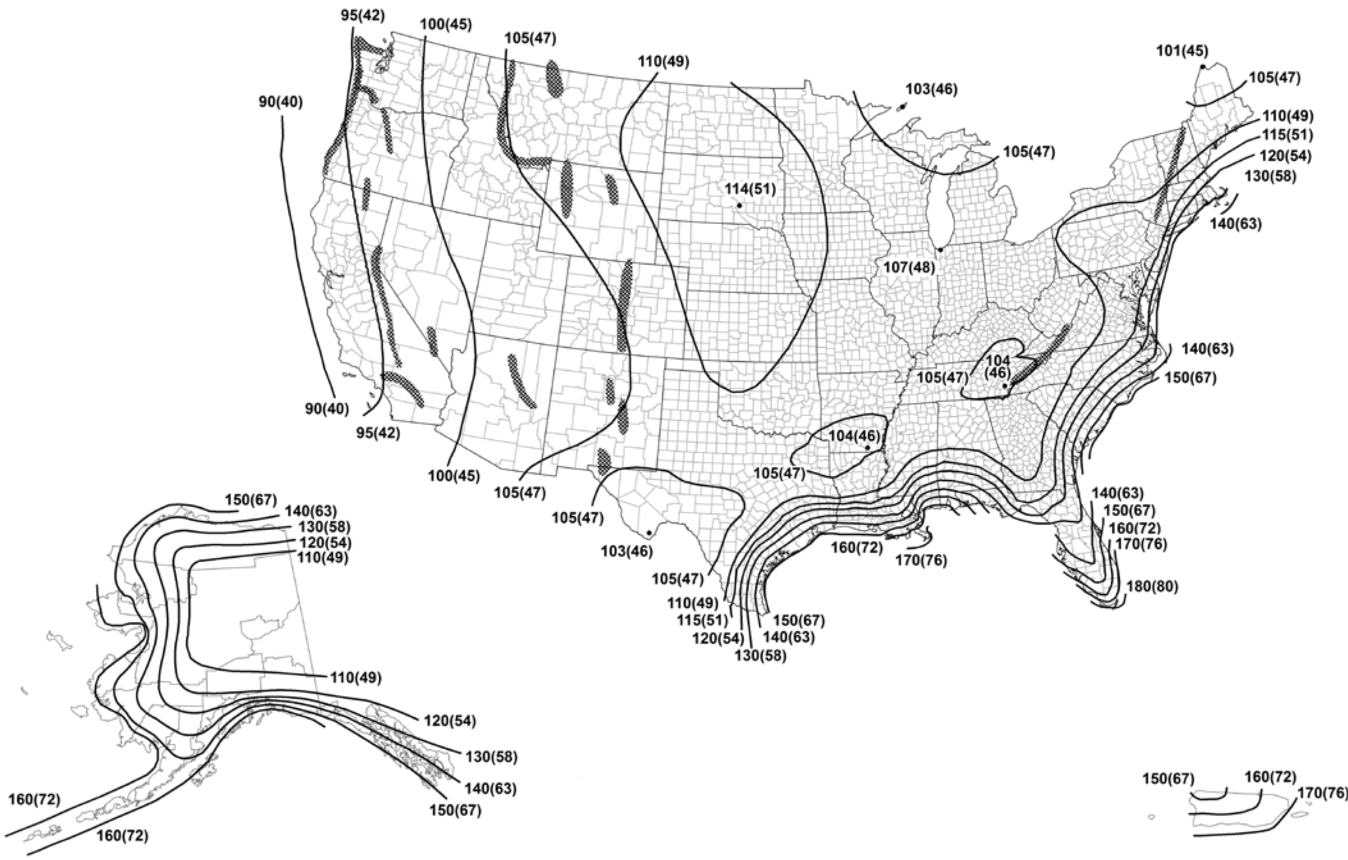
Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 15% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00333, MRI = 300 years)

Attachment I

ASCE7-16 Figure 26.5-1B

Basic Wind Speeds for Risk Category II Buildings and Other Structures

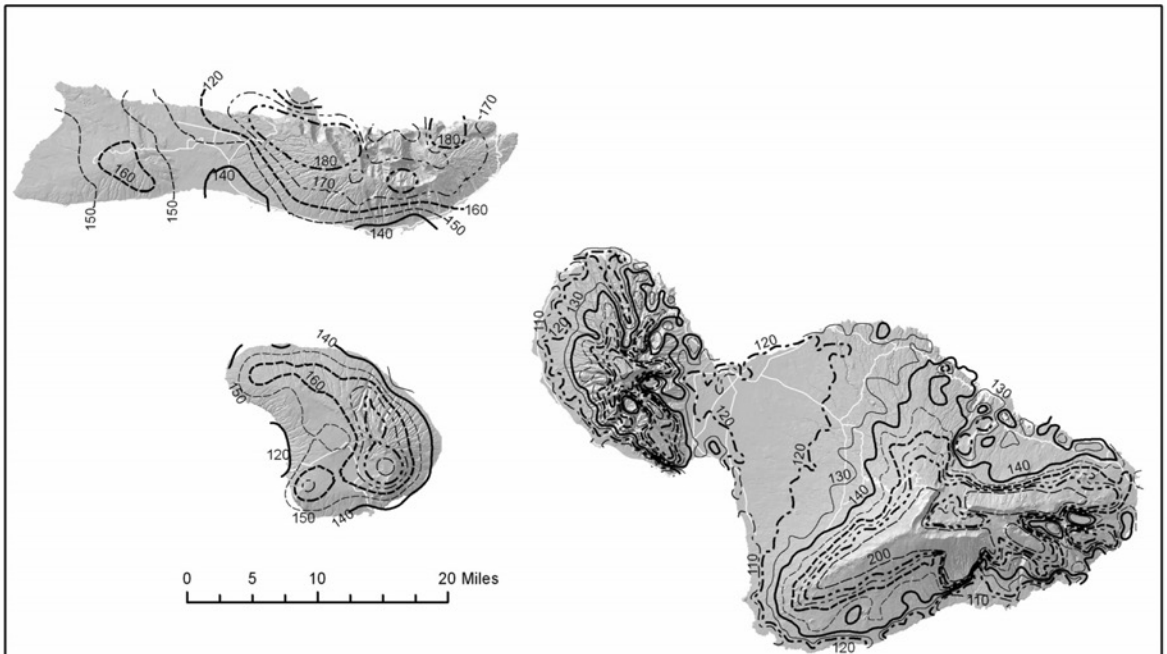


Location	V (mph)	V (m/s)
Guam	195	(87)
Virgin Islands	165	(74)
American Samoa	160	(72)
Hawaii	See Figure 26.5-2B	

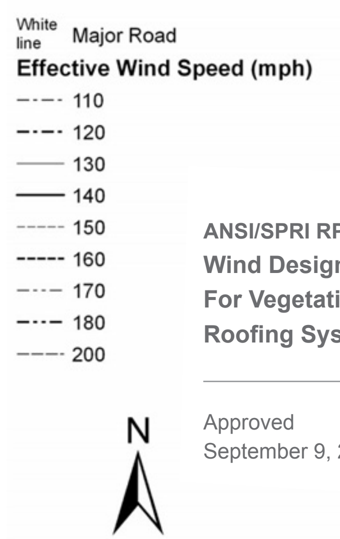
Notes: Dark shading indicates a Special Wind Region.

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C.
2. Linear interpolation is permitted between contours. Point values are provided to aid with interpolation.
3. Islands, coastal areas, and land boundaries outside the last contour shall use the last wind speed contour.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 years).
6. Location-specific basic wind speeds shall be permitted to be determined using www.atcouncil.org/windspeed.

Attachment I
ASCE7-16 Figure 26.5-2B
Basic Wind Speeds for Risk Category II Buildings and Other Structures: Hawaii



Effective Wind Speed Contour for the Islands of Maui, Molokai and Lanai (ASCE 7-2016)
for MWFRS, Risk Category II



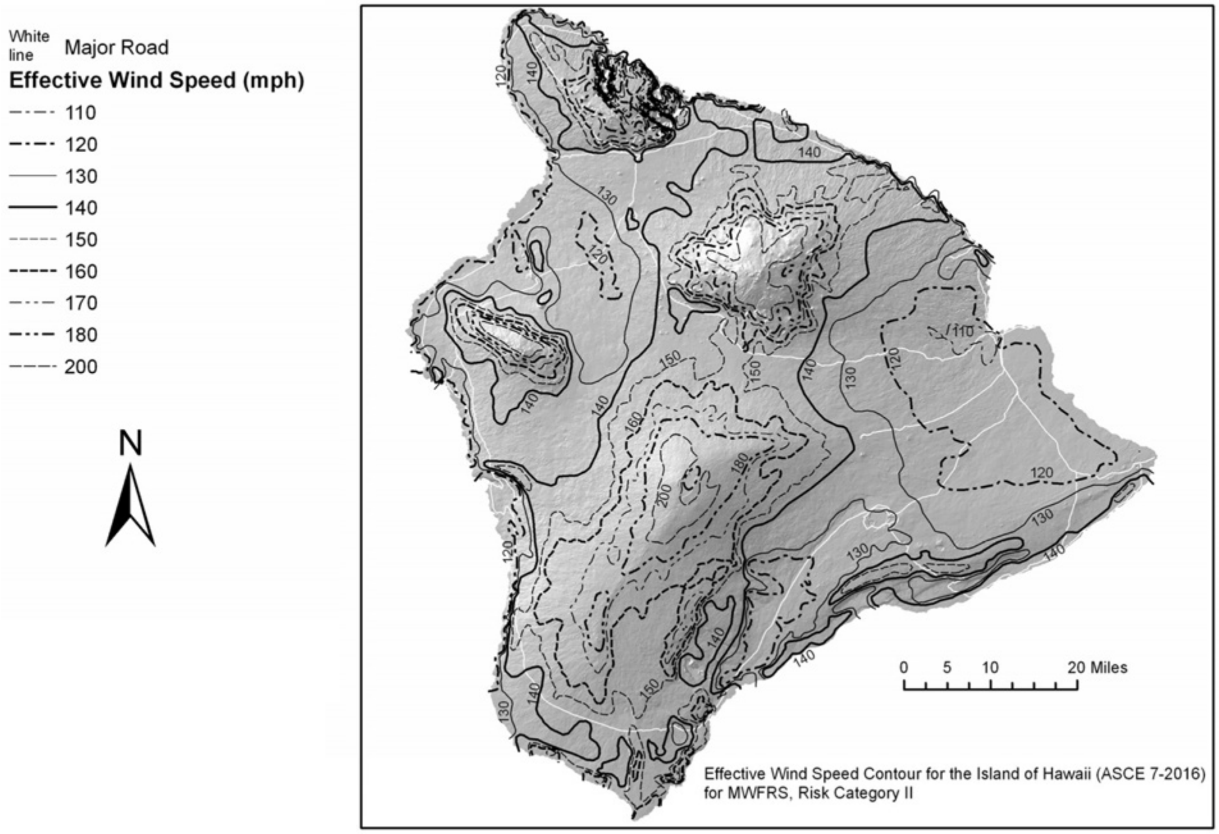
Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 years).

