Project Manager/Estimator Meeting
Wheeling Country Club, Wheeling, WV
March 29, 2024

Emerging Technical Issues and Risks

Mark S. Graham
Vice President, Technical Services
National Roofing Contractors Association
Rosemont, Illinois

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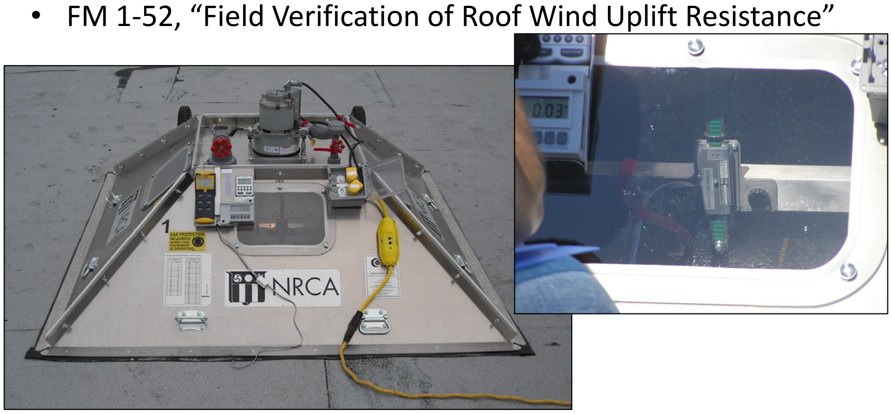
Field wind-uplift testing

- ASTM E907, "Standard Test Method for Field Testing Uplift Resistance for Adhered membrane Roofing Systems"
- FM 1-52, "Field Verification of Roof Wind Uplift Resistance"



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INDUSTRY ISSUE UPDATE

NRCA Member Benefit

Field-uplift testing

ASTM E907 and FM 1-52 tests continue to be problematic

June 2015

NRCA continues to receive a significant number of reports from roofing contractors, manufacturers and designers regarding the use of and problems associated with field-uplift tests as post-installation quality assurance measures for membrane roof systems. NRCA has addressed these testing issues a number of times during the years. Following is a summary of NRCA's previous discussions, as well as updated information and recommendations.

ASTM E907/FM 1-52

There are two recognized field test methods for determining adhered membrane roof systems' uplift resistances: ASTM E907, "Standard Test Method for Field Testing Uplift Resistance of Adhered Membrane Roofing Systems," and FM Global Loss Prevention Data Sheet 1-52 (FM 1-52), "Field Verification of Roof Wind Uplift Resistance."

An example of a test chamber used for negative-pressure uplift testing

Both test methods are similar and provide for affixing a 5- by 5-foot dome-like chamber to a roof surface's topside and applying a defined negative (uplift) pressure inside the chamber to the roof system's exterior-side surface using a vacuum pump (see photo). During the test, membrane surface deflection inside the chamber is visually monitored and measured to determine whether a roof system passes or is "suspect."

Using ASTM E907, a roof system is considered to be suspect if the deflection measured during the test is 25 mm (about 1 inch) or greater. During FM 1-52 testing, a roof system is suspect if the measured deflection is between ¼ of an inch and ⁵⁄₁₆ of an inch depending on the maximum test pressure; 1 inch where a thin topping board (cover board) is used; or 2 inches where a thin cover board or flexible, mechanically attached insulation is used.

If an ASTM E907 or FM 1-52 test yields a suspect result, a test cut should be taken in the test area to determine whether failure has occurred and the specific failure mode.

ASTM E907 and FM 1-52 differ notably in their test cycles and maximum test pressures for determining roof system deflections and whether a roof system passes or is suspect. ASTM E907 testing is conducted in 15-pounds per square foot (psf) pressure intervals up to the calculated design wind (uplift) pressure for the specific roof system being evaluated. FM 1-52 testing is conducted using an initial 15-pounds psf pressure followed by 7.5-pound psf increments up to a maximum test pressure of 1.25 times the design uplift pressure for the specific roof system being evaluated.

Considering maximum test loading and allowable test deflections in combination, FM 1-52 requires 25 percent higher test loads, yet only allows as little as ¼ the test deflection of ASTM E907. That said, FM 1-52 is a significantly more stringent test than ASTM E907.

ASTM E907 originally was published as a recognized consensus standard in 1983, and it was revised in 1996. In 2013, ASTM withdrew ASTM E907 because a consensus could not be reached regarding necessary revisions—most significantly, defining the test method's precision and bias (accuracy). ASTM E907-96 still is available for use and can be obtained directly from ASTM's website, www.astm.org.

FM 1-52 is an FM Global-promulgated evaluation method and not a recognized industry-consensus test standard. FM 1-52's scope indicates it only is intended to confirm acceptable wind-uplift resistance on completed roof systems in hurricane-prone regions, where a partial blow-off has occurred or where inferior roof system construction is suspected or known to be present.

FM 1-52 originally was published by FM Global in October 1970. The negative-pressure uplift test was added in August 1980 and has been revised several times. The current edition is dated July 2012 and includes an option for "visual construction observation (VCO)" as an alternative to negative-pressure uplift testing. VCO provides for full-time, third-party monitoring of a roof system application to verify roof system installation in accordance with contract documents.

NRCA "Industry Issue Update," June 2015

NRCA members' experience:

- Most tests not conducted in accordance with ASTM E907 or FM 1-52.
- No correlation between field test vs. lab. results/classifications
- NRCA survey: 55% passing

Link

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RESEARCH+TECH

Revisiting field uplift testing

NRCA's long-standing concerns continue with this issue

by Mark S. Graham

It has been a while since I have written about NRCA's concerns with field uplift testing, which sometimes is inappropriately used as a way to assess the quality of an adhered membrane roof system installation. Despite the time that has passed, NRCA continues to have reservations about field uplift testing, and the test procedure has not yet been revised to address NRCA's concerns.

ASTM E907

In 2013, ASTM International withdrew its consensus-based test method for field uplift testing, ASTM E907, "Standard Test Method for Field Testing Uplift Resistance of Adhered Membrane Roofing Systems."

ASTM International requires its test method standards to include a precision statement addressing two things:

- Known within-laboratory variability, referred to as "repeatability"
- Relative variability of test results obtained from different laboratories, referred to as "reproducibility"

Test methods also are required to include an estimate of bias in test results.

24 professionalroofing.net DECEMBER/JANUARY 2022-23

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December/January 2022-23

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ASTM Interlaboratory study (ILS)

"Testing the test"

- Built three identical test decks allowing for 24 tests total
- FM Class 90 roof system (FM tested to 90 psf)
- 8 testing entities conducted 3 test each
- Each test run at 15 psf increments up to 90 psf classification
- Membrane deflection is measured
- ASTM ILS staff planned the study and analyzed the test results
- At FM Global's research center in Glocester, RI

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ILS results

"Testing the test"

- Statistical outliers 15-, 30-, 45-, 60- and 90-psf test increments
- Outlier data excluded at 30-, 45- and 90-psf test increments
- 16 of the 24 specimens exhibited failure before completing the 90-psf test increment.
- 5 results at the 45-psf increment and all the tests' results at 60, 75- and 90-psf test increments exceeded FM 1-52's maximum allowable deflection.

All specimens should have exceeded 90 psf

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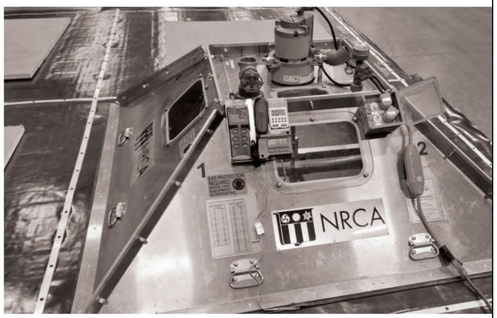
RESEARCH+TECH



Putting the test to the test

Substantial variability has been found in field-uplift testing

by Mark S. Graham

NRCA participated in an ASTM International interlaboratory study to evaluate the accuracy and precision of the field-uplift test method. The study provides some useful data and information for evaluating the appropriateness and effectiveness of field-uplift testing.

Field-uplift testing

There are two recognized field test methods for determining adhered membrane roof systems' uplift resistances: ASTM E907, "Standard Test Method for Field Testing Uplift Resistance of Adhered Membrane Roofing Systems," and FM Global Loss Prevention Data Sheet 1-52 (FM 1-52), "Field Verification of Roof Wind Uplift Resistance." In each of these test methods, a vacuum is created inside a test chamber mounted on a roof surface and membrane deflections resulting from the induced negative (uplift) pressures inside the chamber are measured.

ASTM E907 has been a consensus-based standard since it was originally published in 1983. ASTM International withdrew the standard in 2013 because it lacked a precision statement, which is required for all ASTM International test methods.

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September 2023

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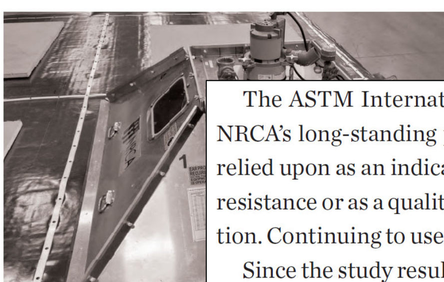
RESEARCH+TECH



The ASTM International interlaboratory study clearly illustrates NRCA's long-standing position that field-uplift testing should not be relied upon as an indicator of an adhered roof assembly's in situ uplift resistance or as a quality-assurance measure of roof assembly installation. Continuing to use it as such is irresponsible.

Since the study results were released, NRCA's Technical Operations Committee has asked FM Global to immediately discontinue use of FM 1-52's field-uplift test as a quality-assurance measure for roof assembly installation.

Putting the test to the test

Substantial variability has been found in field-uplift testing

by Mark S. Graham

Test Method for Field Testing Uplift Resistance of Adhered Membrane Roofing Systems," and FM Global Loss Prevention Data Sheet 1-52 (FM 1-52), "Field Verification of Roof Wind Uplift Resistance." In each of these test methods, a vacuum is created inside a test chamber mounted on a roof surface and membrane deflections resulting from the induced negative (uplift) pressures inside the chamber are measured.

ASTM E907 has been a consensus-based standard since it was originally published in 1983. ASTM International withdrew the standard in 2013 because it lacked a precision statement, which is required for all ASTM International test methods.

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[Link]

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2024 I-codes

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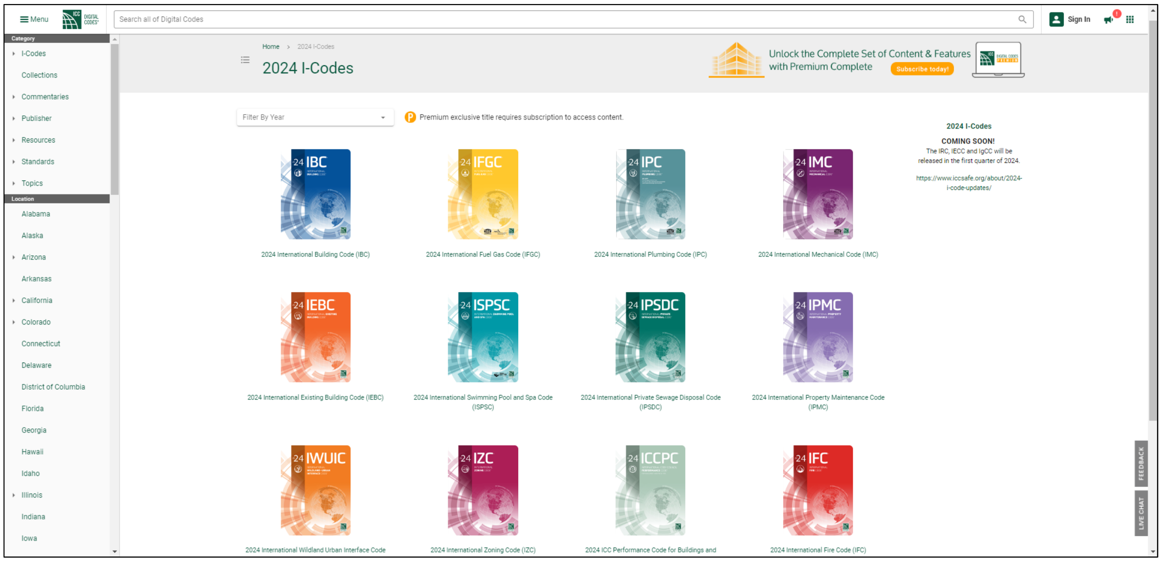
The 2024 I-codes have already been published and are available, except for the *International Residential Code, 2024 Edition* and *International Energy Conservation Code, 2024 Edition*

10

Accessing the I-codes

codes.iccsafe.org



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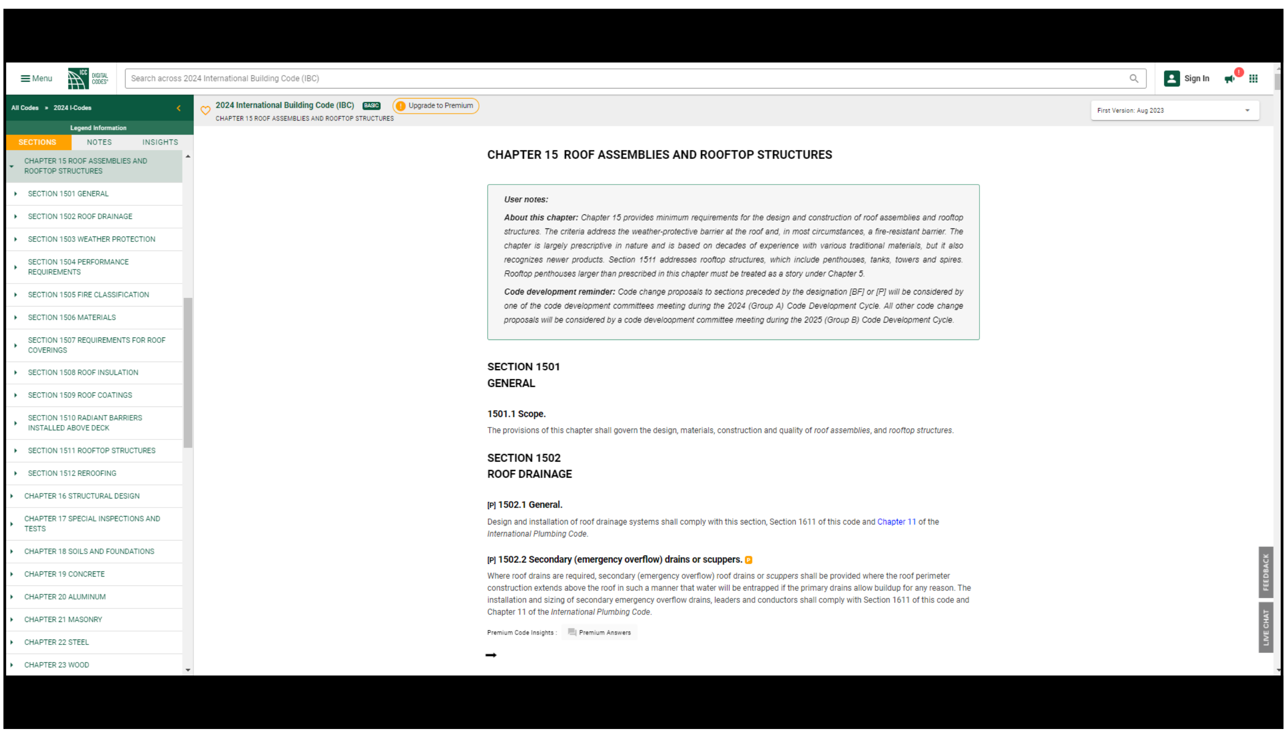