Attachment I

ASCE7-16 Figure 26.5-2B (continued)

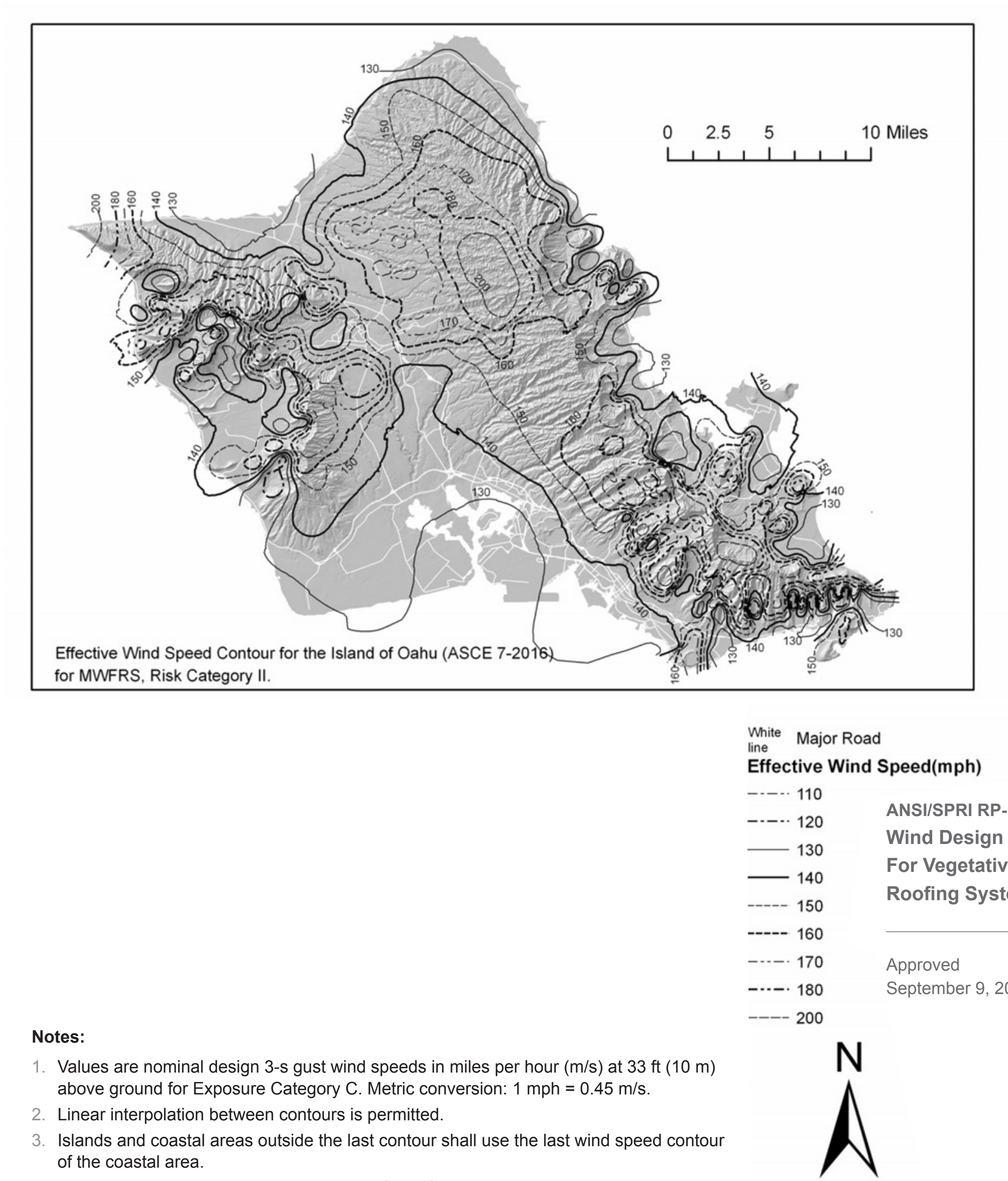
Basic Wind Speeds for Risk Category II Buildings and Other Structures: Hawaii



Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 years).

Attachment I
ASCE7-16 Figure 26.5-2B (continued)
Basic Wind Speeds for Risk Category II Buildings and Other Structures: Hawaii



ANSI/SPRI RP-14 2016

Wind Design Standard For Vegetative Roofing Systems

Approved September 9, 2016

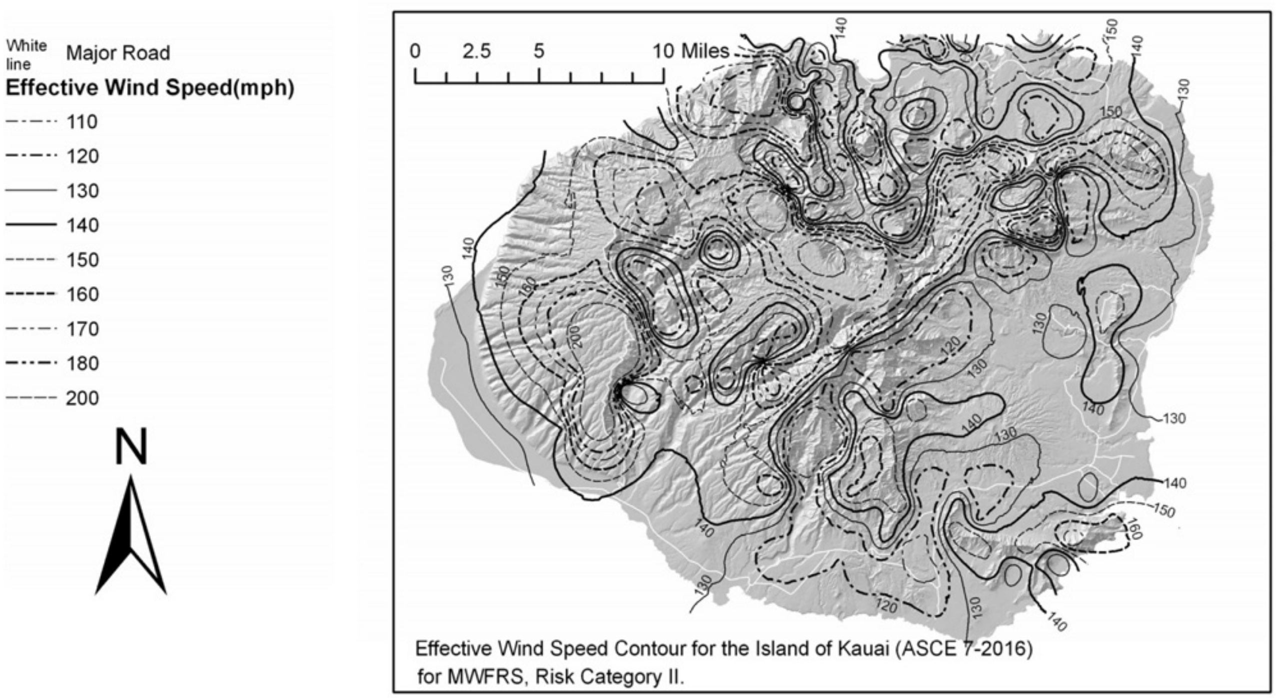
Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 years).

Attachment I

ASCE7-16 Figure 26.5-2B (continued)

Basic Wind Speeds for Risk Category II Buildings and Other Structures: Hawaii



ANSI/SPRI RP-14 2016

Wind Design Standard For Vegetative Roofing Systems

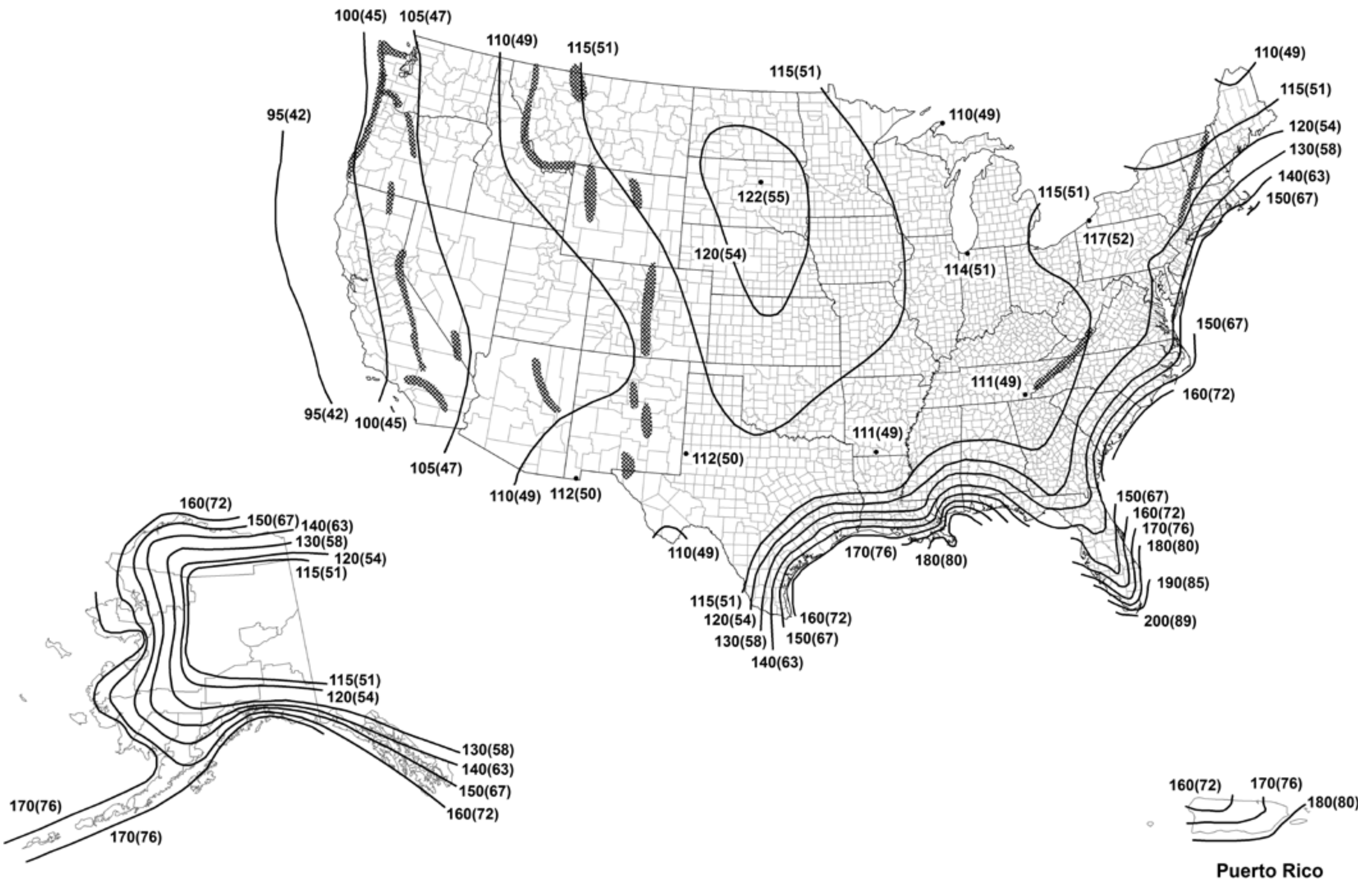
Approved September 9, 2016

Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00143, MRI = 700 years).

Attachment I

ASCE7-16 Figure 26.5-1C
Basic Wind Speeds for Risk Category III Buildings and Other Structures



Location	V (mph)	V (m/s)
Guam	210	(94)
Virgin Islands	175	(78)
American Samoa	170	(76)
Hawaii	See Figure 26.5-2C	

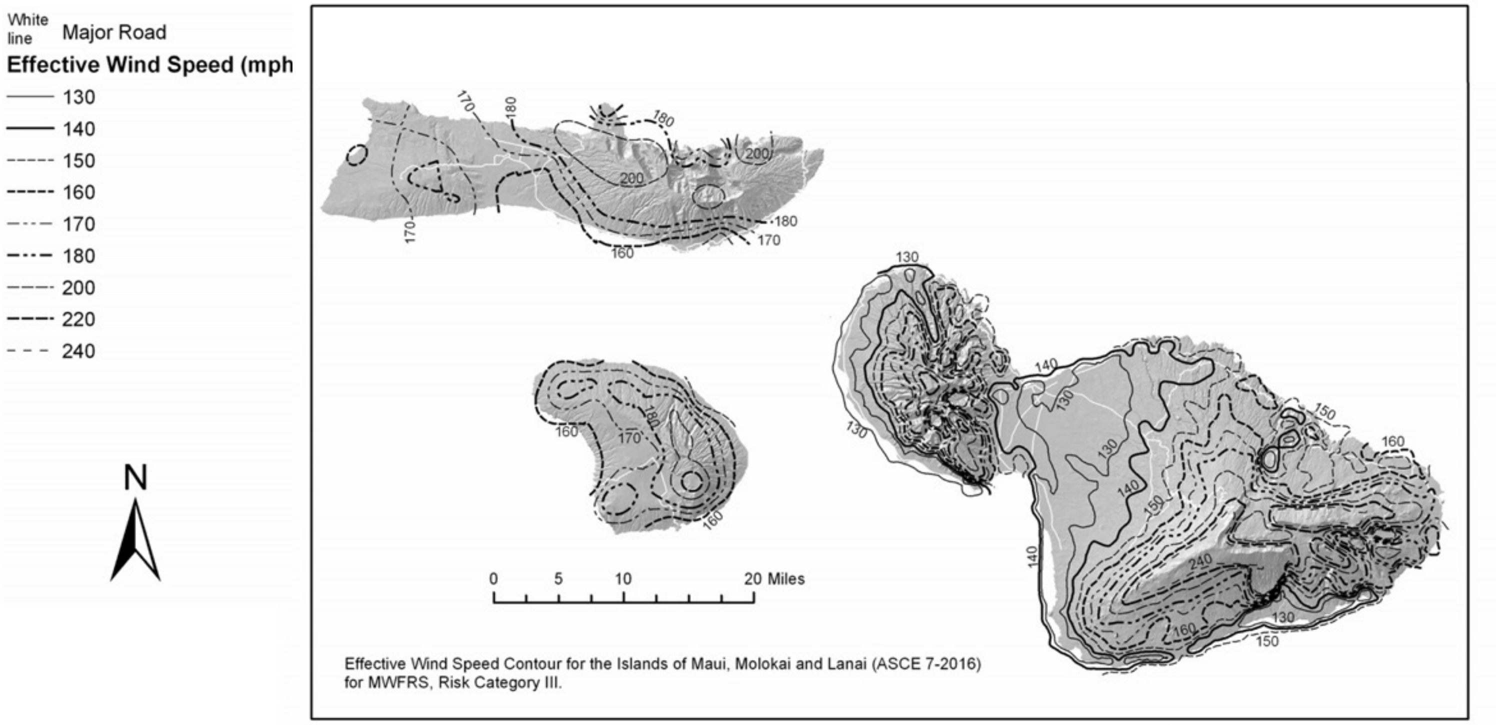
Notes: Dark shading indicates a Special Wind Region.

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C.
2. Linear interpolation is permitted between contours. Point values are provided to aid with interpolation.
3. Islands, coastal areas, and land boundaries outside the last contour shall use the last wind speed contour.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 3% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000588, MRI = 1,700 years).
6. Location-specific basic wind speeds shall be permitted to be determined using www.atcouncil.org/windspeed.

Attachment I

ASCE7-16 Figure 26.5-2C

Basic Wind Speeds for Risk Category III Buildings and Other Structures: Hawaii



Effective Wind Speed Contour for the Islands of Maui, Molokai and Lanai (ASCE 7-2016) for MWFRS, Risk Category III.

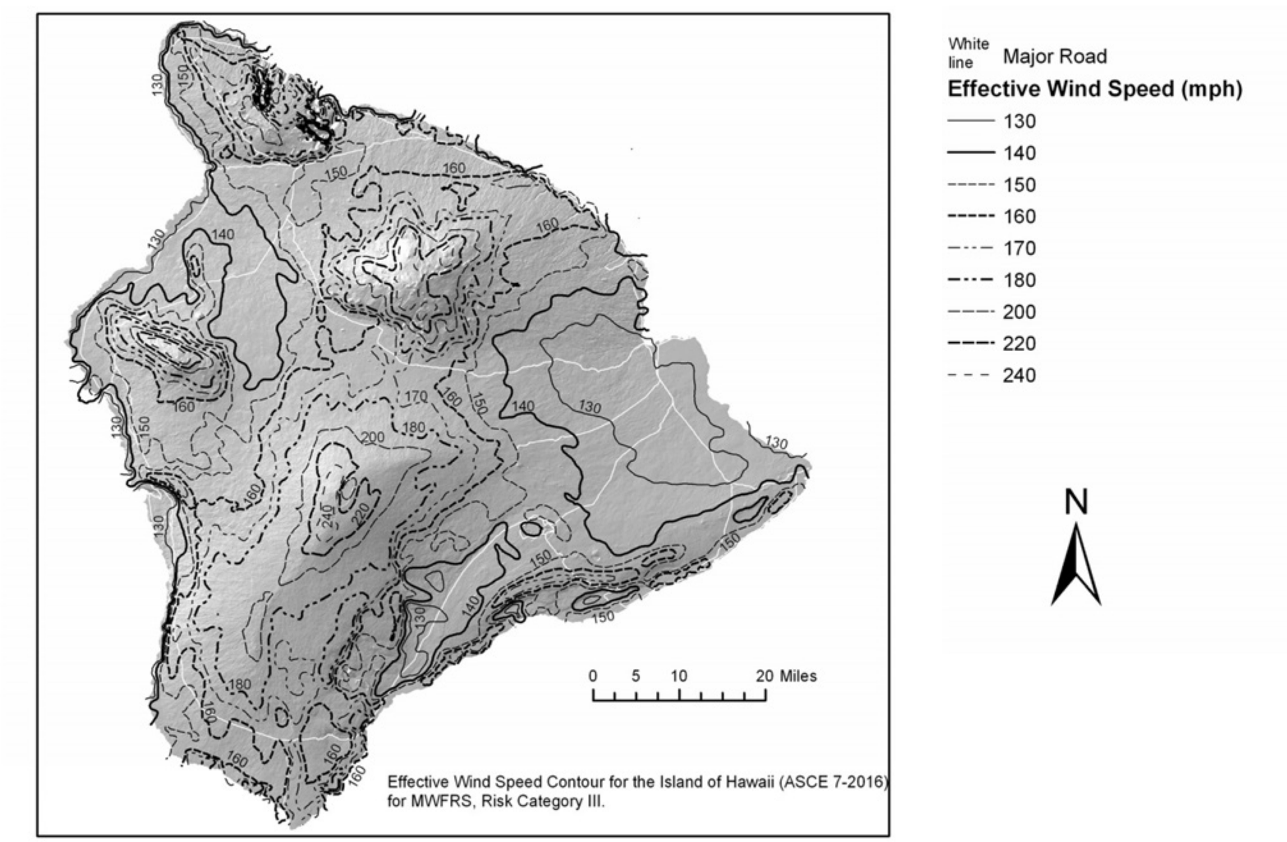
ANSI/SPRI RP-14 2016
Wind Design Standard For Vegetative Roofing Systems

Approved
September 9, 2016

Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 3% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000588, MRI = 1,700 years).

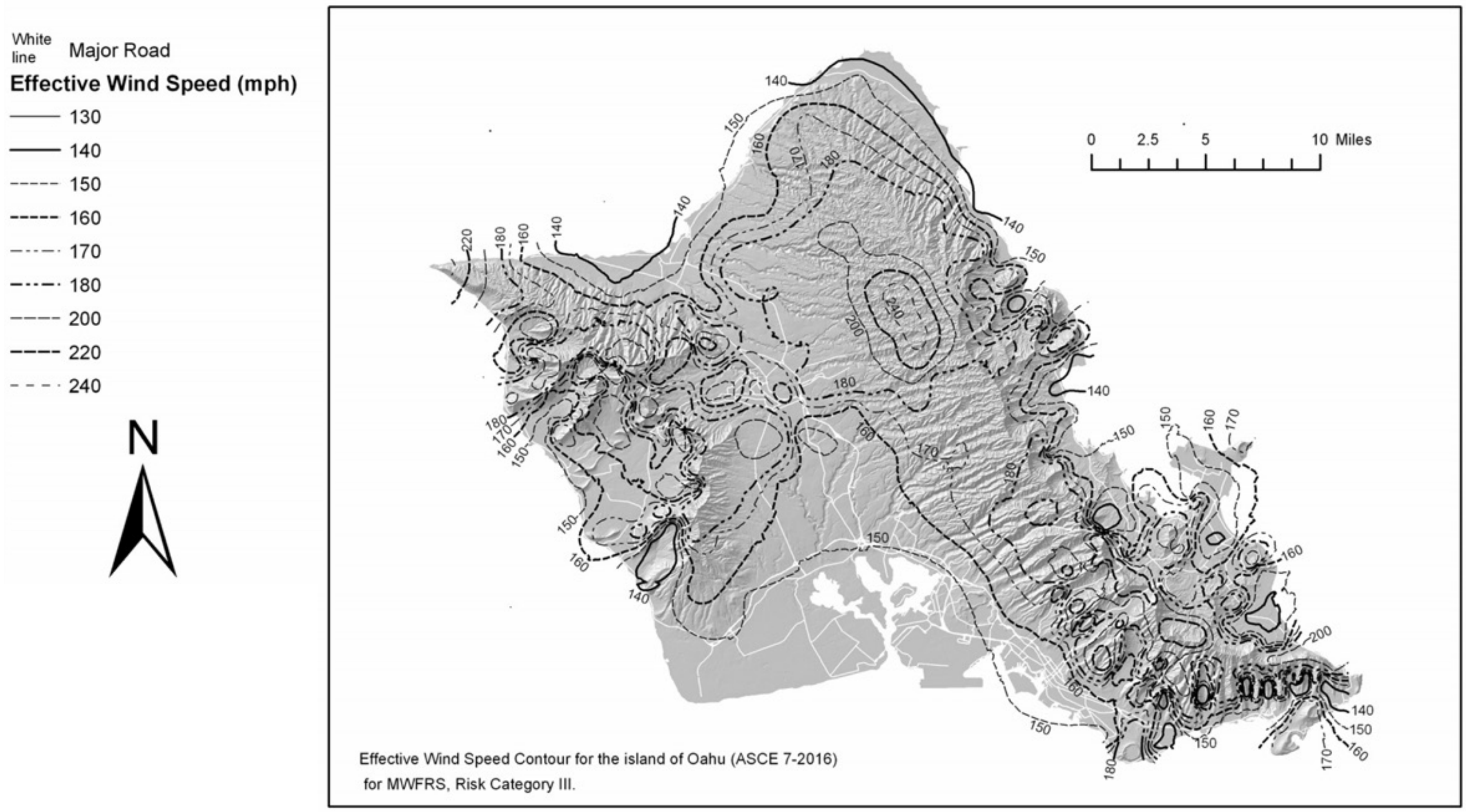
Attachment I
ASCE7-16 Figure 26.5-2C (continued)
Basic Wind Speeds for Risk Category III Buildings and Other Structures: Hawaii



Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 3% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000588, MRI = 1,700 years).