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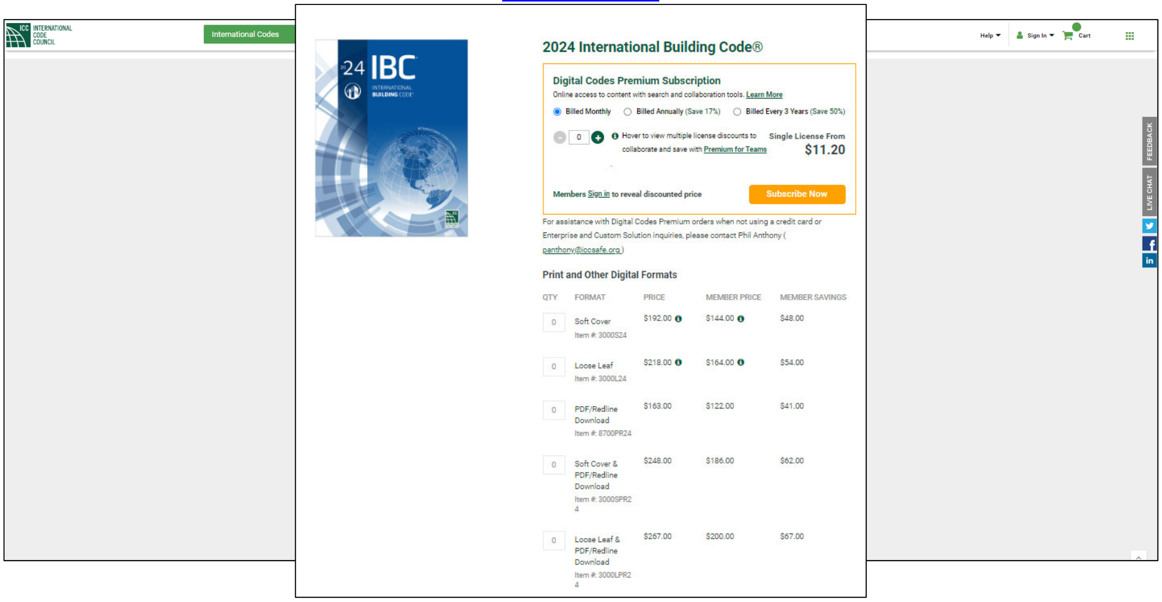
Purchasing the I-codes

shop.iccsafe.org



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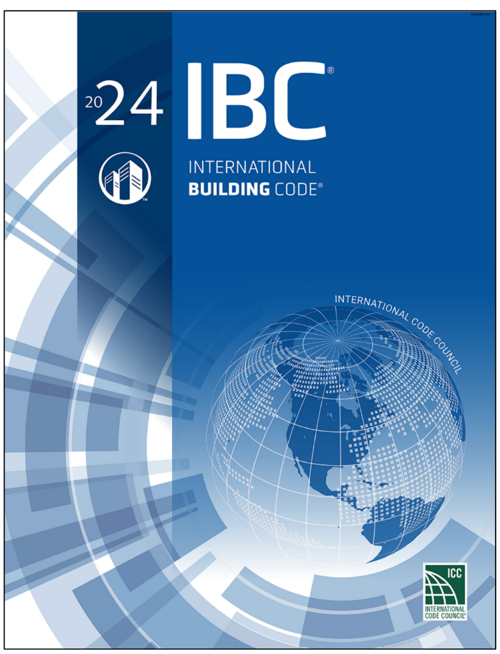

New to the 2024 I-codes

- Single column text format
- Updated font styles
- QR codes identifying changes
- Streamlined lists
- Consistent grouping of related text (e.g., tables follow parent sections)
- Shaded table headers and notes

iccsafe.org/design-updates

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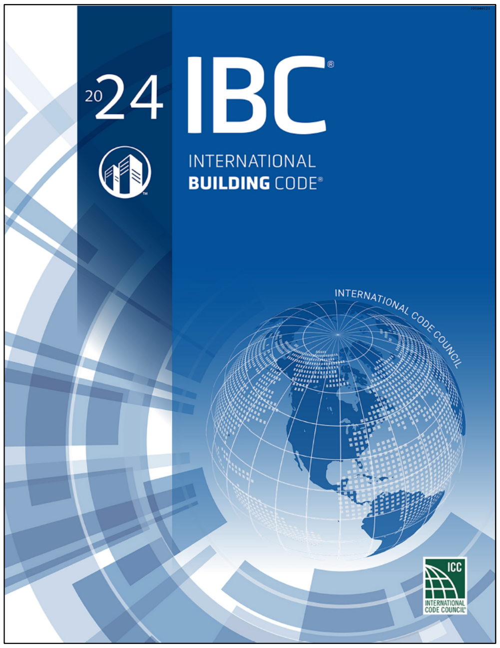

IBC 2024

- Ch. 15: Roof Assemblies and Rooftop Structures
- Ch. 27: Electrical
- Ch. 13: Interior Environment
- Ch. 16: Structural Design

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ROOF ASSEMBLIES AND ROOFTOP STRUCTURES

Scan for Changes
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1507.1 Scope. *Roof coverings* shall be applied in accordance with the applicable provisions of this section and the manufacturer's installation instructions.

1507.1.1 Underlayment. *Underlayment* in accordance with this section is required for asphalt shingles, clay and concrete tile, *metal roof shingles*, mineral-surfaced roll roofing, slate and slate-type shingles, wood shingles, wood shakes, metal roof panels and BIPV roof coverings. Such underlayment shall conform to the applicable standards listed in this chapter. *Underlayment* materials required to comply with ASTM D226, D1970, D2626, D4869, D6380 Class M, D6757 or D8257 shall bear a *label* indicating compliance with the standard designation and, if applicable, type classification indicated in Table 1507.1.1(1). *Underlayment* shall be fastened in accordance with Table 1507.1.1(2). *Underlayment* shall be attached in accordance with Table 1507.1.1(3).

Exception: Structural metal panels that do not require a substrate or *underlayment*.

TABLE 1507.1.1(1)—UNDERLAYMENT TYPES

ROOF COVERING	SECTION	MAXIMUM BASIC WIND SPEED, V < 130 MPH IN HURRICANE-PRONE REGIONS OR V < 140 MPH OUTSIDE HURRICANE-PRONE REGIONS	MAXIMUM BASIC WIND SPEED, $V \geq$ 130 MPH IN HURRICANE-PRONE REGIONS OR $V \geq$ 140 MPH OUTSIDE HURRICANE-PRONE REGIONS
Asphalt shingles	1507.2	ASTM D226 Type I or II ASTM D1970 ASTM D4869 Type I, II, III or IV ASTM D6757 ASTM D8257	ASTM D226 Type II ASTM D1970 ASTM D4869 Type III or IV ASTM D8257
Wood shingles	1507.8	ASTM D226 Type I or II ASTM D4869 Type I, II, III or IV	ASTM D226 Type II ASTM D4869 Type III or IV
Wood shakes applied to a solid sheathing roof deck	1507.9	ASTM D226 Type I or II ASTM D4869 Type I, II, III or IV	ASTM D226 Type II ASTM D4869 Type III or IV

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ROOF ASSEMBLIES AND ROOFTOP STRUCTURES

[BG] 1511.6 Mechanical equipment screens. *Mechanical equipment screens* shall be constructed of the materials specified for the *exterior walls* in accordance with the type of construction of the *building*. Where the *fire separation distance* is greater than 5 feet (1524 mm), *mechanical equipment screens* shall not be required to comply with the *fire-resistance rating* requirements.

[BG] 1511.6.1 Height limitations. *Mechanical equipment screens* shall not exceed 18 feet (5486 mm) in height above the *roof deck*, as measured to the highest point on the *mechanical equipment screen*.

Exception: Where located on *buildings* of Type IA construction, the height of *mechanical equipment screens* shall not be limited.

[BG] 1511.6.2 Type I, II, III or IV construction. Regardless of the requirements in Section 1511.6, *mechanical equipment screens* that are located on the *roof decks* of *buildings* of Type I, II, III or IV construction shall be permitted to be constructed of combustible materials in accordance with any one of the following limitations:

1. The *fire separation distance* shall be not less than 20 feet (6096 mm) and the height of the *mechanical equipment screen* above the roof deck shall not exceed 4 feet (1219 mm) as measured to the highest point on the *mechanical equipment screen*.
2. The *fire separation distance* shall be not less than 20 feet (6096 mm) and the *mechanical equipment screen* shall be constructed of *fire-retardant-treated wood* complying with Section 2303.2 for exterior installation.
3. Where exterior wall covering panels are used, the panels shall have a *flame spread index* of 25 or less when tested in the minimum and maximum thicknesses intended for use, with each face tested independently in accordance with ASTM E84 or UL 723. The panels shall be tested in the minimum and maximum thicknesses intended for use in accordance with, and shall comply with the acceptance criteria of, NFPA 285 and shall be installed as tested. Where the panels are tested as part of an *exterior wall* assembly in accordance with NFPA 285, the panels shall be installed on the face of the *mechanical equipment screen* supporting structure in the same manner as they were installed on the tested *exterior wall* assembly.

[BG] 1511.6.3 Type V construction. The height of *mechanical equipment screens* located on the *roof decks* of *buildings* of Type V construction, as measured from *grade plane* to the highest point on the *mechanical equipment screen*, shall be permitted to exceed the maximum *building height* allowed for the building by other provisions of this code where complying with any one of the following limitations, provided that the *fire separation distance* is greater than 5 feet (1524 mm):

1. Where the *fire separation distance* is not less than 20 feet (6096 mm), the height above *grade plane* of the *mechanical equipment screen* shall not exceed 4 feet (1219 mm) more than the maximum *building height* allowed.
2. The *mechanical equipment screen* shall be constructed of noncombustible materials.
3. The *mechanical equipment screen* shall be constructed of *fire-retardant-treated wood* complying with Section 2303.2 for exterior installation.
4. Where the *fire separation distance* is not less than 20 feet (6096 mm), the *mechanical equipment screen* shall be constructed of materials having a *flame spread index* of 25 or less when tested in the minimum and maximum thicknesses intended for use with each face tested independently in accordance with ASTM E84 or UL 723.

[BG] 1511.7 Other rooftop structures. *Rooftop structures* not regulated by Sections 1511.2 through 1511.6 shall comply with Sections 1511.7.1 through 1511.7.6, as applicable.

[BG] 1511.7.6 Lightning protection systems. Lightning protection system components shall be installed in accordance with Sections 1511.7.6.1, 1511.7.6.2 and 2703.

[BG] 1511.7.6.1 Installation on metal edge systems or gutters. Lightning protection system components attached to ANSI/SPRI/FM 4435/ES-1 or ANSI/SPRI GT-1 tested metal edge systems or gutters shall be installed with compatible brackets, fasteners or adhesives, in accordance with the metal edge systems or gutter manufacturer's installation instructions. Where the metal edge system or gutter manufacturer is unknown, installation shall be as directed by a *registered design professional*.

[BG] 1511.7.6.2 Installation on roof coverings. Lightning protection system components directly attached to or through the *roof covering* shall be installed in accordance with this chapter and the *roof covering* manufacturer's installation instructions. Flashing shall be installed in accordance with the *roof assembly* manufacturer's installation instructions and Sections 1503.2 and 1507 where the lightning protection system installation results in a penetration through the *roof covering*. Where the *roof covering* manufacturer is unknown, installation shall be as directed by a *registered design professional*.

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ELECTRICAL

SECTION 2703—LIGHTNING PROTECTION SYSTEMS

2703.1 General. Where provided, lightning protection systems shall comply with Sections 2703.2 through 2703.3.

2703.2 Installation. Lightning protection systems shall be installed in accordance with NFPA 780 or UL 96A. UL 96A shall not be utilized for *buildings* used for the production, handling or storage of ammunition, *explosives*, *flammable liquids, flammable gases* or other *explosive* ingredients including dust.

2703.2.1 Surge protection. Where lightning protection systems are installed, surge protective devices shall also be installed in accordance with NFPA 70 and either NFPA 780 or UL 96A, as applicable.

2703.3 Interconnection of systems. All lightning protection systems on a *building* or *structure* shall be interconnected in accordance with NFPA 780 or UL 96A, as applicable.

NFPA 780 and UL 96A are the technical basis for LPS installer certification

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ROOF ASSEMBLIES AND ROOFTOP STRUCTURES

[BG] 1511.8 Structural fire resistance. The structural frame and roof construction supporting *loads* imposed upon the roof by any *rooftop structure* shall comply with the requirements of Table 601. The fire-resistance reduction permitted by Table 601, Note a, shall not apply to roofs containing *rooftop structures*.

[BG] 1511.9 Raised-deck systems installed over a roof assembly. *Raised-deck systems* installed above a *roof assembly* shall comply with Sections 1511.9.1 through 1511.9.5.

[BG] 1511.9.1 Installation. The installation of a *raised-deck system* shall comply with all of the following:

1. The perimeter of the *raised-deck system* shall be surrounded on all sides by walls or by a noncombustible enclosure approved to prevent fire intrusion below the *raised-deck system*. The wall or enclosure shall extend at least from the *roof assembly* to the top surface of the *raised-deck system*. The enclosure shall not impede roof drainage in accordance with Section 1511.9.5.
2. A *raised-deck system* shall be installed above a listed *roof assembly*.

   Exception: Where the *roof assembly* is not required to have a fire classification in accordance with Section 1505.2.
3. A *raised-deck system* shall be installed in accordance with the manufacturer's installation instructions.
4. A *raised-deck system* shall not impede the operation of plumbing or mechanical vents, exhaust, air inlets or roof drains. Where required, access for inspection, cleaning or maintenance shall be provided.

[BG] 1511.9.2 Fire classification. The *raised-deck system* shall be listed and identified with a fire classification in accordance with Section 1505 and shall be tested in accordance with either Section 1511.9.2.1 or 1511.9.2.2.

[BG] 1511.9.2.1 Fire testing of the raised deck system installed over a classified roof assembly. The *raised-deck system* shall be tested separately from the *roof assembly* over which it is installed. The fire classification of the *raised-deck system* shall be not less than the fire classification for the *roof assembly* over which it is installed.

Exception: Where the decking or pavers of the *raised-deck system* consists of brick, masonry, concrete or other noncombustible materials, fire testing of the *raised-deck system* is not required.

[BG] 1511.9.2.2 Fire testing of the raised deck system together with the roof assembly. The *roof assembly* and the *raised-deck system* shall be tested together.

[BG] 1511.9.3 Pedestals or supports. The pedestals or supports for the *raised-deck system* shall be installed in accordance with manufacturer's installation instructions.

[BG] 1511.9.4 Structural requirements. The *raised-deck system* shall be designed for all applicable loads in accordance with Chapter 16 and performance requirements in Section 1504.5.

[BG] 1511.9.5 Roof drainage. The *raised-deck system*, including the wall or enclosure between the *roof assembly* and the raised deck, shall be designed and installed to allow for the operation of the roof drainage system as required by Section 1502 and the *International Plumbing Code*. The roof structure shall be designed to support any standing water resulting from the installation of the *raised-deck system*.

[BG] 1511.9.6 Accessibility and egress. The *raised-deck system* shall be accessible in accordance with Chapter 11 and means of egress shall be provided in accordance with Chapter 10.

SECTION 1512—REROOFING

1512.1 General. Materials and methods of application used for recovering or replacing an existing *roof covering* shall comply with the requirements of Chapter 15.