Attachment I
ASCE7-16 Figure 26.5-2C (continued)
Basic Wind Speeds for Risk Category III Buildings and Other Structures: Hawaii



Effective Wind Speed Contour for the island of Oahu (ASCE 7-2016) for MWFRS, Risk Category III.

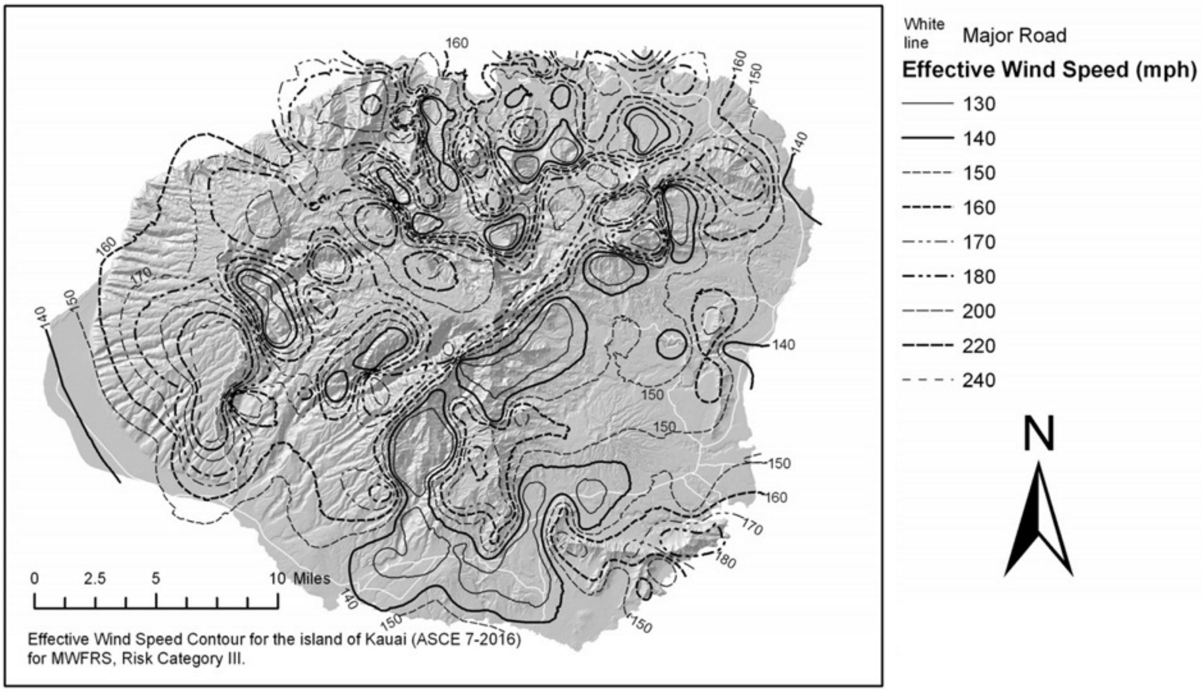
Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 3% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000588, MRI = 1,700 years).

Attachment I

ASCE7-16 Figure 26.5-2C (continued)

Basic Wind Speeds for Risk Category III Buildings and Other Structures: Hawaii



ANSI/SPRI RP-14 2016

Wind Design Standard For Vegetative Roofing Systems

Approved
September 9, 2016

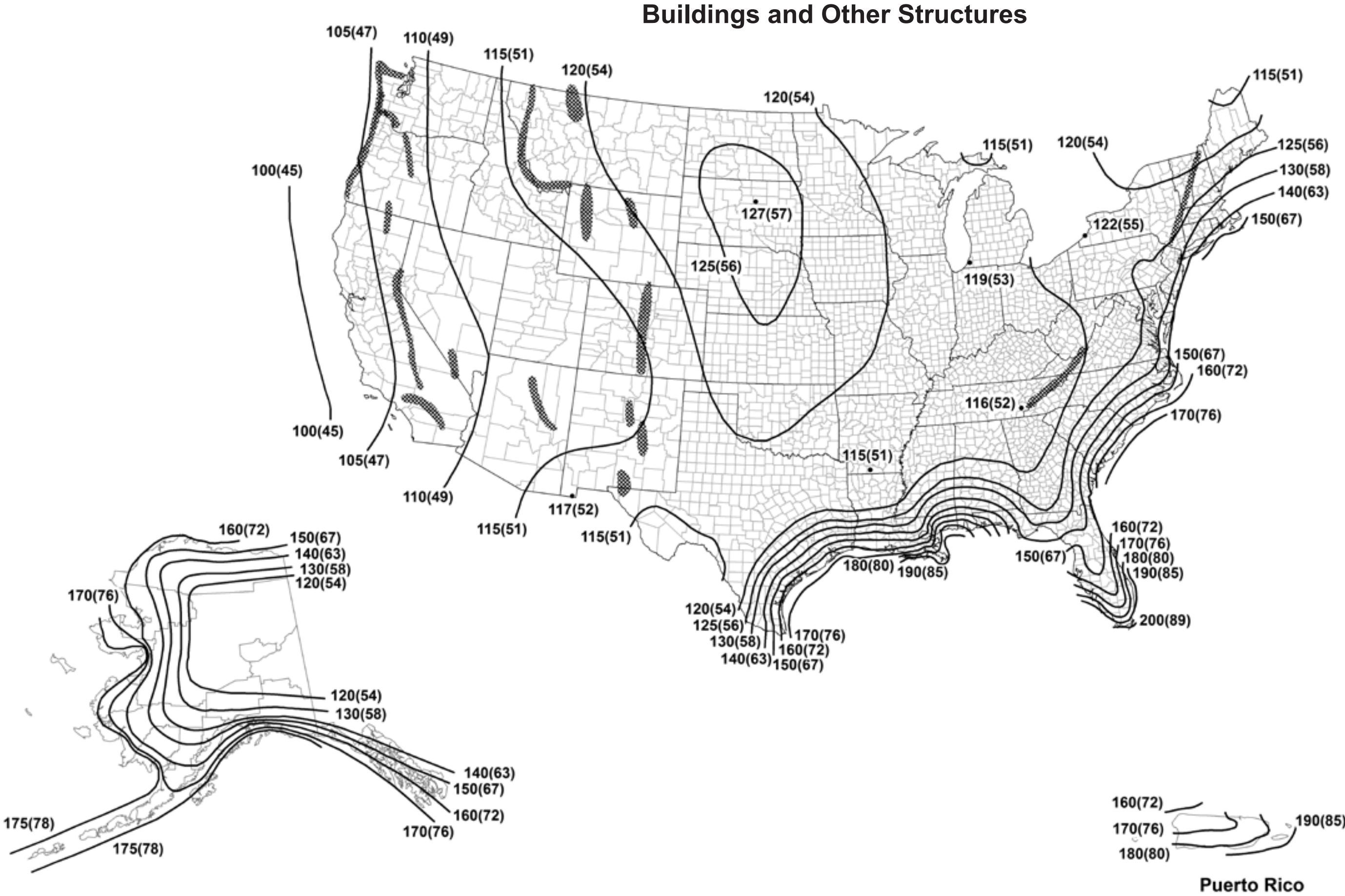
Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 3% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000588, MRI = 1,700 years).

Attachment I

ASCE7-16 Figure 26.5-1D

Basic Wind Speeds for Risk Category IV Buildings and Other Structures



Location	V (mph)	V (m/s)
Guam	180	(80)
Virgin Islands	150	(67)
American Samoa	150	(67)
Hawaii	See Figure 26.5-2D	

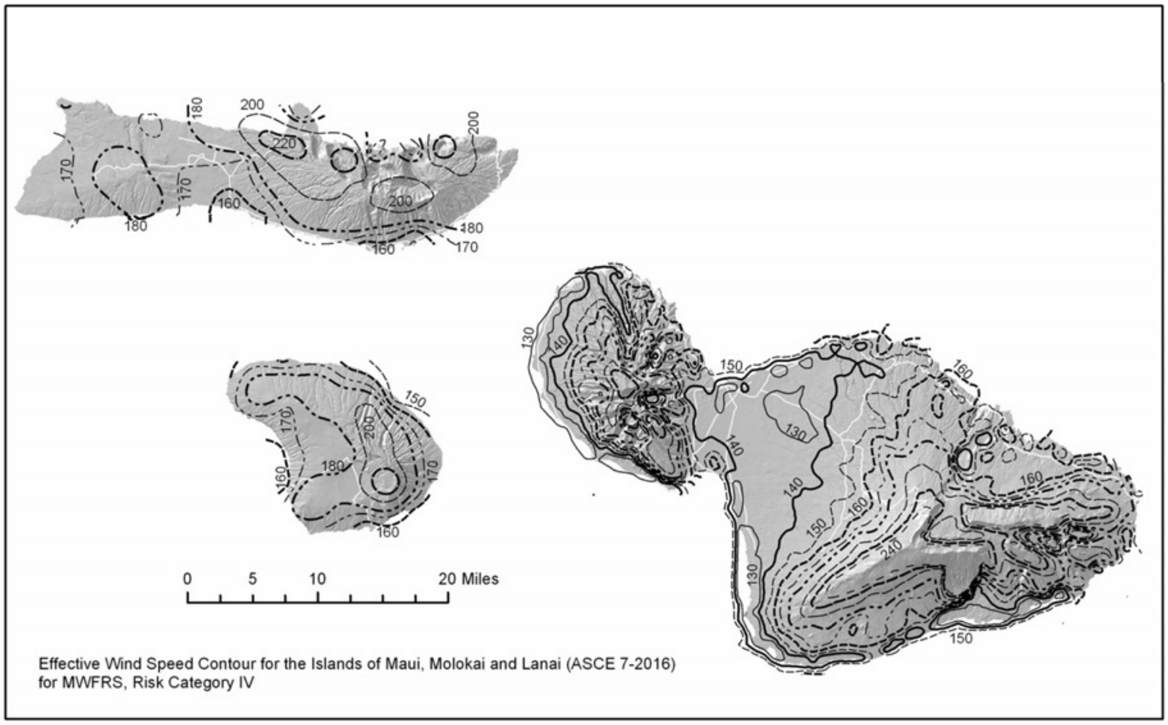
Notes: Dark shading indicates a Special Wind Region.