Exceptions:

1. *Roof replacement* or *roof recover* of existing *low-slope roof coverings* shall not be required to meet the minimum design slope requirement of $^{1}/_{4}$ unit vertical in 12 units horizontal (2-percent slope) in Section 1507 for roofs that provide *positive roof drainage* and meet the requirements of Sections 1608.3 and 1611.2.
2. Recovering or replacing an existing *roof covering* shall not be required to meet the requirement for secondary (emergency overflow) drains or *scuppers* in Section 1502.2 for roofs that provide for *positive roof drainage* and meet the requirements of Sections 1608.3 and 1611.2. For the purposes of this exception, existing secondary drainage or *scupper* systems required in accordance with this code shall not be removed unless they are replaced by secondary drains or *scuppers* designed and installed in accordance with Section 1502.2.

Scan for Changes

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Considerations of "ponding instability"

IBC 2024 and ASCE 7-22

- IBC's reroofing provisions provide pointers to IBC Ch. 16-Structural Design
  - IBC Ch. 16 references ASCE 7-22
  - ASCE 7-22 addresses ponding instability in Sec. 7.11-Ponding Instability
- A complicated and costly analysis
  - Even more costly if drawings identifying the building's structural components are not available
- If structural modifications are needed, added reroofing project complexity and cost

20

A code-accepted way of circumventing IBC 2024's (and ASCE 7-22's) ponding instability provisions is to add tapered insulation to achieve ¼-in-12 or greater slope.

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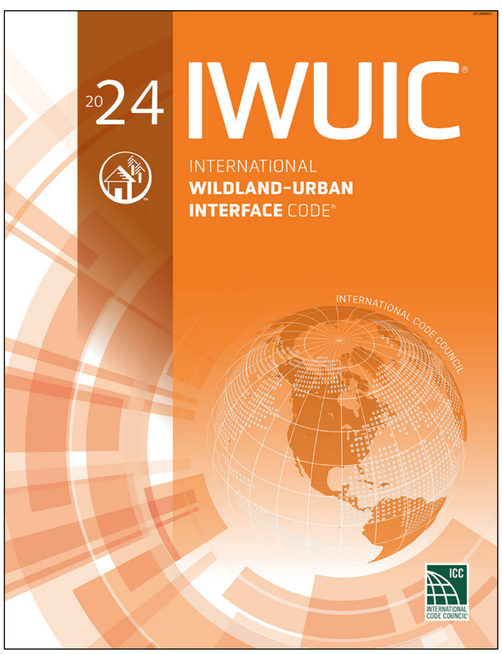

Link

IWUIC 2024

- Overlays the Building Code
- Ch. 5: Special Building Construction Regulations
- Ignition-resistant Construction Class 1, 2 or 3
- Class 1 and 2: Class A roof Class 3: Class B roof
- Valley, eave, gutter and downspout and roof vent requirements

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RESEARCH+TECH

Wildfire mitigation

The International Code Council® provides mitigation regulations in code document

by Mark S. Graham

Catastrophic wildfires, such as those that recently occurred in California, Colorado and Hawaii, have resulted in an increased demand for improved wildfire mitigation. The International Code Council Inc.'s International Wildland-Urban Interface Code® provides code-based regulations for wildfire mitigation, including roofing-specific requirements.

IWUIC

ICC developed the IWUIC in 2003. The current edition is IWUIC 2024.

IWUIC's purpose is to mitigate the risk to life and structures from wildland fire exposures and fire exposures from adjacent structures and to mitigate structure fires from spreading to wildland fuels.

A wildland-urban interface area is a geographic area where structures and other human development meets or intermingles with wildland or vegetative fuels. The adopting agency designates the wildland-urban interface areas within its jurisdiction.

IWUIC is intended to supplement, not replace, a jurisdiction's building and fire codes (if such codes have been adopted) and provide specialized regulations. IWUIC is presented in tiered levels to

20 professionalroofing.net DECEMBER/JANUARY 2023-24

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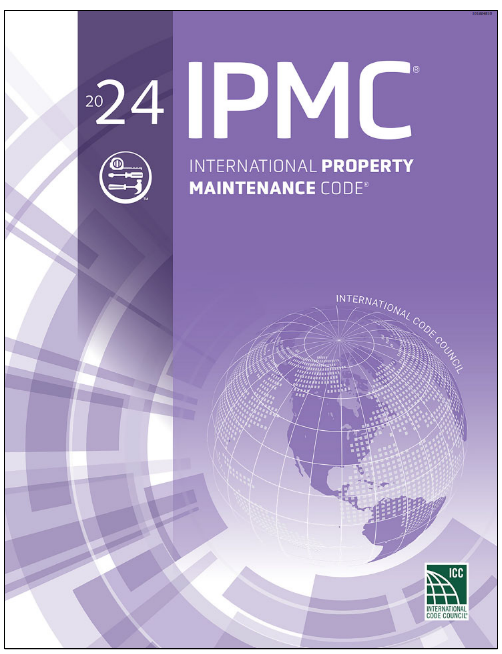

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IPMC 2024

- Sec. 304-Exterior Structure
- Sec. 507-Storm Drainage

24

RESEARCH+TECH

Maintaining compliance

IPMC® provides code requirements for building maintenance

by Mark S. Graham

The International Code Council®'s International Property Maintenance Code® establishes minimum requirements for the maintenance of existing buildings, including their roof systems, through model code regulations. IPMC 2024 has several roofing-related requirements and can be used as a basis for roofing contractors performing periodic roof system maintenance.

IPMC 2024

The IPMC originated in 1996 when a committee consisting of representatives of the three legacy code organizations (Building Officials and Code Administrators International, International Conference of Building Officials and Southern Building Code Congress International) drafted comprehensive guidelines for existing buildings based on the legacy codes' requirements for existing buildings.

In 2000, ICC published the first edition of IPMC using ICC's code development process. New editions have been published every three years since with the most current edition being IPMC 2024.

IPMC 2024 has eight chapters and two appendixes (see figure). The appendixes are not mandatory unless specifically referenced in

26 professionalroofing.net FEBRUARY 2024

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February 2024

Link

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Updates to FM Global datasheets

www.FMGlobalDataSheets.com

- FM 1-15, "Roof-mounted Solar Photovoltaic Panels"
- FM 1-28, "Wind Design"
- FM 1-54, "Roof Loads and Drainage"

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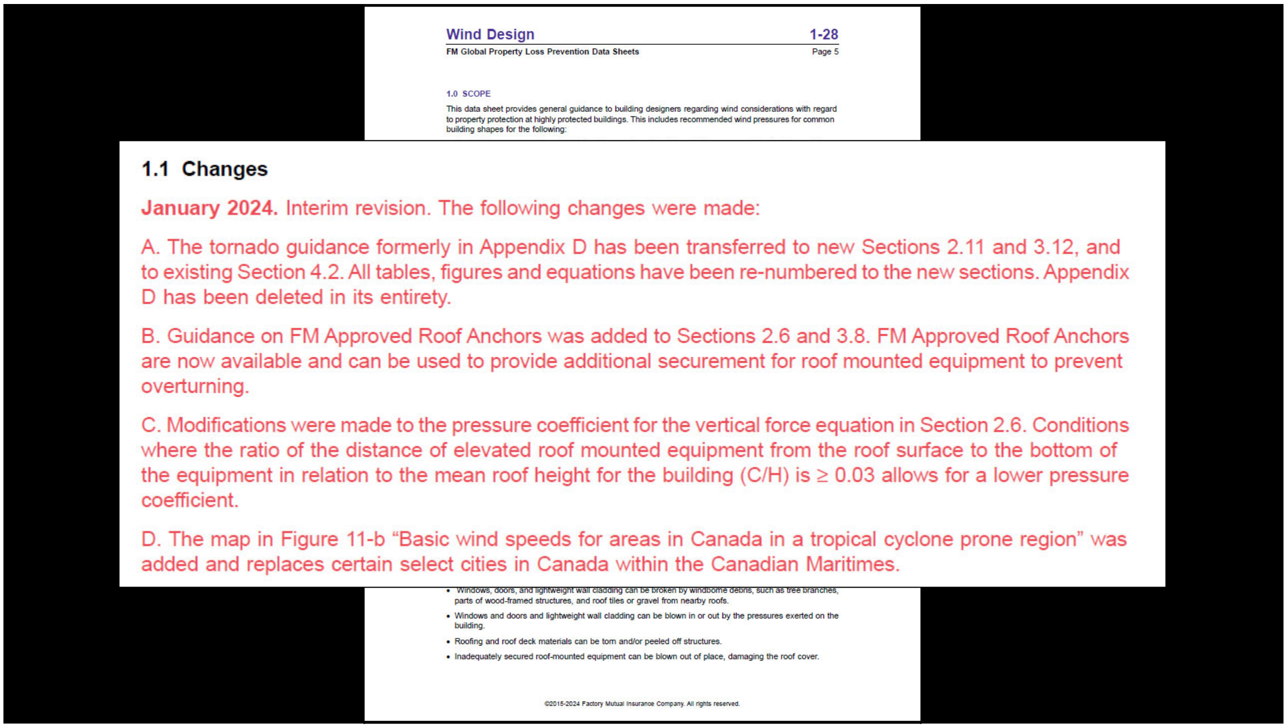

Wind Design 1-28

FM Global Property Loss Prevention Data Sheets Page 5

1.0 SCOPE

This data sheet provides general guidance to building designers regarding wind considerations with regard to property protection at highly protected buildings. This includes recommended wind pressures for common building shapes for the following:

1.1 Changes

January 2024. Interim revision. The following changes were made:

A. The tornado guidance formerly in Appendix D has been transferred to new Sections 2.11 and 3.12, and to existing Section 4.2. All tables, figures and equations have been re-numbered to the new sections. Appendix D has been deleted in its entirety.

B. Guidance on FM Approved Roof Anchors was added to Sections 2.6 and 3.8. FM Approved Roof Anchors are now available and can be used to provide additional securement for roof mounted equipment to prevent overturning.

C. Modifications were made to the pressure coefficient for the vertical force equation in Section 2.6. Conditions where the ratio of the distance of elevated roof mounted equipment from the roof surface to the bottom of the equipment in relation to the mean roof height for the building (C/H) is ≥ 0.03 allows for a lower pressure coefficient.

D. The map in Figure 11-b “Basic wind speeds for areas in Canada in a tropical cyclone prone region” was added and replaces certain select cities in Canada within the Canadian Maritimes.

- Windows, doors, and lightweight wall cladding can be broken by windborne debris, such as tree branches, parts of wood-framed structures, and roof tiles or gravel from nearby roofs.
- Windows and doors and lightweight wall cladding can be blown in or out by the pressures exerted on the building.
- Roofing and roof deck materials can be torn and/or peeled off structures.
- Inadequately secured roof-mounted equipment can be blown out of place, damaging the roof cover.

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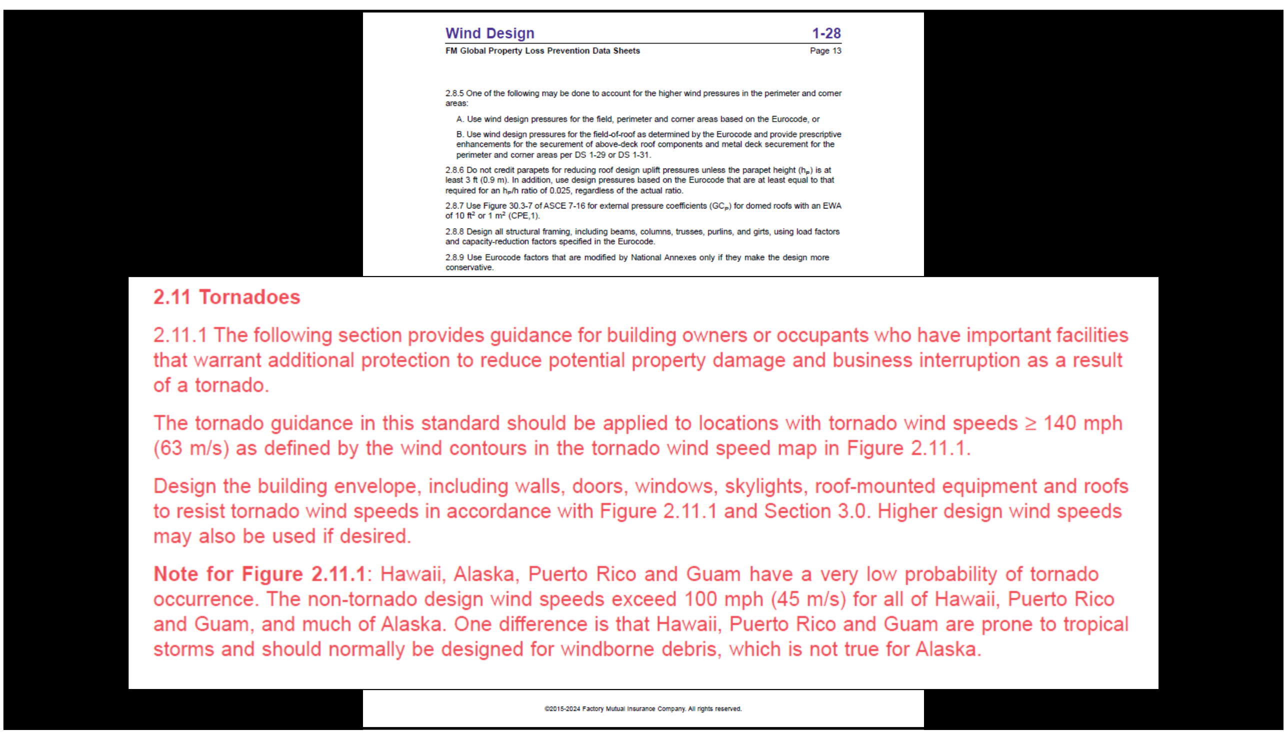

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2.8.5 One of the following may be done to account for the higher wind pressures in the perimeter and corner areas:

A. Use wind design pressures for the field, perimeter and corner areas based on the Eurocode, or

B. Use wind design pressures for the field-of-roof as determined by the Eurocode and provide prescriptive enhancements for the securement of above-deck roof components and metal deck securement for the perimeter and corner areas per DS 1-29 or DS 1-31.

2.8.6 Do not credit parapets for reducing roof design uplift pressures unless the parapet height (h_p) is at least 3 ft (0.9 m). In addition, use design pressures based on the Eurocode that are at least equal to that required for an h_p/h ratio of 0.025, regardless of the actual ratio.

2.8.7 Use Figure 30.3-7 of ASCE 7-16 for external pressure coefficients (GC_p) for domed roofs with an EWA of 10 ft² or 1 m² (CPE,1).

2.8.8 Design all structural framing, including beams, columns, trusses, purlins, and girts, using load factors and capacity-reduction factors specified in the Eurocode.

2.8.9 Use Eurocode factors that are modified by National Annexes only if they make the design more conservative.

2.11 Tornadoes

2.11.1 The following section provides guidance for building owners or occupants who have important facilities that warrant additional protection to reduce potential property damage and business interruption as a result of a tornado.

The tornado guidance in this standard should be applied to locations with tornado wind speeds ≥ 140 mph (63 m/s) as defined by the wind contours in the tornado wind speed map in Figure 2.11.1.

Design the building envelope, including walls, doors, windows, skylights, roof-mounted equipment and roofs to resist tornado wind speeds in accordance with Figure 2.11.1 and Section 3.0. Higher design wind speeds may also be used if desired.

Note for Figure 2.11.1: Hawaii, Alaska, Puerto Rico and Guam have a very low probability of tornado occurrence. The non-tornado design wind speeds exceed 100 mph (45 m/s) for all of Hawaii, Puerto Rico and Guam, and much of Alaska. One difference is that Hawaii, Puerto Rico and Guam are prone to tropical storms and should normally be designed for windborne debris, which is not true for Alaska.