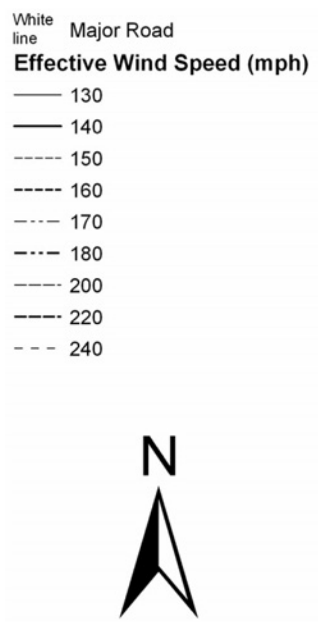
1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C.
2. Linear interpolation is permitted between contours. Point values are provided to aid with interpolation.
3. Islands, coastal areas, and land boundaries outside the last contour shall use the last wind speed contour.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 1.6% probability of exceedance in 50 years (Annual Exceedance Probability = 0.00033, MRI = 3,000 years).
6. Location-specific basic wind speeds shall be permitted to be determined using www.atcouncil.org/windspeed.

Attachment I

ASCE7-16 Figure 26.5-2D

Basic Wind Speeds for Risk Category IV Buildings and Other Structures: Hawaii

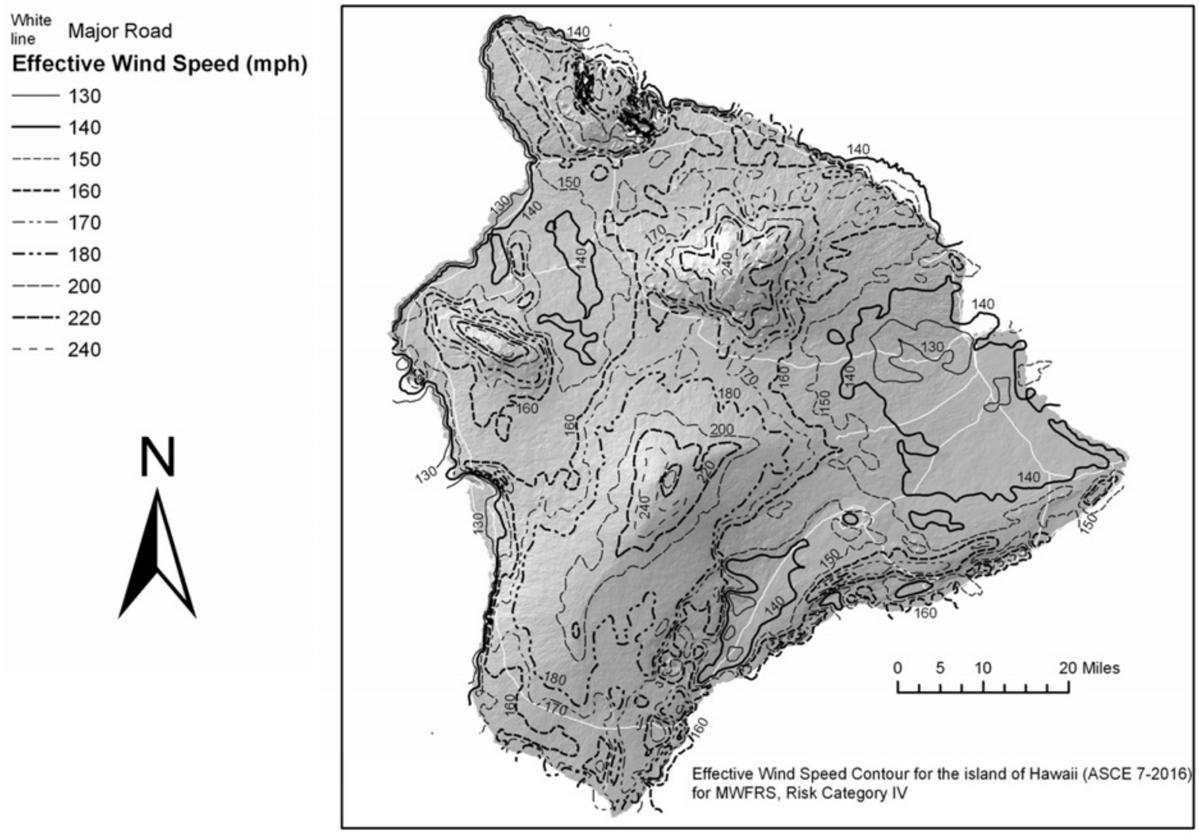




Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 1.7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000333, MRI = 3,000 years).

Attachment I
ASCE7-16 Figure 26.5-2D (continued)
Basic Wind Speeds for Risk Category IV Buildings and Other Structures: Hawaii



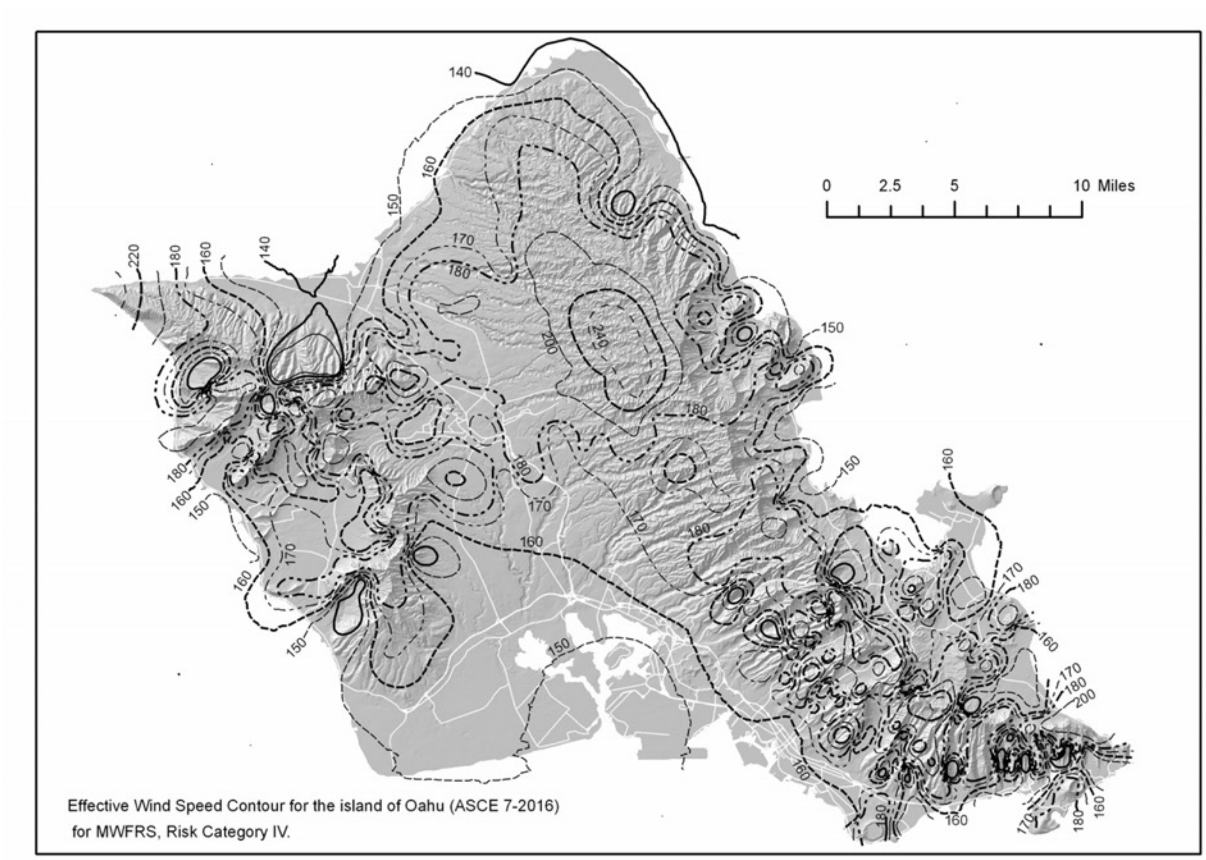
Notes:

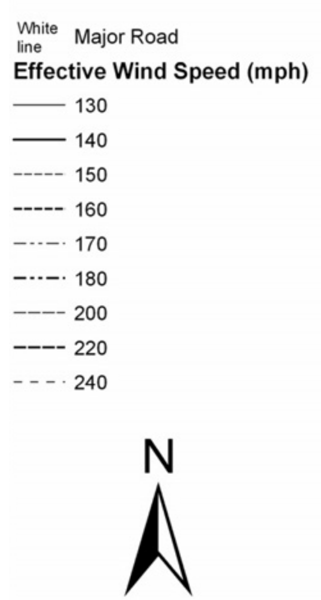
1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 1.7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000333, MRI = 3,000 years).

Attachment I

ASCE7-16 Figure 26.5-2D (continued)

Basic Wind Speeds for Risk Category IV Buildings and Other Structures: Hawaii





ANSI/SPRI RP-14 2016

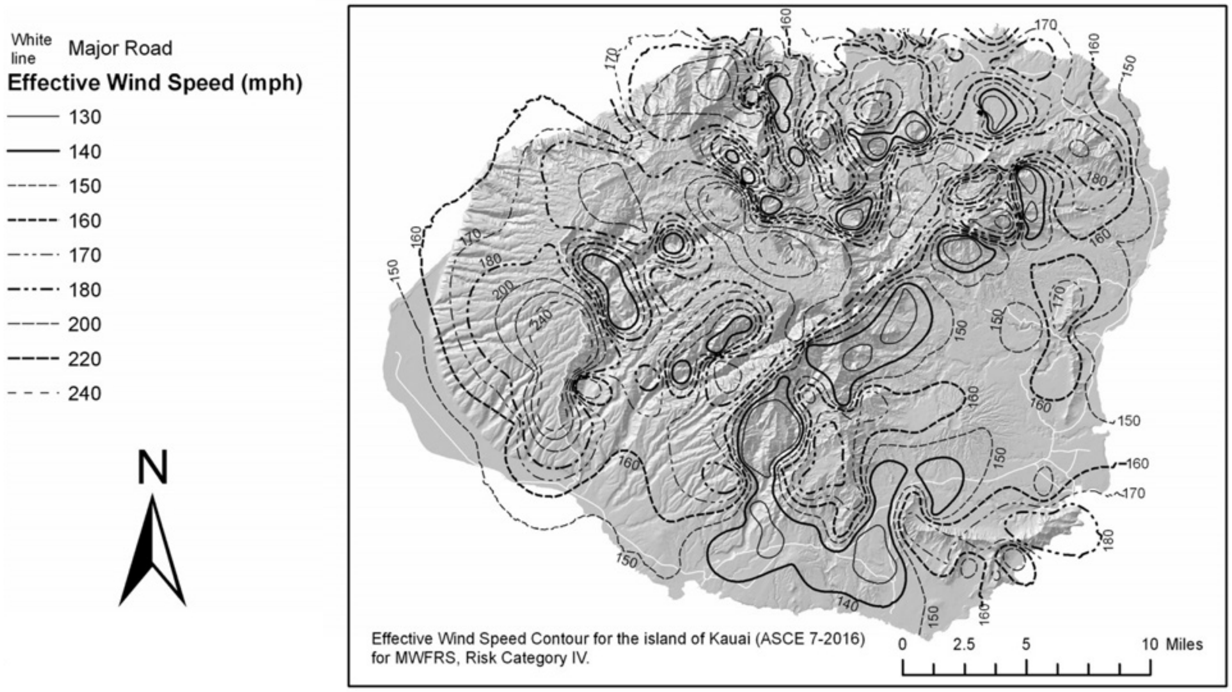
Wind Design Standard For Vegetative Roofing Systems

Approved
September 9, 2016

Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 1.7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000333, MRI = 3,000 years).