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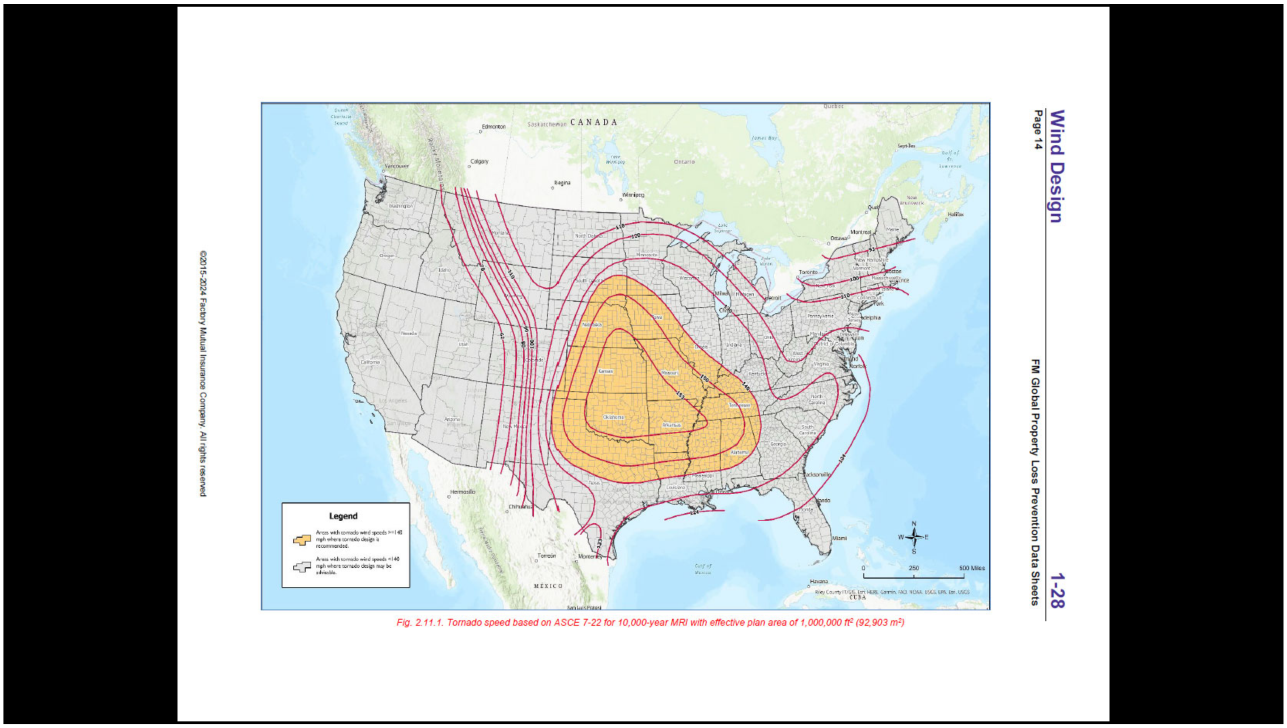

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3.12.4.8 Building Materials Used for Roof Construction

Wind loss experience has been more favorable with structural concrete roof decks than with steel decks. Steel deck may be used, but should be designed for higher pressures. This design could involve the use of any or all of the following:

- Shorter deck spans
- Stiffer (deeper, thicker, etc.) deck
- Increased securement to joists/purlins

Experience has also shown that steel joists may buckle due to the transfer of lateral loads to them, or from compressive stresses that develop in their lower chords while uplift pressures are applied to the roof deck. This buckling could be resolved by enhancing the joist resistance, improving the joist bridging and/or adding lower chord extensions.

Insulated roof assemblies with very high wind resistance can be found in RoofNav®, a publication of FM Approvals. Some assemblies, including those using insulated steel deck, have wind uplift ratings up to approximately 465 psf (22 kPa). These assemblies provide a cost-effective design for higher wind speeds associated with tornados, including the application of pressure coefficients to reflect areas of the roof with higher wind pressures, and a reasonable safety factor.

FM Approval Standard 4431, *Approval Standard for Skylights*

Note: The cost increase to change from a 90 mph (40 m/s) design wind speed (as is the case with the majority of the central United States) to a higher tornado wind design will vary, depending on geography, the specific design criteria, percentage of windows, etc. Increased construction costs for components and cladding are expected in areas not normally designed for increased wind speeds. This cost increase could be as high as 50%.

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CHAPTER 32
TORNADO LOADS

32.1 PROCEDURES

32.1.1 Scope Buildings and other structures classified as Risk Category III or IV and located in the tornado-prone region as shown in Figure 32.1-1, including the main wind force resisting system (MWFRS) and all components and cladding (C&C) thereof, shall be designed and constructed to resist the greater of the tornado loads determined in accordance with the provisions of this chapter or the wind loads determined in accordance with Chapters 26 through 31, using the load combinations provided in Chapter 2.

26). The tornado speed at any given geographic location will range from approximately Enhanced Fujita Scale EF0 – EF2 intensity, depending on the risk category and effective plan area of the building or other structure (see Section C32.5.1). Options for protection of life and property from more intense tornadoes include construction of a storm shelter and/or design for longer-return-period tornado speeds as provided in Appendix G, including performance-based design. A building or other structure designed for tornado loads determined exclusively in accordance with Chapter 32 cannot be designated as a storm shelter without meeting additional critical requirements provided in the applicable building code and ICC 500, the ICC/NSSA *Standard for the Design and Construction of Storm Shelters*. See Commentary Section C32.1.1 for an in-depth discussion on storm shelters.

32.1.2 Permitted Procedures The design tornado loads for buildings and other structures, including the MWFRS and C&C elements thereof, shall be determined using one of the procedures as specified in this section and subject to the applicable limitations of Chapters 26 through 32, excluding Chapter 28.

An outline of the overall process for the determination of the tornado loads, including section references, is provided in Figure 32.1-3.

32.1.2.1 Tornado Loads on the Main Wind Force Resisting System Tornado loads for the MWFRS shall be determined using one or more of the following procedures, as modified by Chapter 32:

1. Directional Procedure for buildings of all heights as specified in Chapter 27 for buildings meeting the requirements specified therein;
2. Directional Procedure for Building Appurtenances (such as rooftop structures and rooftop equipment) and Other Structures (such as solid freestanding walls and solid freestanding signs, chimneys, tanks, open signs, single-plane open frames, and trussed towers) as specified in Chapter 29 for buildings meeting the requirements specified therein; or
3. Wind Tunnel Procedure for all buildings and all other structures as specified in Chapter 31 for buildings meeting the requirements specified therein.

32.1.2.2 Tornado Loads on Components and Cladding Tornado loads on the C&C of all buildings and other structures shall be determined using one or more of the following procedures, as modified by Chapter 32:

1. Analytical Procedures as specified in Parts 1 through 5, as appropriate, of Chapter 30, for buildings or other structures meeting the requirements specified therein; or
2. Wind Tunnel Procedure for all buildings and other structures as specified in Chapter 31, for buildings meeting the requirements specified therein.

32.1.3 Performance-Based Procedures Tornado design of buildings and other structures using performance-based procedures shall be permitted subject to the approval of the Authority Having Jurisdiction. The performance-based tornado design procedures used shall, at a minimum, conform to Section 1.3.1.3 and be documented and submitted to the Authority Having Jurisdiction in accordance with Section 1.3.1.3.

32.2 DEFINITIONS

The following definitions apply to the provisions of Chapter 32. Terms not defined in this chapter shall be defined in accordance with Chapters 26 through 31, as appropriate, excluding Chapter 28.

ASCE TORNADO DESIGN GEODATABASE: The ASCE database (version 2022-1.0) of geocoded tornado speed design data.

OTHER STRUCTURES, SEALED: A structure that is completely sealed or has controlled ventilation such that tornado-induced atmospheric pressure changes will not be transmitted to the inside of the structure, including but not limited to certain tanks and vessels.

TORNADO-PRONE REGION: The area of the conterminous United States most vulnerable to tornadoes, as shown in Figure 32.1-1.

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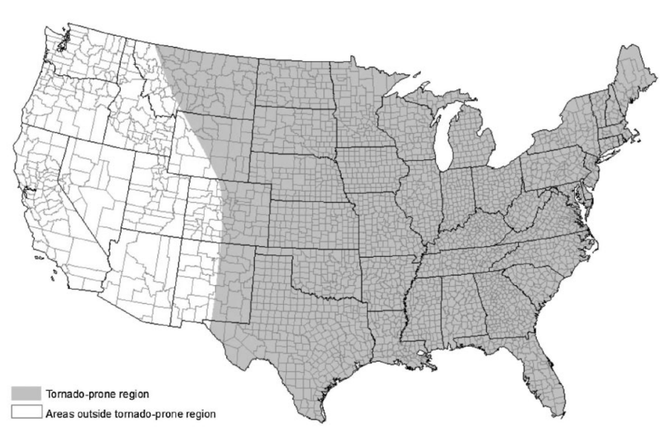

Figure 32.1-1. Tornado-prone region.

the effects of atmospheric pressure change and gust-effect factor, to be used in determination of tornado loads for buildings and some other structures, as determined in Section 32.13

K_{dT} = Tornado directionality factor as defined in Section 32.6

K_{hTor} = Tornado velocity pressure exposure coefficient evaluated at height $z = h$, as determined in Section 32.10

K_{vT} = Tornado pressure coefficient adjustment factor for vertical winds as defined in Section 32.14

K_{zTor} = Tornado velocity pressure exposure coefficient evaluated at height z, as determined in Section 32.10

p_{pT} = Combined net tornado design pressure on a parapet from Equation (32.15-3), lb/ft^2 (N/m^2)

p_T = Design tornado pressure to be used in determination of tornado loads for buildings and for certain other structures, lb/ft^2 (N/m^2)

convention as provided in Section 26.4, where positive pressure acts toward the surface and negative pressure acts away from the surface.

32.4.2 Critical Load Condition Values of external pressures shall be combined algebraically with the combined effects of internal pressures and atmospheric pressure change to determine the most critical load.

32.5 TORNADO HAZARD MAPS

32.5.1 Tornado Speed The tornado speed, V_T, used in the determination of tornado loads on buildings and other structures shall be determined from Figures 32.5-1 and 32.5-2 as follows:

1. For Risk Category III buildings and structures, use Figures 32.5-1A through 32.5-1H.

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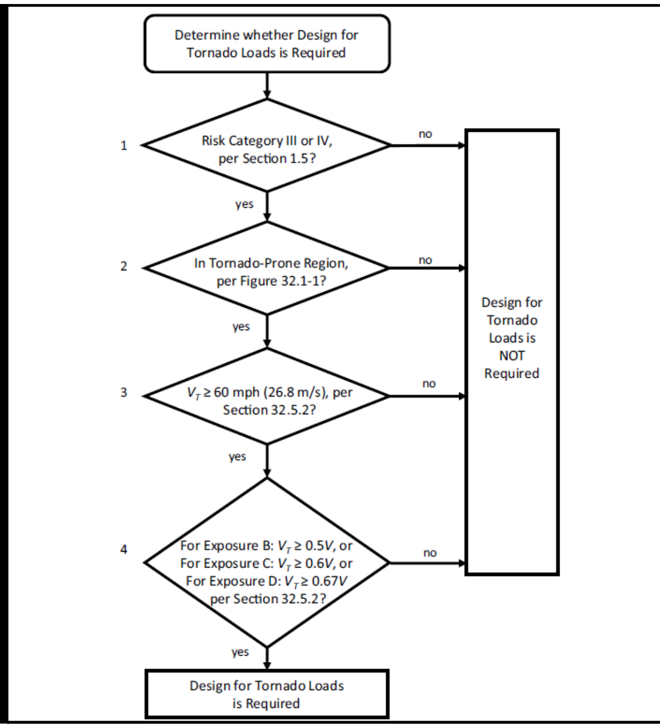

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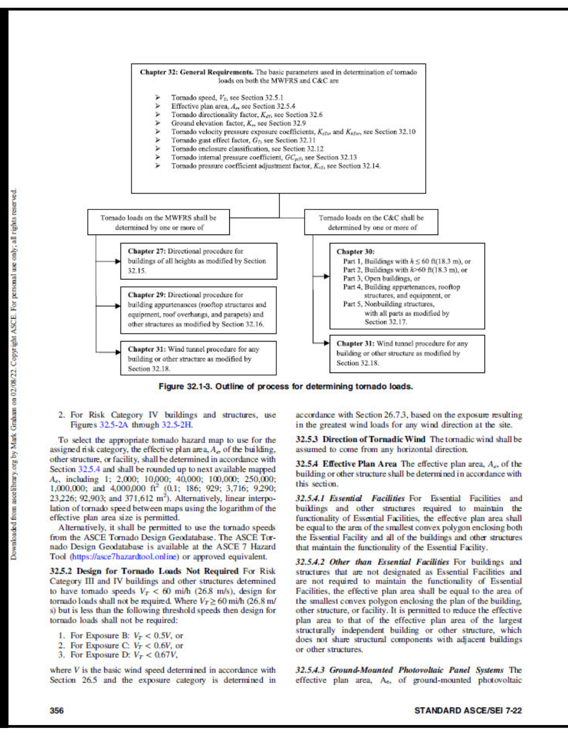

Chapter 32: General Requirements. The basic parameters used in determination of tornado loads on both the MWFRS and C&C are

- Tornado speed, V_T, see Section 32.5.1
- Effective plan area, A_e, see Section 32.5.4
- Tornado directionality factor, K_{dT}, see Section 32.6
- Ground elevation factor, K_e, see Section 32.9
- Tornado velocity pressure exposure coefficients, K_{zTor} and K_{hTor}, see Section 32.10
- Tornado gust effect factor, G_T, see Section 32.11
- Tornado enclosure classification, see Section 32.12
- Tornado internal pressure coefficient, GC_{piT}, see Section 32.13
- Tornado pressure coefficient adjustment factor, K_{vT}, see Section 32.14.

Tornado loads on the MWFRS shall be determined by one or more of

Chapter 27: Directional procedure for buildings of all heights as modified by Section 32.15.

Chapter 29: Directional procedure for building appurtenances (rooftop structures and equipment, roof overhangs, and parapets) and other structures as modified by Section 32.16.

Chapter 31: Wind tunnel procedure for any building or other structure as modified by Section 32.18.

Tornado loads on the C&C shall be determined by one or more of

Chapter 30:
Part 1, Buildings with $h \leq 60$ ft(18.3 m), or
Part 2, Buildings with h>60 ft(18.3 m), or
Part 3, Open buildings, or
Part 4, Building appurtenances, rooftop structures, and equipment, or
Part 5, Nonbuilding structures, with all parts as modified by Section 32.17.

Chapter 31: Wind tunnel procedure for any building or other structure as modified by Section 32.18.

Figure 32.1-3. Outline of process for determining tornado loads.

2. For Risk Category IV buildings and structures, use Figures 32.5-2A through 32.5-2H.

To select the appropriate tornado hazard map to use for the assigned risk category, the effective plan area, A_e, of the building, other structure, or facility, shall be determined in accordance with Section 32.5.4 and shall be rounded up to next available mapped A_e, including 1; 2,000; 10,000; 40,000; 100,000; 250,000; 1,000,000; and 4,000,000 ft^2 (0.1; 186; 929; 3,716; 9,290; 23,226; 92,903; and 371,612 m^2). Alternatively, linear interpolation of tornado speed between maps using the logarithm of the effective plan area size is permitted.

Alternatively, it shall be permitted to use the tornado speeds from the ASCE Tornado Design Geodatabase. The ASCE Tornado Design Geodatabase is available at the ASCE 7 Hazard Tool (https://asce7hazardtool.online) or approved equivalent.