Attachment I
ASCE7-16 Figure 26.5-2D (continued)
Basic Wind Speeds for Risk Category IV Buildings and Other Structures: Hawaii



Notes:

1. Values are nominal design 3-s gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure Category C. Metric conversion: 1 mph = 0.45 m/s.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. It is permitted to use the standard values of K_{zt} of 1.0 and K_d as given in Table 26.6-1.
5. Ocean promontories and local escarpments shall be examined for unusual wind conditions.
6. Wind speeds correspond to approximately a 1.7% probability of exceedance in 50 years (Annual Exceedance Probability = 0.000333, MRI = 3,000 years).

Commentary to SPRI RP-14

This Commentary consists of explanatory and supplementary material designed to assist designers and local building code committees and regulatory authorities in applying the requirements of the preceding standard.

The Commentary is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at them.

The sections of this Commentary are numbered to correspond to the sections of the RP-14 standard to which they refer. Since it is not necessary to have supplementary material for every section in the standard, there are gaps in the numbering of the Commentary.

All metric conversions within the standard are "soft metric" within the tolerances of the inch pounds dimensions.

Metric engineering lengths: mm = millimeter, m = meter

Wind speed = m/s meters per second

Weight = kg/m^2

Pressure = Pa = Pascal

All conversions are based upon the 2009 ASHRAE Book of Fundamentals.

C1.0 Introduction

Green roofs, also known as vegetative roofs, eco-roofs, and rooftop gardens fall into two main categories -intensive, primarily defined as having more than 6 inches (0.15 m) of growing medium, greater loading capacity requirements, and greater plant diversity, and extensive, defined as having less than 6 inches (0.15 m) of growing media, less loading capacity requirements and fewer options for plants.

These systems are considered to be roof gardens or landscaped roofs or part of a roof garden or landscaped roof. Vegetative roofs are complex systems consisting of many parts critical to the functioning of the system. A few of the components generally found in these systems include, but are not limited to: insulation, waterproofing membrane, protection mats/boards, root barrier, drainage layer, filter fabric, *growth media*, and vegetations. A vegetative roof may consist of more than just *growth media* and vegetation with such things as walkways, water features, stone decoration, and benches included. Requirements between manufacturers vary, and some items may be optional.

RP-14 is a minimum standard and may be enhanced by designer or manufacture requirements.

A *vegetative roofing system* may cover the whole roof or share a portion of the surface with a conventional roofing system. They are versatile systems with many strong attributes including storm water management, reduced heat island effect, and aesthetics to name a few.

When large shrubs and trees are used attention should be given to ensure adequate anchorage and structural support.

While the standard is intended as a reference for designers and installers, the design responsibility rests with the "designer of record."

C2.1 Vegetative roofing systems

A *vegetative roofing system* consists of vegetation, *growth media*, drainage system, and waterproofing over a roof deck. Where the membrane is not impervious to root penetration, root barriers shall be necessary. The system can be considered to be a roof garden or landscaped roof.

Several wind performance tests on *vegetative roofing systems* have been conducted. They have shown that the systems are very stable when vegetation is present or when a soil tackifier or erosion mat is included in non-vegetative areas. See References #24, 29 and 30.

There are several types of vegetative roofs that are generically described in Section 4.

C2.2 Ballast

The *ballast* used in roofing systems is made up of a number of types. For the *growth media*, the designs that follow in the document consider the exposed media is the worst case scenario therefore the wind erosion mats and soil tackifiers are used to cover the exposed media to prevent wind scour. However, when the plants cover the media, the media gets the benefit of the windbreak provided by the plants and the holding power of the root system in the zone around the plants. Combinations of large aggregate or stones and *growth media* can also be considered as part of the *ballast* weight when they are protected by vegetation.

Ballast is any object having weight that is used to hold or steady an object. In ballasted roofing systems, the most common *ballast* used is stone. However, materials such as concrete pavers, lightweight concrete pavers, rubber pavers, and weighted insulation panels are often used to *ballast* roofing systems. With the advent of vegetative roofs, *growth media* and pre-constructed vegetative modular trays also act as *ballast*. These *ballast* systems have been organized into categories based on their ability to resist the forces of the wind.

Ballast can also provide drainage options.

C2.5 Basic Wind Speed

The wind speed used in this document is from ASCE 7. When the current code in the area of the building being constructed is not ASCE 7, but an older ASCE wind map, the commonly used conversion is; fastest mile plus 20 mph (8.9 m/s) is approximately equal to the 3-second gust speed. When more detail is needed, consult ASCE 7.

Ballasted roofs are not recommended where the *basic wind speed* is greater than 140 mph (63 m/s). However they can be designed using Reference 1, consultation with a wind design engineer, or wind tunnel studies of the specific building and system.

- Special Wind Regions (mountains or valleys): Refer to Section C6.5.4.1 of the ASCE 7 Commentary.
- The intensifying effects of topography (hills or escarpments) are to be accounted for. Information on speed up over hills and escarpments can be found in ASCE 7 *Minimum Design Loads for Buildings and Other Structures*; Section 6.5.7. ASCE 7 provides data for wind pressure increase, but does not give specific advice for wind speed tables as are used in this document. Consult a wind engineer to determine the roof top wind speed. The increase in wind speed due to hills is the K_{zt} factor from the above ASCE reference. (i.e. multiply the wind speed by K_{zt} and use this new wind speed as the design wind speed.) A conservative approach is to add the height of the hill to the height of the building. Hills less than 60 ft (18 m) above the surrounding terrain in Ground Roughness A & B and 15 ft (4.6 m) above the surrounding terrain in Ground Roughness C & D, need not be considered

  Wind Borne Debris Regions: ASCE 7 defines these regions as areas within hurricane regions located:

  1. within one mile of the coastal high water line where the *basic wind speed* is equal or greater than 110 mph (49 m/s) and in Hawaii; or
  2. in areas where the *basic wind speed* is equal to or greater than 120 mph (54 m/s). This document requires the use of #2 *Ballast* only, in these areas. For vegetative roofs used in this area, consideration shall be taken to minimize woody vegetation that could become wind borne debris. Trees, palms, woody bushes could have limbs break off in the wind leading to building damage.

     The “authority having jurisdiction” is the only source for approval of designs not covered in this document. ASCE 7 gives guidance on how non-standard conditions should be evaluated. (See Reference 1, or conduct wind tunnel studies in accordance with ASCE 7 for information to determine requirements for designs or systems not covered).

C2.6.1 **Corners are not always square.** They are formed by the intersection of two walls. This document is using the definition of the angle formed by the two walls as being between 45 and 135 degrees to signify a *corner*. The designer may choose to include angles outside this range as a *corner*.

C2.6.2 & 2.6.3 **The corners and perimeters** used in this document are 0.4 times the building height, which is greater than the 0.1 times the building height in ASCE 7. This 0.4 factor adds a significant conservative factor for taller buildings. This is particularly true for tall narrow buildings where a 90 ft (27 m) high roof designed to this standard would require a 36 ft (11 m) wide perimeter.

C2.7 **Exposure Categories/Surface Roughness**

A roof being designed in a city center may be either too tall to benefit from the protection of adjacent buildings, or is low enough to be affected by wind channeling between them. Wind profiles are much more complex in city centers, and therefore not necessarily subject to the more rational directionality as studied in the wind tunnels. Choosing Exposure Category C reduces the wind speeds at which the system is safely installed. Because of the effects on ballasted roof systems performance if *ballast* disruption were to occur, city centers and individual tall buildings should be evaluated to determine if a more stringent wind exposure category should be used in the design. ASCE 7 has photos that show the various categories in its commentary C6.5.6

C2.8 **Impervious Deck**

The first thing that comes to mind when thinking about materials such as poured concrete and gypsum is that they are impervious to the flow of air. However, in deck constructions there are from time to time penetrations that are cut through these decks that air can pass through. There are also constructions where the expansion joint is located at the deck-wall junction or the wall construction itself (stud or cavity wall construction) can let air in under the roof system. The designer should investigate to assure the “impervious construction” is truly that. All penetrations (new or existing) are to be sealed to prevent the system from pressurization. Unless proper detailing is considered the system is to be treated as pervious. (See Reference 7 for detailing)

C3.2 **Building Height**

Vegetative roofs with heights greater than 150 ft (46 m) can be designed using Reference 1, consultation with a wind design engineer, or wind tunnel studies of the specific building and system.

C3.7 **Membrane Requirements**

Membranes not having a consensus Product Standard should meet the specific requirements of their manufacturers.

EPDM	ASTM D-4637
PVC	ASTM D-4434
TPO	ASTM D-6878
KEE	ASTM D-6754
SBS MB	ASTM D-6164, 6163, 6162
APP	ASTM D-6222, 6223, 6509
BUR	As defined by the standards referenced in the International Building Code Fully Adhered Hot-Applied Reinforced Waterproofing System ASTM D 6622

Certain membranes contain plasticizers that may be extracted from the membrane. They may require a slip-sheet between the membrane and some insulations and *growth media*.

C3.8 **Membrane Perimeter and Angle Change Attachment**

This standard addresses the basic requirements for membrane termination. For more details on the design of edging and attachment of nailers, see ANSI/SPRI/FM 4435/ES-1 *Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems.*

Perimeter Attachment

Some wall constructions allow pressure from the interior of the building to flow up wall cavities, bypassing the deck and entering the space between the roof covering and roof deck. This can be mitigated by following Reference 7 or consulting the manufacturer for expert design.

Exterior through wall scuppers, if not sealed on the exterior, can allow air on the windward side of the parapet wall to pressurize the space under the roof covering.

Parapets

The use of parapets will improve the wind performance of the roofing system. The designer, whenever possible, should use a parapet design that will improve the roof system's ability to resist the wind. When parapets are less than 1 ft (0.3 m), vegetative systems are limited to 75 ft (23 m). The improvement in wind resistance is a function of parapet height. See tables for response.