32.5.2 Design for Tornado Loads Not Required For Risk Category III and IV buildings and other structures determined to have tornado speeds $V_T < 60$ mi/h (26.8 m/s), design for tornado loads shall not be required. Where $V_T \geq 60$ mi/h (26.8 m/s) but is less than the following threshold speeds then design for tornado loads shall not be required:

1. For Exposure B: $V_T < 0.5V$, or
2. For Exposure C: $V_T < 0.6V$, or
3. For Exposure D: $V_T < 0.67V$,

where V is the basic wind speed determined in accordance with Section 26.5 and the exposure category is determined in accordance with Section 26.7.3, based on the exposure resulting in the greatest wind loads for any wind direction at the site.

32.5.3 Direction of Tornadic Wind The tornadic wind shall be assumed to come from any horizontal direction.

32.5.4 Effective Plan Area The effective plan area, A_e, of the building or other structure shall be determined in accordance with this section.

32.5.4.1 Essential Facilities For Essential Facilities and buildings and other structures required to maintain the functionality of Essential Facilities, the effective plan area shall be equal to the area of the smallest convex polygon enclosing both the Essential Facility and all of the buildings and other structures that maintain the functionality of the Essential Facility.

32.5.4.2 Other than Essential Facilities For buildings and structures that are not designated as Essential Facilities and are not required to maintain the functionality of Essential Facilities, the effective plan area shall be equal to the area of the smallest convex polygon enclosing the plan of the building, other structure, or facility. It is permitted to reduce the effective plan area to that of the effective plan area of the largest structurally independent building or other structure, which does not share structural components with adjacent buildings or other structures.

32.5.4.3 Ground-Mounted Photovoltaic Panel Systems The effective plan area, A_e, of ground-mounted photovoltaic

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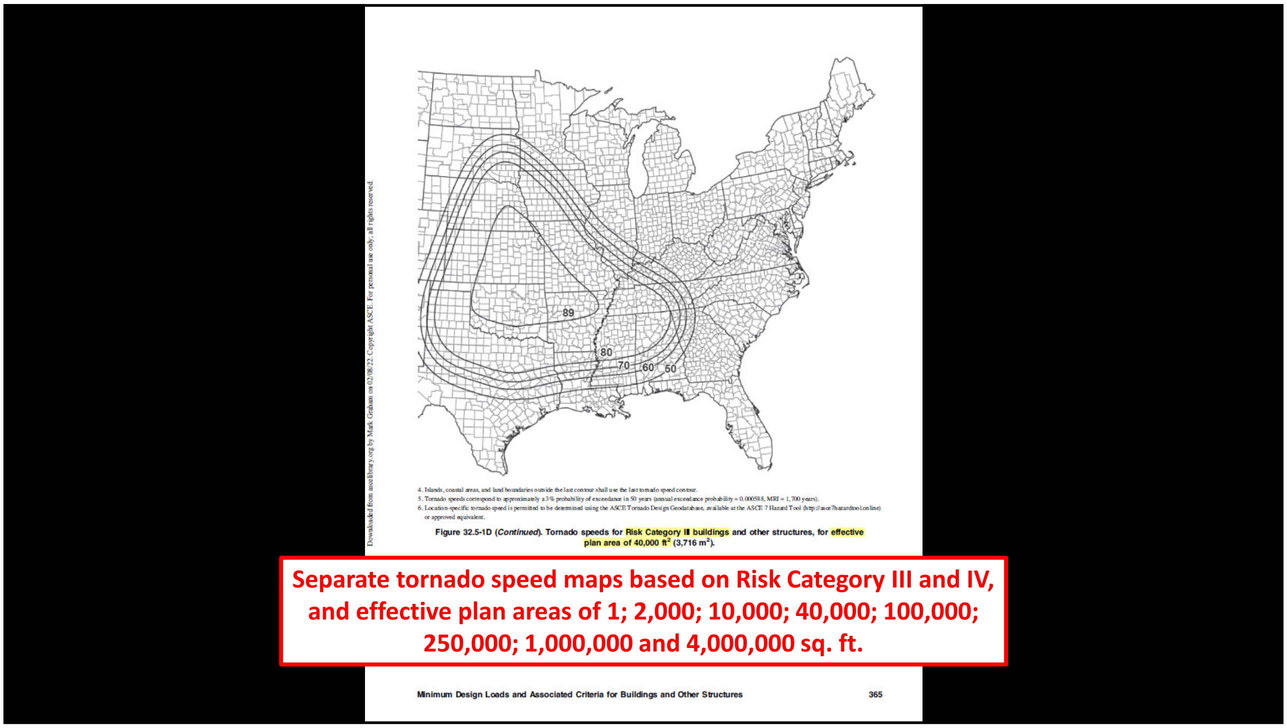
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4. Islands, coastal areas, and land boundaries outside the last contour shall use the last tornado speed contour.
5. Tornado speeds correspond to approximately a 3% probability of exceedance in 50 years (annual exceedance probability = 0.000588, MRI = 1,700 years).
6. Location-specific tornado speed is permitted to be determined using the ASCE Tornado Design Geodatabase, available at the ASCE 7 Hazard Tool (http://asce7hazardtool.online) or approved equivalent.
Figure 32.5-1D (Continued). Tornado speeds for Risk Category III buildings and other structures, for effective plan area of 40,000 ft2 (3,716 m2).
Separate tornado speed maps based on Risk Category III and IV, and effective plan areas of 1; 2,000; 10,000; 40,000; 100,000; 250,000; 1,000,000 and 4,000,000 sq. ft.
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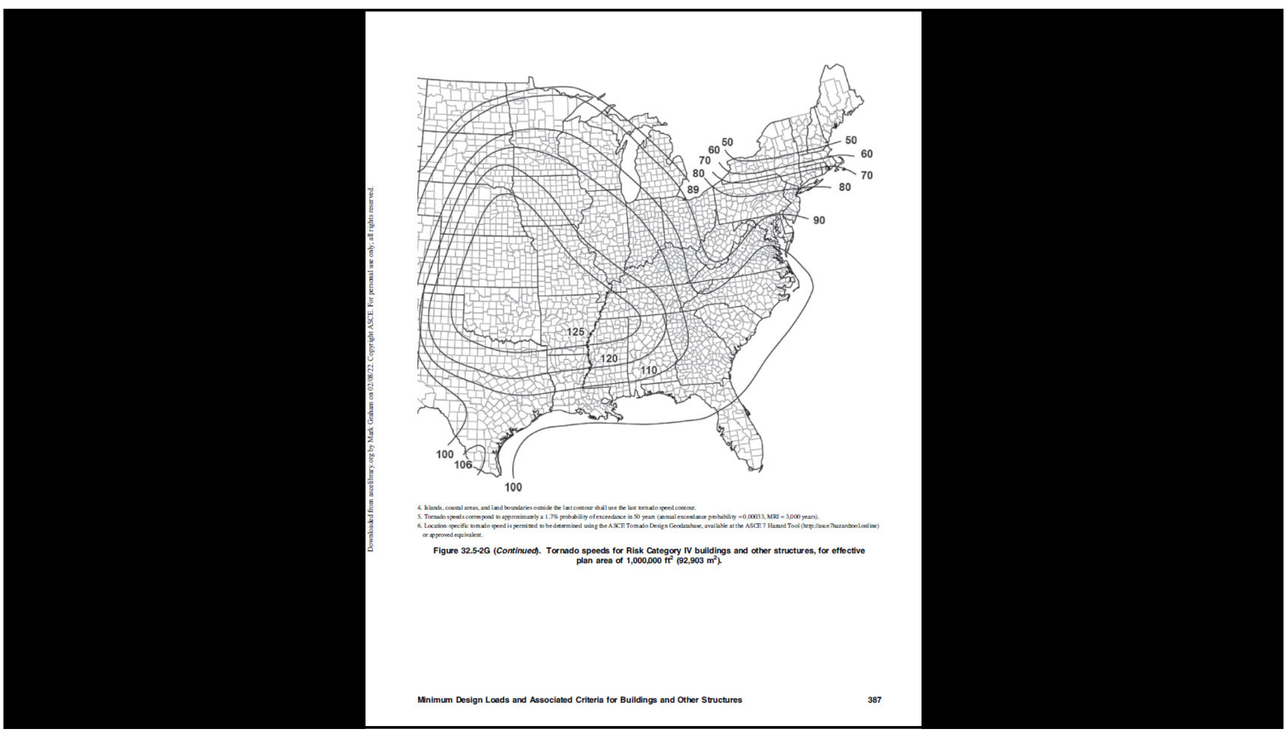
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4. Islands, coastal areas, and land boundaries outside the last contour shall use the last tornado speed contour.
5. Tornado speeds correspond to approximately a 1.7% probability of exceedance in 50 years (annual exceedance probability = 0.00033, MRI = 3,000 years).
6. Location-specific tornado speed is permitted to be determined using the ASCE Tornado Design Geodatabase, available at the ASCE 7 Hazard Tool (http://asce7hazardtool.online) or approved equivalent.
Figure 32.5-2G (Continued). Tornado speeds for Risk Category IV buildings and other structures, for effective plan area of 1,000,000 ft2 (92,903 m2).
Minimum Design Loads and Associated Criteria for Buildings and Other Structures
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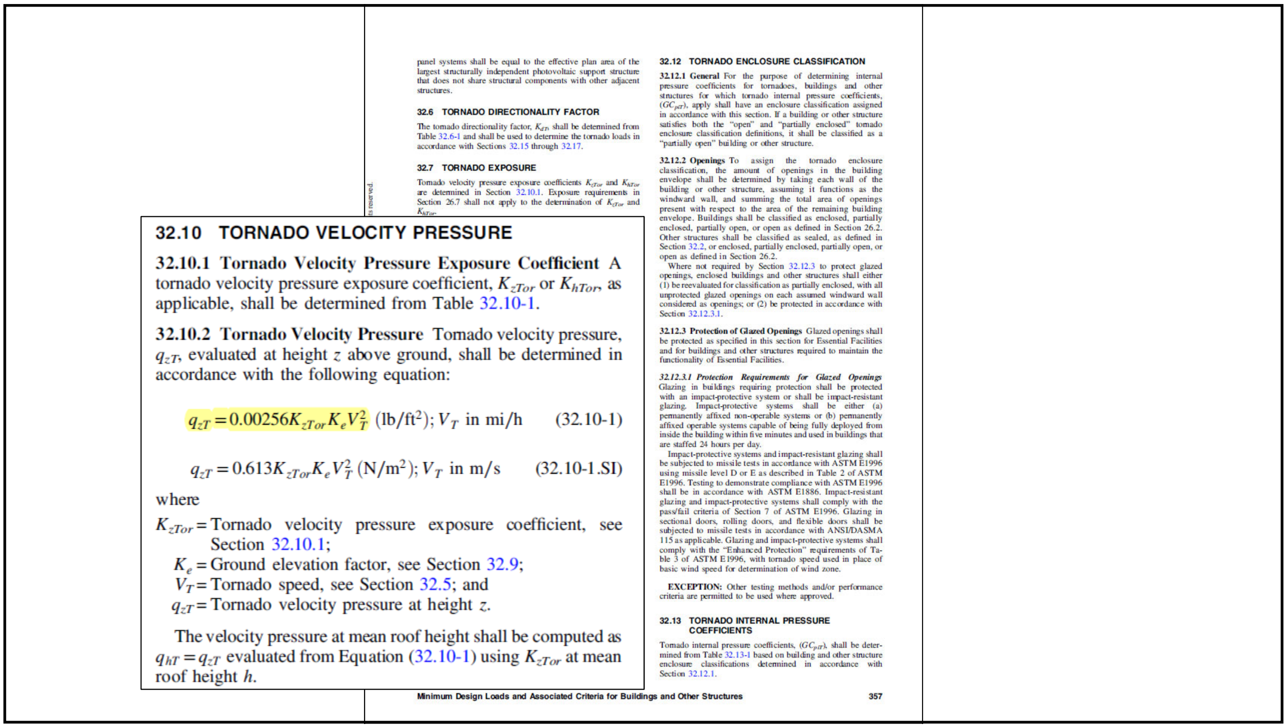

panel systems shall be equal to the effective plan area of the largest structurally independent photovoltaic support structure that does not share structural components with other adjacent structures.

32.6 TORNADO DIRECTIONALITY FACTOR

The tornado directionality factor, K_{dT}, shall be determined from Table 32.6-1 and shall be used to determine the tornado loads in accordance with Sections 32.15 through 32.17.

32.7 TORNADO EXPOSURE

Tornado velocity pressure exposure coefficients K_{zTor} and K_{hTor} are determined in Section 32.10.1. Exposure requirements in Section 26.7 shall not apply to the determination of K_{zTor} and K_{hTor}.

32.10 TORNADO VELOCITY PRESSURE

32.10.1 Tornado Velocity Pressure Exposure Coefficient A tornado velocity pressure exposure coefficient, K_{zTor} or K_{hTor}, as applicable, shall be determined from Table 32.10-1.

32.10.2 Tornado Velocity Pressure Tornado velocity pressure, q_{zT}, evaluated at height z above ground, shall be determined in accordance with the following equation:

$$q_{zT} = 0.00256 K_{zTor} K_e V_T^2 \text{ (lb/ft}^2\text{)}; V_T \text{ in mi/h} \quad (32.10\text{-}1)$$

$$q_{zT} = 0.613 K_{zTor} K_e V_T^2 \text{ (N/m}^2\text{)}; V_T \text{ in m/s} \quad (32.10\text{-}1.\text{SI})$$

where

K_{zTor} = Tornado velocity pressure exposure coefficient, see Section 32.10.1;
K_e = Ground elevation factor, see Section 32.9;
V_T = Tornado speed, see Section 32.5; and
q_{zT} = Tornado velocity pressure at height z.

The velocity pressure at mean roof height shall be computed as $q_{hT} = q_{zT}$ evaluated from Equation (32.10-1) using K_{zTor} at mean roof height h.

32.12 TORNADO ENCLOSURE CLASSIFICATION

32.12.1 General For the purpose of determining internal pressure coefficients for tornadoes, buildings and other structures for which tornado internal pressure coefficients, (GC_{piT}), apply shall have an enclosure classification assigned in accordance with this section. If a building or other structure satisfies both the "open" and "partially enclosed" tornado enclosure classification definitions, it shall be classified as a "partially open" building or other structure.

32.12.2 Openings To assign the tornado enclosure classification, the amount of openings in the building envelope shall be determined by taking each wall of the building or other structure, assuming it functions as the windward wall, and summing the total area of openings present with respect to the area of the remaining building envelope. Buildings shall be classified as enclosed, partially enclosed, partially open, or open as defined in Section 26.2. Other structures shall be classified as sealed, as defined in Section 32.2, or enclosed, partially enclosed, partially open, or open as defined in Section 26.2.

Where not required by Section 32.12.3 to protect glazed openings, enclosed buildings and other structures shall either (1) be reevaluated for classification as partially enclosed, with all unprotected glazed openings on each assumed windward wall considered as openings; or (2) be protected in accordance with Section 32.12.3.1.

32.12.3 Protection of Glazed Openings Glazed openings shall be protected as specified in this section for Essential Facilities and for buildings and other structures required to maintain the functionality of Essential Facilities.

32.12.3.1 Protection Requirements for Glazed Openings Glazing in buildings requiring protection shall be protected with an impact-protective system or shall be impact-resistant glazing. Impact-protective systems shall be either (a) permanently affixed non-operable systems or (b) permanently affixed operable systems capable of being fully deployed from inside the building within five minutes and used in buildings that are staffed 24 hours per day.

Impact-protective systems and impact-resistant glazing shall be subjected to missile tests in accordance with ASTM E1996 using missile level D or E as described in Table 2 of ASTM E1996. Testing to demonstrate compliance with ASTM E1996 shall be in accordance with ASTM E1886. Impact-resistant glazing and impact-protective systems shall comply with the pass/fail criteria of Section 7 of ASTM E1996. Glazing in sectional doors, rolling doors, and flexible doors shall be subjected to missile tests in accordance with ANSI/DASMA 115 as applicable. Glazing and impact-protective systems shall comply with the "Enhanced Protection" requirements of Table 3 of ASTM E1996, with tornado speed used in place of basic wind speed for determination of wind zone.

EXCEPTION: Other testing methods and/or performance criteria are permitted to be used where approved.

32.13 TORNADO INTERNAL PRESSURE COEFFICIENTS

Tornado internal pressure coefficients, (GC_{piT}), shall be determined from Table 32.13-1 based on building and other structure enclosure classifications determined in accordance with Section 32.12.1.

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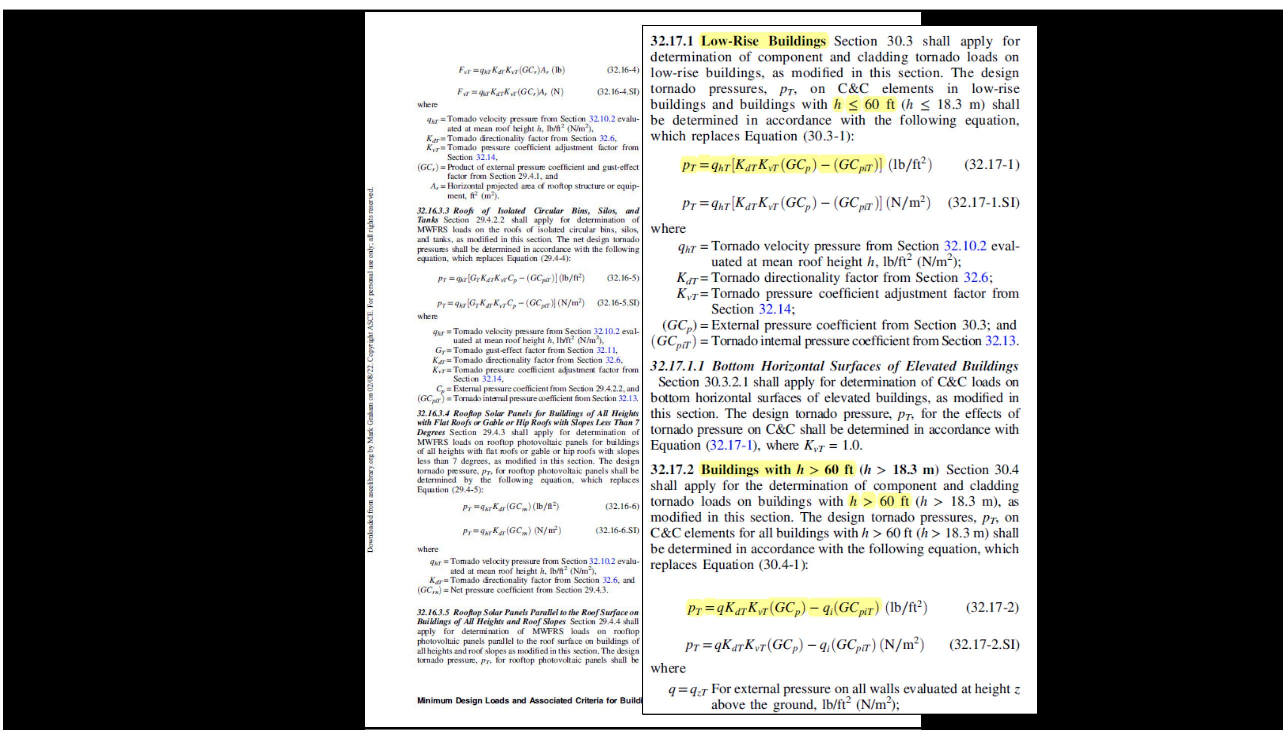

$$F_{vT} = q_{hT} K_{dT} K_{vT} (GC_r) A_r \text{ (lb)} \quad (32.16\text{-}4)$$

$$F_{vT} = q_{hT} K_{dT} K_{vT} (GC_r) A_r \text{ (N)} \quad (32.16\text{-}4.\text{SI})$$

where

q_{hT} = Tornado velocity pressure from Section 32.10.2 evaluated at mean roof height h, lb/ft^2 (N/m^2),
K_{dT} = Tornado directionality factor from Section 32.6,
K_{vT} = Tornado pressure coefficient adjustment factor from Section 32.14,
(GC_r) = Product of external pressure coefficient and gust-effect factor from Section 29.4.1, and
A_r = Horizontal projected area of rooftop structure or equipment, ft^2 (m^2).

32.16.3.3 Roofs of Isolated Circular Bins, Silos, and Tanks Section 29.4.2.2 shall apply for determination of MWFRS loads on the roofs of isolated circular bins, silos, and tanks, as modified in this section. The net design tornado pressures shall be determined in accordance with the following equation, which replaces Equation (29.4-4):

$$p_T = q_{hT} [G_T K_{dT} K_{vT} C_p - (GC_{piT})] \text{ (lb/ft}^2\text{)} \quad (32.16\text{-}5)$$

$$p_T = q_{hT} [G_T K_{dT} K_{vT} C_p - (GC_{piT})] \text{ (N/m}^2\text{)} \quad (32.16\text{-}5.\text{SI})$$

where

q_{hT} = Tornado velocity pressure from Section 32.10.2 evaluated at mean roof height h, lb/ft^2 (N/m^2),
G_T = Tornado gust-effect factor from Section 32.11,
K_{dT} = Tornado directionality factor from Section 32.6,
K_{vT} = Tornado pressure coefficient adjustment factor from Section 32.14,
C_p = External pressure coefficient from Section 29.4.2.2, and
(GC_{piT}) = Tornado internal pressure coefficient from Section 32.13.

32.16.3.4 Rooftop Solar Panels for Buildings of All Heights with Flat Roofs or Gable or Hip Roofs with Slopes Less Than 7 Degrees Section 29.4.3 shall apply for determination of MWFRS loads on rooftop photovoltaic panels for buildings of all heights with flat roofs or gable or hip roofs with slopes less than 7 degrees, as modified in this section. The design tornado pressure, p_T, for rooftop photovoltaic panels shall be determined by the following equation, which replaces Equation (29.4-5):

$$p_T = q_{hT} K_{dT} (GC_m) \text{ (lb/ft}^2\text{)} \quad (32.16\text{-}6)$$

$$p_T = q_{hT} K_{dT} (GC_m) \text{ (N/m}^2\text{)} \quad (32.16\text{-}6.\text{SI})$$

where

q_{hT} = Tornado velocity pressure from Section 32.10.2 evaluated at mean roof height h, lb/ft^2 (N/m^2),
K_{dT} = Tornado directionality factor from Section 32.6, and
(GC_m) = Net pressure coefficient from Section 29.4.3.

32.16.3.5 Rooftop Solar Panels Parallel to the Roof Surface on Buildings of All Heights and Roof Slopes Section 29.4.4 shall apply for determination of MWFRS loads on rooftop photovoltaic panels parallel to the roof surface on buildings of all heights and roof slopes as modified in this section. The design tornado pressure, p_T, for rooftop photovoltaic panels shall be

Minimum Design Loads and Associated Criteria for Buildi

32.17.1 Low-Rise Buildings Section 30.3 shall apply for determination of component and cladding tornado loads on low-rise buildings, as modified in this section. The design tornado pressures, p_T, on C&C elements in low-rise buildings and buildings with $h \le 60$ ft ($h \le 18.3$ m) shall be determined in accordance with the following equation, which replaces Equation (30.3-1):

$$p_T = q_{hT} [K_{dT} K_{vT} (GC_p) - (GC_{piT})] \text{ (lb/ft}^2\text{)} \quad (32.17\text{-}1)$$

$$p_T = q_{hT} [K_{dT} K_{vT} (GC_p) - (GC_{piT})] \text{ (N/m}^2\text{)} \quad (32.17\text{-}1.\text{SI})$$

where

q_{hT} = Tornado velocity pressure from Section 32.10.2 evaluated at mean roof height h, lb/ft^2 (N/m^2);
K_{dT} = Tornado directionality factor from Section 32.6;
K_{vT} = Tornado pressure coefficient adjustment factor from Section 32.14;
(GC_p) = External pressure coefficient from Section 30.3; and
(GC_{piT}) = Tornado internal pressure coefficient from Section 32.13.

32.17.1.1 Bottom Horizontal Surfaces of Elevated Buildings Section 30.3.2.1 shall apply for determination of C&C loads on bottom horizontal surfaces of elevated buildings, as modified in this section. The design tornado pressure, p_T, for the effects of tornado pressure on C&C shall be determined in accordance with Equation (32.17-1), where $K_{vT} = 1.0$.

32.17.2 Buildings with $h > 60$ ft ($h > 18.3$ m) Section 30.4 shall apply for the determination of component and cladding tornado loads on buildings with $h > 60$ ft ($h > 18.3$ m), as modified in this section. The design tornado pressures, p_T, on C&C elements for all buildings with $h > 60$ ft ($h > 18.3$ m) shall be determined in accordance with the following equation, which replaces Equation (30.4-1):

$$p_T = q K_{dT} K_{vT} (GC_p) - q_i (GC_{piT}) \text{ (lb/ft}^2\text{)} \quad (32.17\text{-}2)$$

$$p_T = q K_{dT} K_{vT} (GC_p) - q_i (GC_{piT}) \text{ (N/m}^2\text{)} \quad (32.17\text{-}2.\text{SI})$$

where

$q = q_{zT}$ For external pressure on all walls evaluated at height z above the ground, lb/ft^2 (N/m^2);

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Design Guide for New Tornado Load Requirements in ASCE 7-22

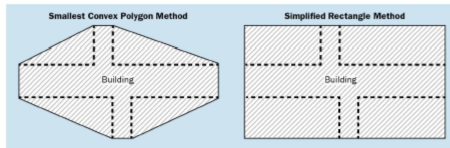

Figure 5: Effective plan areas for buildings that are not essential facilities (Adapted from ASCE 7, Figure C32.5-1; used with permission from ASCE)

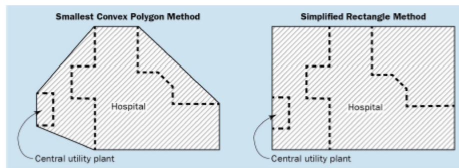

Figure 6: Effective plan area for essential facilities (Adapted from ASCE 7, Figure C32.5-2; used with permission from ASCE)

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January 2023 - 1

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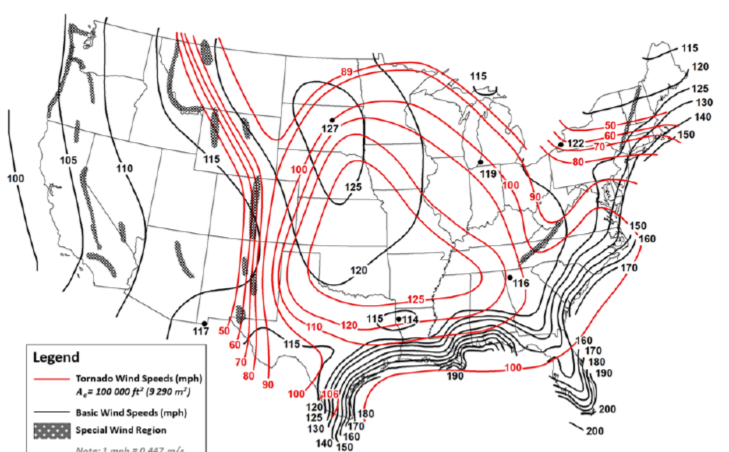
NIST Technical Note 2214

Economic Analysis of ASCE 7-22 Tornado Load Requirements



Basic wind speeds shown are based on Risk Category IV

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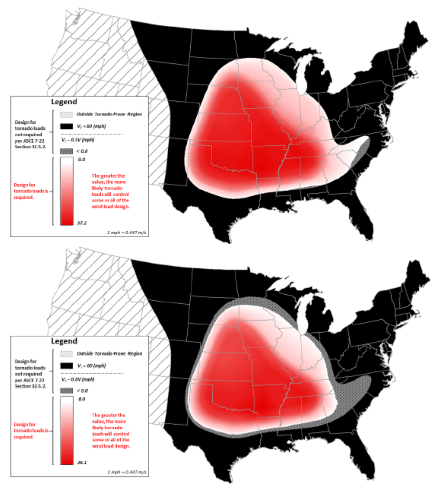

Fig. 8. Map of likelihood that design for tornado loads is required for a Risk Category III A_e = 100 000 ft^2 (9290 m^2) building or other structure in Exposure B (top) and Exposure C (bottom)

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More information on tornado design will be forthcoming…

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STRUCTURAL DESIGN

6. Design load-bearing values of soils.
7. Rain load data.

1603.1.1 Floor live load. The uniformly distributed, concentrated and impact floor *live load* used in the design shall be indicated for floor areas. Use of *live load* reduction in accordance with Section 1607.13 shall be indicated for each type of *live load* used in the design.

1603.1.2 Roof live load. The *roof live load* used in the design shall be indicated for roof areas.

1603.1.3 Roof snow load data. The ground snow *load*, p_g, shall be indicated. In areas where the ground snow *load*, p_g, exceeds 15 pounds per square foot (psf) (0.72 kN/m²), the following additional information shall also be provided, regardless of whether snow *loads* govern the design of the roof:

1. Flat-roof snow *load*, p_f.
2. Snow exposure factor, C_e.
3. *Risk category*.
4. Thermal factor, C_t.
5. Slope factor(s), C_s.
6. Drift surcharge load(s), p_d, where the sum of p_d and p_f exceeds 30 psf (1.44 kN/m²).
7. Width of snow drift(s), w.
8. Winter wind parameter for snow drift, W_2.

1603.1.4 Wind and tornado design data. The following information related to wind *loads* and, where required by Section 1609.5, tornado loads shall be shown, regardless of whether wind or tornado *loads* govern the design of the lateral force-resisting system of the *structure*:

1. Basic *wind speed*, *V*, mph (m/s), tornado speed, V_T, mph (m/s), and *allowable stress design wind speed*, V_{asd}, mph (m/s), as determined in accordance with Section 1609.3.1.
2. *Risk category*.
3. Effective plan area, A_e, for tornado design in accordance with Chapter 32 of ASCE 7.
4. Wind exposure. Applicable wind direction if more than one wind exposure is utilized.
5. Applicable internal pressure coefficients, and applicable tornado internal pressure coefficients.
6. Design wind pressures and their applicable zones with dimensions to be used for exterior component and cladding materials not specifically designed by the *registered design professional* responsible for the design of the *structure*, pounds per square foot (kN/m²). Where design for tornado loads is required, the design pressures shown shall be the maximum of wind or tornado pressures.

1603.1.6 Geotechnical information. The design load-bearing values of soils shall be shown on the *construction documents*.

1603.1.7 Flood design data. For *buildings* located in whole or in part in *flood hazard areas* as established in Section 1612.3, the documentation pertaining to design, if required in Section 1612.4, shall be included and the following information, referenced to the datum on the community's *Flood Insurance Rate Map* (*FIRM*), shall be shown, regardless of whether *flood loads* govern the design of the *building*:

1. *Flood design* class assigned according to ASCE 24.
2. In *flood hazard areas* other than *coastal high hazard areas* or *coastal A zones*, the elevation of the proposed *lowest floor*, including the basement.
3. In *flood hazard areas* other than *coastal high hazard areas* or *coastal A zones*, the elevation to which any nonresidential *building* will be dry floodproofed.
4. In *coastal high hazard areas* and *coastal A zones*, the proposed elevation of the bottom of the lowest horizontal structural member of the *lowest floor*, including the basement.