C3.9 Wind Erosion

There are several ways to prevent wind erosion of *growth media*. The most common approach is to use a wind erosion mat. When the vegetation does not nominally cover the *growth media* a wind erosion mat or erosion soil conditioner or tackifier is to be installed over the roof to prevent *growth media* from being wind blown. The mat shall be anchored in place using techniques that provide pull out resistance capable of withstanding the calculated load as tested according to Attachment I with consideration for the porosity of the mat. Wind erosion mats can be attached to the deck or held by a paver at the perimeter of the vegetation. Mats can use soil staples or other devices to hold them in place. Wind erosion can also be prevented by the installation of pavers in place of *growth media* or wind screens. Pre-cultivated mats have also been shown to hold the *growth media* in place.

The requirements for soil stabilizers or tackifiers will vary with the soil used and the wind loads. Products should be tested for the soil conditions on the roof being installed. Most are not designed for prolonged exposure. When pre-cultivated mats are not used, wind erosion control should be used until the minimum establishment period of the vegetation is reached, as determined by the green roof design professional. An established root system can help prevent wind erosion.

C3.11 **In wind borne debris regions** consideration shall be taken to minimize woody vegetation that could become wind borne debris.

C3.12 *Ballast* is any object having weight that is used to hold or steady an object. In ballasted roofing systems, the most common *ballast* used is stone. However, materials such as concrete pavers, lightweight concrete pavers, rubber pavers, and weighted insulation panels are often used to *ballast* roofing systems. With the advent of vegetative roofs, *growth media* and pre-constructed vegetative modular tray also act as *ballast*. These *ballast* systems have been organized into categories based on their ability to resist the forces of the wind.

Ballast Weight: The minimum *ballast* weight is based on the wind design requirements of the system. Structural design should consider that the installed system will have variation of weight across the surface and with the amount of water retention in the system. Additional structural capacity should always be considered.

You may be able to have a lower weight based on tray pressure equalization when there is a ¼ in gap between the tray and the membrane using current wind engineering practices consistent with ASCE 7.

The dry weight of the *growth media* can be determined using ASTM E2399.

Combinations

Combinations of any of the types of *ballast* can be used on any roof, and combinations of stone and *growth media* etc. can be used to achieve the *ballast* weight required.

All stone *ballast* comes with some **fines** mixed in. ASTM standard D-448 allows up to 5 percent fines. This may lead to problems at drains, scuppers, etc. due to build-up of these fines. If the source of stone is including too many fines, it may be advisable to have it "double washed". The research basis for the stone *ballast* was model stone that approximated the gradations of ASTM D-448. This included fines and the largest sizes in the simulated gradation. The average size of the stone was deemed to be the controlling factor in wind performance.

Vegetative Roofing Systems also bring the problem of root growth that may work their way into the drain leading to clogging problems. On *Vegetative Roofing Systems* using less than 4 inches (100 mm) of *growth media* depth, stone *ballast* should be placed around the drain extending out a minimum of 1 ft (0.3 m) (a clear space around drains is required but stones are optional for modular tray systems). For systems with greater than 4 inches (100 mm) depth of *growth media*, a perforated drain box wrapped with a filter fabric is to be installed over the drain to keep the *growth media* and as an aide to keep the plant roots out of the drain. The drain box should have a cover. Drains should be inspected twice a year to make sure they are clean.

Air/drainage layers are often incorporated. When these layers contain inorganic matter, such as stone the weight of the inorganic matter can be considered part of the *ballast* weight.

C4.0 Design Options

The Design Options of Section 4, which also references the Design Tables in Table 2, are built on the wind tunnel work done by Kind and Wardlaw and supported by extensive field investigations (see references). The base used as the design criteria from the wind tunnel work was Critical Wind Speed VC2, the gust wind speed above which scouring of stones would continue more or less indefinitely but not blow off the roof if the wind speed were maintained.

The *corners* and *perimeter areas* are where the greatest effects of the disrupted airflow over the building will occur. The worst case scenario is the wind coming onto a *corner* at a 45° angle. These situations generate wind vortices along the roof edges causing low-pressure areas over the roof system as well as wind turbulence that can scour *ballast* and balloon the membrane. Typically, scour occurs first. To prevent *ballast* movement, enhanced design provisions are required in some cases for these areas.

The terminology "documented as demonstrated as equivalent with the provisions of the standard" means that a proprietary system has been evaluated through one or all of the following methods:

- Wind tunnel testing conducted in accordance with ASCE 7;
- In a Full Scale Test conducted by a *registered design professional*; and/or.
- Field Documented Studies

The results would show performance levels that meet the locations design requirements.

Test methods typically used to evaluate roof systems for their ability to resist uplift forces are ANSI/FM4474 *American National Standard for Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures*, and Underwriters Laboratories ANSI/UL1897 *Uplift Tests for Roof Covering Systems*. Both testing facilities publish the results for the specific roof systems tested. Contact them for additional information.

C4.3 Protected Vegetative Roofing System

A protected *vegetative roof system* consists of vegetation, *ballast* as defined in 2.2, a fabric that is pervious to air and water, insulation, membrane and substrate materials installed over a structural deck capable of supporting the system. The waterproofing membrane is fully bonded directly to the roof deck.

In protected Vegetative Roof designs, the insulation is placed above the roofing membrane. When working with this design, the designer needs to account for the potential rafting of the insulation as it might float. A diffusion open fabric or similar material shall be installed above the insulation.

The water-and-air pervious fabric is used for four purposes: (i) provide temporary UV protection for foam plastic insulation, (ii) prevent gravel fines from working down between the insulation joints to the membrane which could potentially cause damage to the membrane, (iii) prevent clogging of the drainage layer, and (iv) to control insulation board rafting in a floatation situation. Rafting is when insulation board, which may be floating due to heavy rainfall or a slow draining roof, moves out of place.

For information on air retarders, see References 7 and 10. Although all systems may benefit from well-installed air retarders, this standard is based on having no deliberately installed air retarders for all systems with 10-lbs/sq. ft or more of *ballast* weight. For systems less than10-lbs/sq. ft, air retarders are required, but this standard assumes the air retarder is imperfect.

Several options exist for increased interconnectivity and securement of the perimeters. Heavy weight *ballast* is a non-proprietary way of achieving this requirement.

System 3 design can be achieved by consulting References 6, 7, 8, and 9 or manufacturer's proprietary designs.

C6.0 Determination of Ballasted System Roof Design

When a building does not fit the criteria of this document the designer should refer to Reference 1 and ASCE 7.

C7.0 Maintenance

Vegetative roofing systems shall be maintained to provide vegetation that nominally covers the visible surface of the *growth media*. When wind scour occurs to an existing v*egetative roof system* and the scour is less than 50 square ft (4.6 m^2), the *growth media* and plants shall be replaced. For scour areas greater than 50 square ft (4.6 m^2), the vegetative roof design shall be upgraded a minimum of one system design level per Section 4.0. Maintenance shall be the responsibility of the building owner.

Vegetative roofs should always be inspected after a wind event and at least 2 times per year to make sure the vegetation and *growth media* are in place, drains are open, and do any weeding necessary to maintain the performance and desired look of the system. The system needs to be maintained to promote the growth of the vegetation for the loss of the vegetation will have major impact on the wind and water retention performance and fire properties of the system, let alone the aesthetics of the system. Items like watering and fertilizing are important functions to support the vegetation. For more information on the care and maintenance of *vegetative roof systems*, see Reference 22, Guideline for the Planning, Execution and Upkeep of Green-Roof Sites. The requirements for maintenance must be clearly spelled out to the owner of the roof, and the maintenance is a responsibility of the building owner.

References

1. Kind, R.J. and Wardlaw, R.L., "Design of Rooftops Against Gravel Blow-Off", National Research Council of Canada, Report No. 15544, September 1976.
2. Kind, R.J. and Wardlaw, R.L., "The Development of a Procedure for the Design of Rooftops Against Gravel Blow-off and Scour in High Winds," Proceedings of the Symposium on Roofing Technology, 1977, pp. 112.
3. Gillenwater, R.J., "Wind Design Guide For Ballasted Roofing Systems", Proceedings of the Second International Symposium on Roofing Technology, 1985, pp. 219.
4. Kind, R.J. and Wardlaw, R.L., "Wind Tunnel Tests on Loose-Laid Roofing Systems for Flat Roofs," Proceedings of the Second International Symposium on Roofing Technology, 1985, pp. 230.
5. Schneider, K.G. Jr., "A Study of the Behavior of Loose-Laid, Ballasted Single-Ply Roofing Systems Subjected to Violent Winds," Proceedings of the Second Inter- national Symposium on Roofing Technology, 1985, pp. 243.
6. Kind, R.J., Savage, M.G., and Wardlaw, R.L., "Further Model Studies of the Wind Resistance of Two Loose-Laid Roof Systems (High-Rise Buildings), National Research Council of Canada, Report LTR-LA-269, April 1984.
7. "A Guide To Achieve the Secure Single-Ply", Technical Note No. 20, The Dow Chemical Company, 1986.
8. Kind, R.J., Savage, M.G., and Wardlaw, R.L., "Further Wind Tunnel Tests of Loose-Laid Roofing Systems", National Research Council of Canada, Report LTR-LA-294, April 1987.
9. Kind, R.J., Savage, M.G., and Wardlaw, R.L., Pressure Distribution Data Measured During the September 1986 Wind Tunnel Tests on Loose-Laid Roofing Systems, September 1987.
10. Dregger, P.D., "Role of Air Retarders Deserve Closer Scrutiny," Professional Roofing, October 1991, pp. 46.
11. Smith, T.L., Kind, R.J., McDonald, J.R., "Hurricane Hugo: Evaluation of Wind Performance and Wind Design Guidelines for Aggregate Ballasted Single-Ply Membrane Roof Systems," Proceedings of the VIII International Roofing and Waterproofing Congress, 1992, pp. 598.
12. Proceedings of the Ballasted Single-Ply System Wind Design Conference, held in Carlisle, PA, 1984.
13. American Society of Civil Engineers Standard ASCE 7[1], "Minimum Design Loads For Buildings And Other Structures".

    [1.] With permission from ASCE: the wind speed map shown as Attachment I is an element of the ANSI/ASCE 7 document, "Minimum Design Loads for Buildings and Other Structures", an American National Standards Institute Standard, copyrighted by the American Society of Civil Engineers. Copies of this standard may be purchased from the American Society of Civil Engineers at 1801 Alexander Bell Drive, Reston, VA 20191.
14. Bienkiewicz, B. and R. N. Maroney, "Wind Effects on Roof Ballast Pavers", Journal of Structural Mechanics, Proc. ASCE, Vol. 114, No. 6 June 1988, pp. 1250-1267.
15. Bienkiewicz, B. and Y. Sun, "Wind-Tunnel Study of Wind Loading on Loose-Laid Roofing Systems", Journal of Wind Engineering and Industrial Aerodynamics, Vol. 41-44, 1992, pp. 1817-1828
16. Bienkiewicz, B. and Y. Sun, "Numerical and Experimental Studies of Wind Loading on Loose-laid Roofing Systems", U.S. National Conference on Wind Engineering, UCLA 1993
17. ANSI/SPRI/FM 4435/ES-1 Wind Design Standard for Edge Systems Used With Low Slope Roofing Systems. SPRI, Waltham, MA.
18. ANSI/SPRI WD-1 Wind Design Standard Practice for Roofing Assemblies, SPRI, Waltham, MA 2014

19. Manual of Roof Inspection, Maintenance, and Emergency Repair for Existing Single Ply Roofing Systems. SPRI/NRCA Waltham, MA/Rosemont, IL.