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Continuing concerns with steel roof decks

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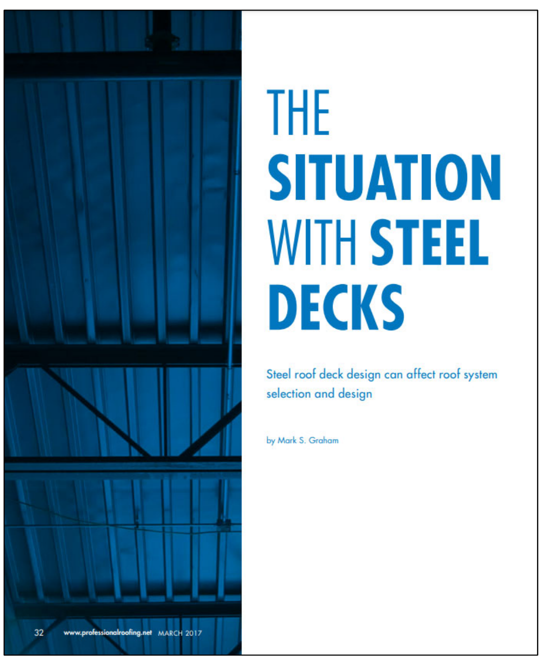

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CONSTRUCTION ISSUES

discussion of construction issues and techniques

Are Your Roof Members Overstressed?

By James M. Fisher, Ph.D., P.E., Dist. M.ASCE and Thomas Sputo, Ph.D., P.E., S.E., F.ASCE

James M. Fisher is Vice President Emeritus, Computerized Structural Design, Milwaukee, WI, and Consulting Engineer to the Steel Joist Institute. He may be reached at **jfisher.florida@gmail.com**.

Thomas Sputo is President of Sputo and Lammert Engineering, LLC, Gainesville, FL, and Technical Director of the Steel Deck Institute. He may be reached at **tsputo50@gmail.com**.

Membrane roof systems installed on steel roof decks traditionally result in a uniform transfer of wind (uplift) loads from the roof membrane to the steel roof deck and underlying supporting structure (e.g., steel joists). For example, in a built-up membrane roof system – which has been used commonly in the U.S. roofing industry for more than 125 years – the built-up membrane is continuously adhered to rigid board insulation. The rigid board insulation, which is used to span the steel deck's flutes, is mechanically attached to the steel roof deck in a closely-spaced pattern (e.g., 1 fastener per every 3 square feet), resulting in a near uniform uplift load path. Polymer-modified bitumen roof systems and adhered single-ply membrane roof systems are installed in similar configurations and result in a similar uniform uplift load path.

In the 1960s, single-ply membrane roof systems were first introduced into the U.S. roofing market. By the late 1970s, the seam-fastened, mechanically attached method of installation was first introduced. With this installation method, the single-ply membrane sheet is mechanically attached along its outer edges into the roof deck, which results in a larger tributary uplift load per fastener and placement of fasteners in linear, non-uniform loading configurations of the roof deck and underlying supporting structure. When first introduced, membrane sheet widths in seam-fastened single-ply membrane roof systems typically were five feet wide, resulting in rows of mechanical fasteners spaced at five feet on-center. Since the early 2000s, single-ply membrane sheet widths have become wider, with 10-foot-wide sheets now commonplace – resulting in rows of mechanical fasteners spaced at 10 feet on-center.

Currently, single-ply membrane roof systems have clearly overtaken conventional built-up and polymer-modified bitumen membrane systems in market share. The seam-fastened, mechanically-attached method of installation also has overtaken traditionally adhered methods of application. The National Roofing Contractors Association (NRCA) annual market survey shows seam-fastened, mechanically attached single-ply membrane roof systems make up the majority of all membrane roof systems currently installed.

With the present emphasis on wind resistance in design, a closer look at how seam-fastened mechanically attached single-ply membrane roof systems interact with steel roof deck and joist construction is in order.

A common method of single-ply membrane sheet layout is shown in *Figure 1*. A common placement of mechanical fasteners is shown in *Figure 2*. These concentrated line loads can severely overstress the steel deck and may also cause the steel joist below the deck to be overstressed under uplift loading. The behavior of such fastening systems, when the roof system is subjected to uplift loadings, is shown in *Figure 3*. The current trend in securement is for the membrane installer to mechanically fasten the membrane to the deck only along the edge of the sheet rolls to speed up the roof installation, thereby lowering installation costs. Unfortunately, the Structural Engineer of Record, and the steel deck and joist suppliers, are usually unaware of the concentrated load pattern of the roof membrane attachment. In fact, the architect of record may not be aware of the ramifications of such attachments. The Architectural roofing specifications may simply state that the roof membrane shall be installed per manufacturers recommendations. The roofing installers foreman is the one who generally decides on the exact layout of the membrane sheets on the roof. That decision is made based on what layout can be installed in the fastest and least expensive

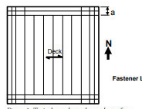

Figure 1. Typical membrane layout by roofers.

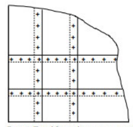
Figure 2. Typical fastener layout at corner zones.

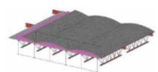
Figure 3. Line attached membrane under uplift. Courtesy of the Steel Deck Institute.

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Structure magazine

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FM Global
Property Loss Prevention Data Sheets **1-29**

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Interim Revision July 2022
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ROOF DECK SECUREMENT AND ABOVE-DECK ROOF COMPONENTS

Note to Insureds of Factory Mutual Insurance Company: Contact the local FM Global office before beginning any roofing work.

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2.2.2.5 Prevent over-stressing of the roof deck due to possible high concentrated loads during construction. This includes rolls of membrane and gravel carts. When the weight of individual rolls of single-ply membrane exceeds 1100 lb (500 kg), use precautions such as plywood sheets over steel deck to reduce point loads.

2.2.2.6 Protect roof expansion joints by filling the space between nailers with noncombustible, compressible insulation, such as mineral wool. Cover the expansion joint with flashing made of galvanized steel, zinc-aluminum-coated steel, or stainless steel secured in accordance with Data Sheet 1-49. An example is shown in Figure 2. Similar details can be found in the *NRCA Roofing Manual: Membrane Roof Systems*.

2.2.2.7 Provide adequate separation and/or noncombustible insulation between hot exhaust stacks and combustible roof components. See DS 1-13, *Chimneys*, for details.

2.2.2.8 Ensure all above-deck components are dry and surfaces are free of debris or dirt prior to adhering roof covers to them. This will help ensure complete adhesion of the cover to its substrate.

2.2.2.9 In locations that are prone to tropical cyclones, plan roof installations that use cold-process adhesives to ensure adequate curing time prior to potential exposure from a tropical cyclone. Also, see Section 3.1.2.2.

2.2.2.10 Apply adhesives in accordance with the manufacturer's temperature limitations.

2.2.3 Steel Roof Deck

2.2.3.1 Select a Roof*Nav* assembly after determining the needed wind, hail, and interior and exterior fire ratings. Use the center-to-center spacing of supports to determine the deck span.

2.2.3.2 When designing the steel deck, give consideration to the needed wind rating, and how the load is applied (concentrated vs. uniformly distributed) from the above-deck components to the deck. Where the distance between rows of roof cover fasteners is greater than half the deck span, treat as a concentrated load.

As an alternative to using Tables 1A or 1B for concentrated loads, a performance-based approach may be used if calculations are conducted by a licensed S.E. or P.E. in structural engineering. This applies to situations where the distance between rows of roof cover fasteners is greater than one-half the deck span. Make the following assumptions:

A. Assume a 3-span structural condition.

B. Assume the first row of roof cover fasteners is located at mid-point of the first deck span.

C. Assume maximum allowable strength is determined using allowable strength design (ASD) in accordance with AISI S100-2016, or comparable standard outside the United States.

Due to the more brittle nature of higher grade steels, the maximum yield stress used in the analysis is 60,000 psi (414 MPa), even for 80,000 psi (552 MPa) yield stress steel. Use Tables 1A through 1E as follows to facilitate deck selection:

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Roof Deck Securement and Above-Deck Roof Components 1-29

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Table 1A. Use for roof covers or base plies that are mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is more than half the deck span and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with a minimum yield stress of 33,000 psi (228 MPa).

Table 1B. Use for roof covers or base plies that are mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is more than half the deck span and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with a minimum yield stress of 60,000 psi (414 MPa).

Note: Where the minimum specified yield stress is between 33,000 psi (228 MPa) and 60,000 psi (414 MPa), it is reasonably accurate to interpolate the maximum deck span linearly based on Tables 1A and 1B.

Table 1C. Use for roof covers or base plies that are adhered to insulation or cover board, or mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is one-half the deck span or less and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with minimum yield stresses of 33,000 psi (228 MPa) and ultimate wind ratings of from 60 to 225 psf (2.9 to 10.8 kPa).

Table 1D. Use for roof covers or base plies that are adhered to insulation or cover board, or mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is one-half the deck span or less and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with minimum yield stresses of 33,000 psi (228 MPa) and ultimate wind ratings of from 240 to 405 psf (11.5 to 19.4 kPa).

Table 1E. Use for roof covers or base plies that are adhered to insulation or cover board, or mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is one-half the deck span or less and the deck is 3 in. (75 mm) deep, with an 8 in. (200 mm) rib spacing (Type N) with minimum yield stresses of 33,000 psi (228 MPa) and ultimate wind ratings of from 60 to 225 psf (2.9 to 10.8 kPa).

NOTE for Tables 1A through 1E: Maximum spans may vary slightly depending on the exact section properties for the specific deck.

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Table 1C. Maximum Steel Deck Span (ft) for 1½ in. (38 mm) Deep, Wide Rib (Type B) Steel Deck with an Adhered Roof Cover, for Wind Ratings from 60 to 225 psf (2.9 to 10.8 kPa)
(NOTE: Use this table when the distance between rows of roof cover fasteners is one-half the deck span or less. Green font indicates that deflection governs over bending stress.)

Yield Stress psi	Deck Gauge	Ultimate Wind Rating per RoofNav (psf) Maximum Span (ft)											
		60	75	90	105	120	135	150	165	180	195	210	225
33,000	22	7.10	7.10	7.10	7.10	7.07	6.67	6.33	6.03	5.78	5.55	5.35	5.17
	20	7.78	7.78	7.78	7.78	7.78	7.43	7.05	6.72	6.44	6.18	5.96	5.76
	18	9.08	9.08	9.08	9.08	9.08	8.66	8.22	7.84	7.50	7.21	6.95	6.71
	16	10.36	10.36	10.36	10.36	10.36	9.89	9.38	8.94	8.56	8.23	7.93	7.66
40,000	22	7.10	7.10	7.10	7.10	7.10	7.10	6.96	6.64	6.35	6.10	5.88	5.68
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.76	7.40	7.08	6.80	6.56	6.33
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.04	8.62	8.25	7.93	7.64	7.38
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.32	9.84	9.42	9.05	8.72	8.43
45,000	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.04	6.74	6.48	6.24	6.03
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.51	7.22	6.95	6.72
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	8.76	8.41	8.11	7.83
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	9.99	9.60	9.25	8.94
50,000	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	6.93	6.66	6.42	6.20
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.72	7.42	7.15	6.91
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.00	8.65	8.33	8.05
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.28	9.87	9.51	9.19
55,000	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	6.90	6.67
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.69	7.43
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	8.97	8.66
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.24	9.89
60,000 +	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	6.97
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.77
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.06
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.34

Green font indicates that deflection governs over bending stress.

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1-29 Roof Deck Securement and Above-Deck Roof Components

Table 1B. Maximum Steel Deck Span (ft) for 1½ in. (38 mm) Deep, Yield Stress ≥ 60,000 psi (414 MPa) with a mechanically fastened Roof Cover (continued)
(Note: Use this table when the distance between rows of roof cover fasteners is more than one-half the deck span.)

Max Deck Spans By Wind Rating/Fastener Spacing, Sheet Gauge for 80 ksi, 1½ in. Deep Wide Rib Deck																				
Roof Cover Fastener Row Spacing (ft)	Gauge	Wind Rating [psf]																		
		330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
8.5	18	-	-	-	-	-	4	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	4	4	4.5	5.5	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6	6
9	18	-	-	-	-	-	-	4	4	4.5	5	5.5	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6
9.5	18	-	-	-	-	-	-	4	4	4	4.5	5	5.5	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	4	4	4.5	5	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6
10	18	-	-	-	-	-	-	-	4	4	4.5	4.5	5	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	4	4.5	4.5	5.5	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4.5	5.5	6	6
10.5	18	-	-	-	-	-	-	-	4	4	4.5	4.5	5	5.5	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	4	4	4.5	5	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6
11	18	-	-	-	-	-	-	-	-	4	4	4.5	5	5	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6
11.5	18	-	-	-	-	-	-	-	-	-	4	4	4.5	5	5.5	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6
12	18	-	-	-	-	-	-	-	-	-	4	4	4.5	5	5.5	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5	5.5	6
Roof Cover Fastener Row Spacing	Gauge	330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
		Wind Rating [psf]																		