20. Bienkiewicz, B. and Y. Sun; “Wind loading and resistance of loose-laid roof paver systems”, Journal of Wind Engineering and Industrial Aerodynamics, Vol. 72, 1997, pp. 401-410

21. Hurricanes Charley and Ivan Wind Investigation Report, RICOWI Inc. Powder Springs, GA 30127, 2006

22. FLL Standard “Guideline for the Planning, Execution and Upkeep of Green-Roof Sites”, Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V. – FLL, Colmantstr, Bonn, Germany

23. Gerhardt, H.J., The Effect of Wind on Roofing Systems, Shaker Verlag (publishers) Aachen, Germany, 1999

24. Gomez, J. Gerhardt, H. J. Assessment of Positional Security Against Wind Uplift for a Roof Planting System that is Permeable to Wind,1999

25. ENV 1991-2-4. European Wind Loading Standard for Structures.

26. DIN “1055-Part 4. Design Loads for Structures”. Wind Effect Standards

27. Minnesota Department of Transportation, Standards for Construction, 2000

28. Soil Erosion Control, Mulches Blankets and Mats, Metropolitan Council. St. Paul, MN 55101 ·

29. Bofah, K.K., Gerhardt, H.J., Kramer, C. “Calculations of Pressure Equilibrium Underneath Loose Laid flow Permeable Roof insulation Boards” Journal of Wind Engineering and Industrial Aerodynamics, Volume 59, Issue 1, January 1996, Pages 23-37

30. Retzlaff, B., Celik, S., Morgan, S., Luckett, K. Wind Uplift of Pre-Vegetated Mats, Southern Illinois University, Edwardsville. January 2010.

31. Crowley, J., Bell,D., Kopp-Holtwiesche,B., Environmentally-Favorable Erosion Control with a Polyvinyl Acetate-Based Formulation, Cognis Corporation, Cincinnati, Ohio

32. Retzlaff, B., Cleik, S., Morgan, S., Luckett, K., Graham, M., Wind Uplift of Green Roof Systems, Southern Illinois University, Edwardsville. March 2009.

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. An American National Standard is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an American National Standard does not in any respect preclude anyone, whether he has approved the standard or not, from manufacturing, marketing, purchasing or using products, processes, or procedures not conforming to the standard. American National Standards are subject to periodic review and users are cautioned to obtain the latest editions.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute.

Caution Notice: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken to reaffirm, revise or withdraw this standard no later than five years from the date of approval. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

INTERNATIONAL

Designation: E2398 – 11

ANNEXE G

StandardTest Method for Water Capture and Media Retention of Geocomposite Drain Layers for Vegetative (Green) Roof Systems[1]

This standard is issued under the fixed designation E2398; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the water and media retention of synthetic drains layers used in vegetative (green) roof systems.

1.2 This test method is applicable to geocomposite drain layers that retain water and media in cup-like receptacles on their upper surface. Examples include shaped plastic membranes and closed-cell plastic foam boards

1.3 This test method does not apply to products manufactured from water-absorptive materials.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E631 Terminology of Building Constructions

E2114 Terminology for Sustainability Relative to the Performance of Buildings

E2397 Practice for Determination of Dead Loads and Live Loads Associated with Vegetative (Green) Roof Systems

3. Terminology

3.1 *Definitions:*

3.1.1 For terms related to building construction, refer to Terminology E631.

3.1.2 For terms related to sustainability relative to the performance of buildings, refer to Terminology E2114.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *captured water, n*—the quantity of water that is retained in the drainage layer of a vegetative (green) roof system after new water additions have ceased and that cannot escape the roof except through evaporation or plant transpiration.

3.2.2 *coupon, n*—a portion of a material or laboratory sample from which multiple specimens can be taken for testing.

3.2.3 *geocomposite drain layer, n*—a synthetic sheet, mat, or panel that is specifically designed to convey water horizontally toward the roof deck drains, gutters, or scuppers.

3.2.3.1 *Discussion*—Geocomposite drainage layers include absorptive drainage mats whose principle function is drainage, but which will also contribute to water retention (see *retained water*). Some geocomposite drainage layers may incorporate receptacles on their upper surfaces that will capture water (see *captured water*).

3.2.4 *retained water, n*—the quantity of water that will be retained for a prolonged period against gravity drainage in a vegetative (green) roof system, or in one of its components, after new additions by rainfall or artificial irrigation have ceased.

3.2.4.1 *Discussion*—Most of this water will not become runoff but will be used to the plant-mediated processes of evapo-transpiration.

3.2.5 *unit media retention volume, n*—the volume, ft^3/ft^2 (cm^3/cm^2), that is required to fill a geocomposite drain layer to the upper most asperities of the geocomposite drain layer.

3.2.6 *unit water capture volume, n*—the maximum volume of water, ft^3/ft^2 (cm^3/cm^2), that a geocomposite drain layer can hold at a specified inclination.

3.2.6.1 *Discussion*—For vegetative (green) roofs systems where the geocomposite drain layer will be filled with granular drainage medium, the actual volume is assumed to be 25 % of the measured volume. This assumption will allow a direct comparison between geocomposite sheet drains without, regard to the granular drainage media used. In computing the actual water capture of a geocomposite sheet drain employed in

---

[1] This test method is under the jurisdiction of ASTM Committee D08 on Roofing and Waterproofing and is the direct responsibility of Subcommittee D08.24 on Sustainability.

Current edition approved Feb. 15, 2011. Published March 2011. Originally approved in 2005. Last previous edition approved in 2005 as E2398 – 05. DOI: 10.1520/E2398-11.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

a specific vegetative (green) roof assembly, the porosity of the granular drainage medium used must be considered (Practice E2397)

4. Summary of Test Method

4.1 This procedure provides a method for measuring the volume of granular media or water, or both, that geocomposite drain layers can hold. The test involves filling the geocomposite drain layers with sand and water to establish the respective volumes. Since water capture will be influenced by the inclination of the geocomposite drain layer, the tests are conducted at several inclinations.

5. Significance and Use

5.1 Determining these performance characteristics of vegetative (green) roof systems provides information to facilitate the assessment of related engineering aspects of the facility. Such aspects may include structural design requirements, mechanical engineering and thermal design requirements, and fire and life safety requirements.

5.1.1 Accurate information about the water and media holding capacity of geocomposite drain layers is essential to predict dead load for vegetative (green) roof systems.

5.2 Determining these performance characteristics of vegetative (green) roof systems provides information to facilitate assessment of the performance of one vegetative (green) roof system relative to one another.

5.2.1 Water capture is also useful in assessing irrigation requirements for vegetative (green) roof designs.

5.2.2 Information about the unit media retention volume is required to predict the quantity of material that will be required to construct a vegetative (green) roof with a specified total thickness.

6. Apparatus

6.1 *Apparatus*—contains the following:

6.1.1 Scale, accurate to 0.005 oz (0.14 g),

6.1.2 Scoop,

6.1.3 Water dropper,

6.1.4 4-in. (10-cm) wide strip of aluminum or copper sheet metal,

6.1.5 Latex caulk, and

6.1.6 Ruler.

7. Conditioning

7.1 Cut out a rectangular coupon of the geocomposite drain layer to be tested.

7.2 The coupon should contain only complete, intact receptacles. The coupon should contain a minimum of four receptacles and be at least 6 in. (15 cm) square.

8. Procedure

8.1 Weigh the coupon in a dry condition, and record.

8.2 With the coupon on a level surface, fill the receptacles with water using a dropper. Excise caution not to moisten other parts of the coupon.

8.3 Transfer the coupon to the scale and record the weight of the coupon with the filled receptacles.

8.4 Using a ruler, measure the distance between the centers of adjacent receptacles along the width and length of the coupon.

NOTE 1—This measurement methods assumes that the receptacles are arranged in a rectangular pattern

8.5 Repeat the test after filling the coupon on inclined surfaces. The test should be completed for the following inclinations:

8.5.1 2 degrees (3.5 %),

8.5.2 5 degrees (8.7 %),

8.5.3 10 degrees (17.6 %), and

8.5.4 20 degrees (36.4 %).

8.6 Form a fence around the margin of the coupon using the metal strip material. As necessary, seal the edge of the fence using latex caulk. Allow the caulk to cure. Using the ruler, measure the inside dimensions of the fence.

8.7 Weigh the system and record.

8.8 Fill the geocomposite drain layer with coarse sand until the uppermost asperities are covered. Weigh and record.

8.9 Determined the unit weight, lb/ft^3 (kg/m^3), of the coarse sand.

9. Calculation of Results

9.1 Compute the unit media retention volume as follows:

$$Rm = 144 * Ws/(x\gamma * y) \text{ (in. – lb)} \quad (1)$$

$$(Rm = 1 \times 10^6 * Ws/(x\gamma * y)) \text{ (SI)}$$

where:

Rm = unit media retention volume, ft^3/ft^2 (cm^3/cm^2),
Ws = weight of system filled with sand minus weight of system without sand, lb (kg),
x = width fence, in. (cm),
y = length fence, in. (cm), and
γ = unit weight of sand, lb/ft^3 (kg/m^3).

9.2 Compute the unit water capture volume as follows:

$$Rw = (2.31 * Ww)/(N * X * Y) \text{ (in. – lb)} \quad (2)$$

$$(Rw = (1 \times 10^3 * Ww) / (N * X * Y)) \text{ (SI)}$$

$$Rf = 0.25 * Rw;$$

where:

Rw = unit water capture volume, ft^3/ft^2 (cm^3/cm^2),
Rf = unit water capture volume, when in-filled with media, ft^3/ft^2 (cm^3/cm^2),
Ww = weight of coupon filled with water minus weight of coupon dry, lb (kg),
N = number of receptacles on the coupon,
X = receptacle spacing along the width of the coupon, in. (cm), and
Y = receptacle spacing along the length of the coupon, in. (cm).

9.3 Conduct all tests in duplicate. If the results of two tests differ by more than 5 %, then repeat.

10. Report

10.1 Report the following information:

10.1.1 Product designation,

10.1.2 Size of the coupon tested,

10.1.3 Number of receptacles included on the coupon,

10.1.4 Unit media retention volume, and

10.1.5 Unit water capture volume, both *Rw* and *Rf* for the five inclinations.

11. Precision and Bias

11.1 *Precision*—The precision of the procedure for these test methods for measuring the media retention and water capture capacity of geocomposite drain layers is being determined. Parties interested in participating in interlaboratory test programs should contact Committee E60.

11.2 *Bias*—The bias for these measurements is undetermined because there no reference values available for the materials used.

12. Keywords

12.1 geocomposite drain layers; media retention; vegetative (green) roof; water capture