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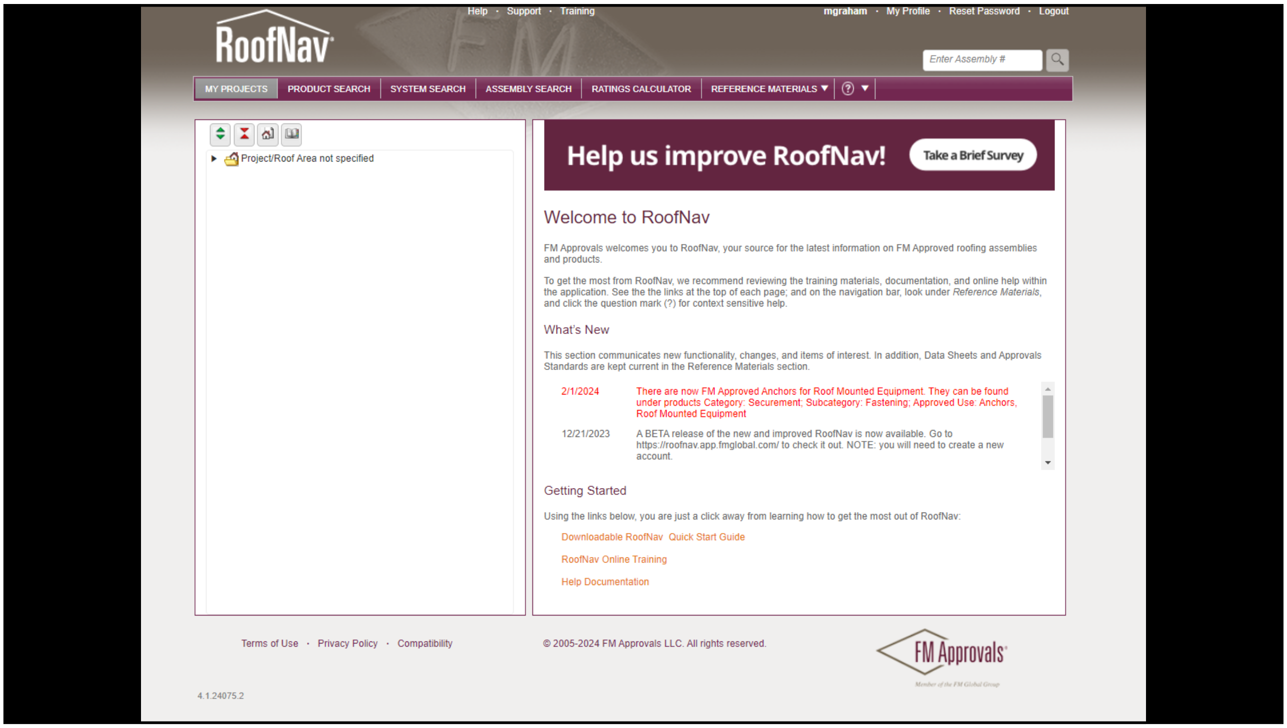
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RoofNav
Enter Assembly #
MY PROJECTS
PRODUCT SEARCH
SYSTEM SEARCH
ASSEMBLY SEARCH
RATINGS CALCULATOR
REFERENCE MATERIALS
Project/Roof Area not specified
Help us improve RoofNav!
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What's New
This section communicates new functionality, changes, and items of interest. In addition, Data Sheets and Approvals Standards are kept current in the Reference Materials section.
2/1/2024
There are now FM Approved Anchors for Roof Mounted Equipment. They can be found under products Category: Securement; Subcategory: Fastening; Approved Use: Anchors, Roof Mounted Equipment
12/21/2023
A BETA release of the new and improved RoofNav is now available. Go to https://roofnav.app.fmglobal.com/ to check it out. NOTE: you will need to create a new account.
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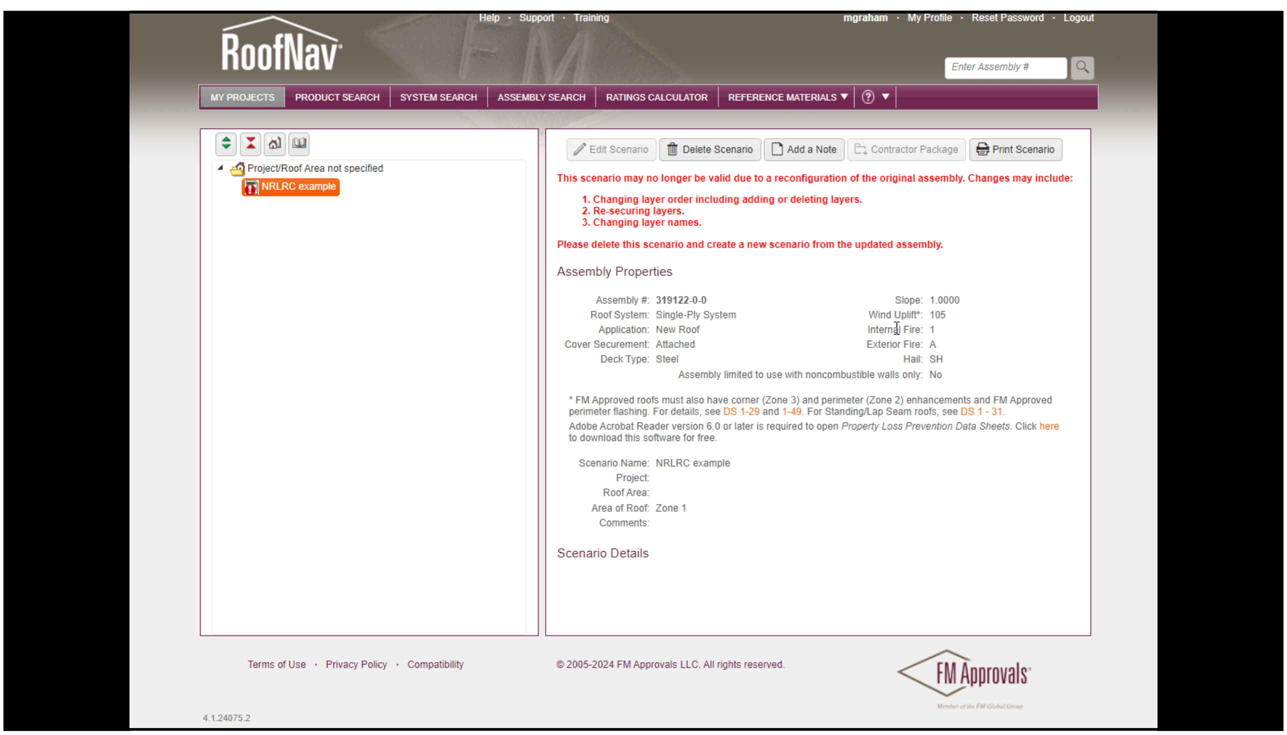
Help · Support · Training
mgraham · My Profile · Reset Password · Logout
RoofNav
Enter Assembly #
MY PROJECTS
PRODUCT SEARCH
SYSTEM SEARCH
ASSEMBLY SEARCH
RATINGS CALCULATOR
REFERENCE MATERIALS
Project/Roof Area not specified
NRLRC example
Edit Scenario
Delete Scenario
Add a Note
Contractor Package
Print Scenario
This scenario may no longer be valid due to a reconfiguration of the original assembly. Changes may include:
1. Changing layer order including adding or deleting layers.
2. Re-securing layers.
3. Changing layer names.
Please delete this scenario and create a new scenario from the updated assembly.
Assembly Properties
Assembly #: 319122-0-0
Roof System: Single-Ply System
Application: New Roof
Cover Securement: Attached
Deck Type: Steel
Slope: 1.0000
Wind Uplift*: 105
Internal Fire: 1
Exterior Fire: A
Hail: SH
Assembly limited to use with noncombustible walls only: No
* FM Approved roofs must also have corner (Zone 3) and perimeter (Zone 2) enhancements and FM Approved perimeter flashing. For details, see DS 1-29 and 1-49. For Standing/Lap Seam roofs, see DS 1 - 31.
Adobe Acrobat Reader version 6.0 or later is required to open Property Loss Prevention Data Sheets. Click here to download this software for free.
Scenario Name: NRLRC example
Project:
Roof Area:
Area of Roof: Zone 1
Comments:
Scenario Details
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4.1.24075.2

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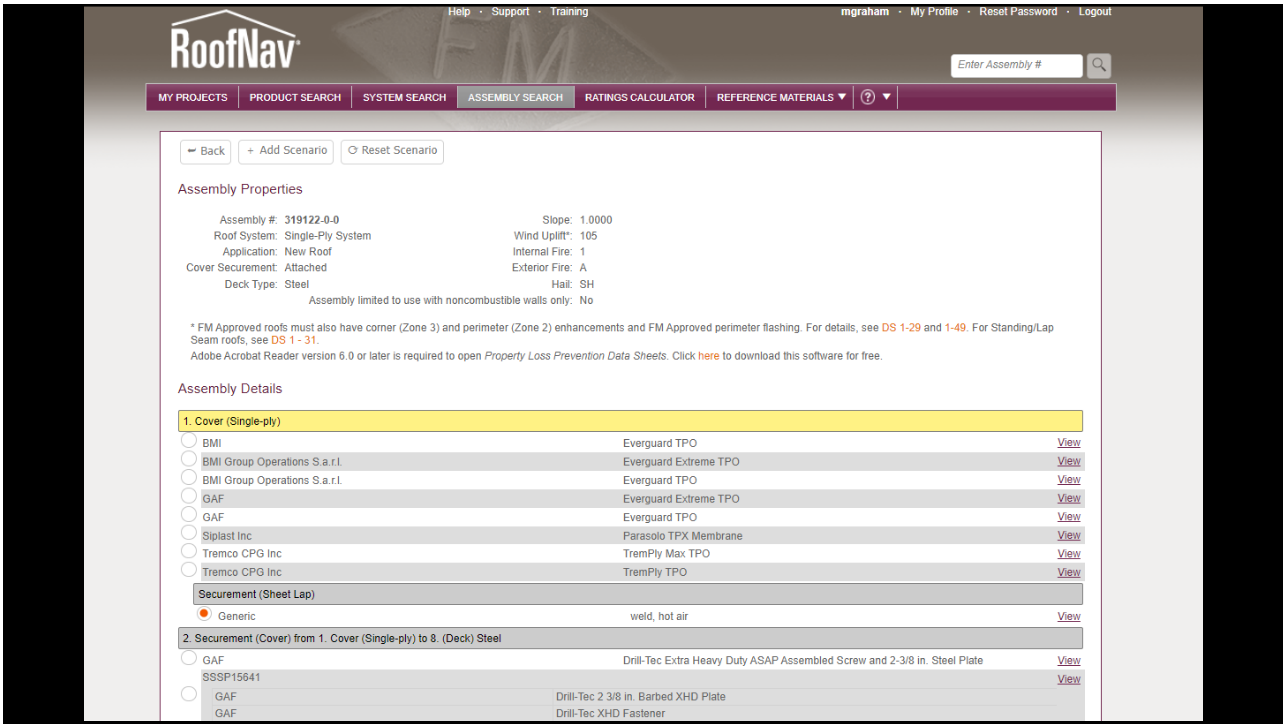
Help · Support · Training
mgraham · My Profile · Reset Password · Logout
RoofNav
Enter Assembly #
MY PROJECTS
PRODUCT SEARCH
SYSTEM SEARCH
ASSEMBLY SEARCH
RATINGS CALCULATOR
REFERENCE MATERIALS
Back
+ Add Scenario
Reset Scenario
Assembly Properties
Assembly #: 319122-0-0
Roof System: Single-Ply System
Application: New Roof
Cover Securement: Attached
Deck Type: Steel
Slope: 1.0000
Wind Uplift*: 105
Internal Fire: 1
Exterior Fire: A
Hail: SH
Assembly limited to use with noncombustible walls only: No
* FM Approved roofs must also have corner (Zone 3) and perimeter (Zone 2) enhancements and FM Approved perimeter flashing. For details, see DS 1-29 and 1-49. For Standing/Lap Seam roofs, see DS 1 - 31.
Adobe Acrobat Reader version 6.0 or later is required to open Property Loss Prevention Data Sheets. Click here to download this software for free.
Assembly Details
1. Cover (Single-ply)
BMI Everguard TPO View
BMI Group Operations S.a.r.l. Everguard Extreme TPO View
BMI Group Operations S.a.r.l. Everguard TPO View
GAF Everguard Extreme TPO View
GAF Everguard TPO View
Siplast Inc Parasolo TPX Membrane View
Tremco CPG Inc TremPly Max TPO View
Tremco CPG Inc TremPly TPO View
Securement (Sheet Lap)
Generic weld, hot air View
2. Securement (Cover) from 1. Cover (Single-ply) to 8. (Deck) Steel
GAF Drill-Tec Extra Heavy Duty ASAP Assembled Screw and 2-3/8 in. Steel Plate View
SSSP15641 View
GAF Drill-Tec 2 3/8 in. Barbed XHD Plate
GAF Drill-Tec XHD Fastener

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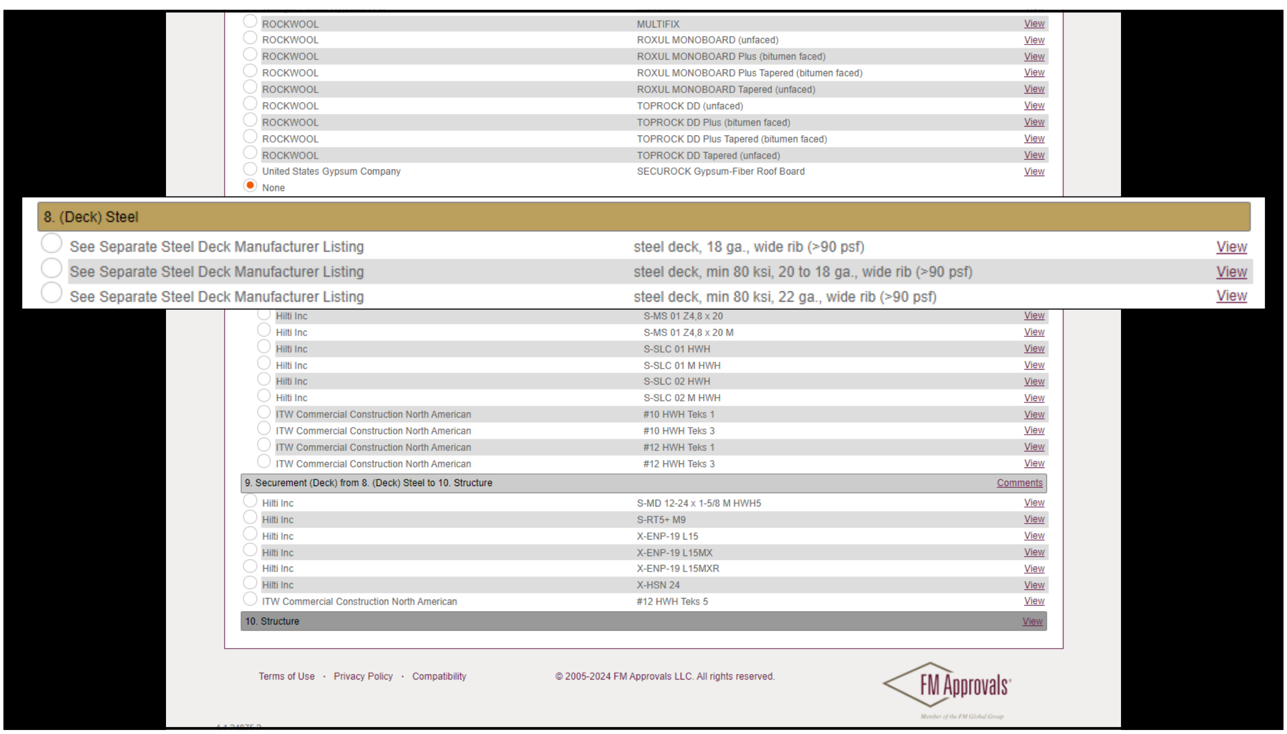
ROCKWOOL MULTIFIX View
ROCKWOOL ROXUL MONOBOARD (unfaced) View
ROCKWOOL ROXUL MONOBOARD Plus (bitumen faced) View
ROCKWOOL ROXUL MONOBOARD Plus Tapered (bitumen faced) View
ROCKWOOL ROXUL MONOBOARD Tapered (unfaced) View
ROCKWOOL TOPROCK DD (unfaced) View
ROCKWOOL TOPROCK DD Plus (bitumen faced) View
ROCKWOOL TOPROCK DD Plus Tapered (bitumen faced) View
ROCKWOOL TOPROCK DD Tapered (unfaced) View
United States Gypsum Company SECUROCK Gypsum-Fiber Roof Board View
None
8. (Deck) Steel
See Separate Steel Deck Manufacturer Listing steel deck, 18 ga., wide rib (>90 psf) View
See Separate Steel Deck Manufacturer Listing steel deck, min 80 ksi, 20 to 18 ga., wide rib (>90 psf) View
See Separate Steel Deck Manufacturer Listing steel deck, min 80 ksi, 22 ga., wide rib (>90 psf) View
Hilti Inc S-MS 01 Z4,8 x 20 View
Hilti Inc S-MS 01 Z4,8 x 20 M View
Hilti Inc S-SLC 01 HWH View
Hilti Inc S-SLC 01 M HWH View
Hilti Inc S-SLC 02 HWH View
Hilti Inc S-SLC 02 M HWH View
ITW Commercial Construction North American #10 HWH Teks 1 View
ITW Commercial Construction North American #10 HWH Teks 3 View
ITW Commercial Construction North American #12 HWH Teks 1 View
ITW Commercial Construction North American #12 HWH Teks 3 View
9. Securement (Deck) from 8. (Deck) Steel to 10. Structure Comments
Hilti Inc S-MD 12-24 x 1-5/8 M HWH5 View
Hilti Inc S-RT5+ M9 View
Hilti Inc X-ENP-19 L15 View
Hilti Inc X-ENP-19 L15MX View
Hilti Inc X-ENP-19 L15MXR View
Hilti Inc X-HSN 24 View
ITW Commercial Construction North American #12 HWH Teks 5 View
10. Structure View
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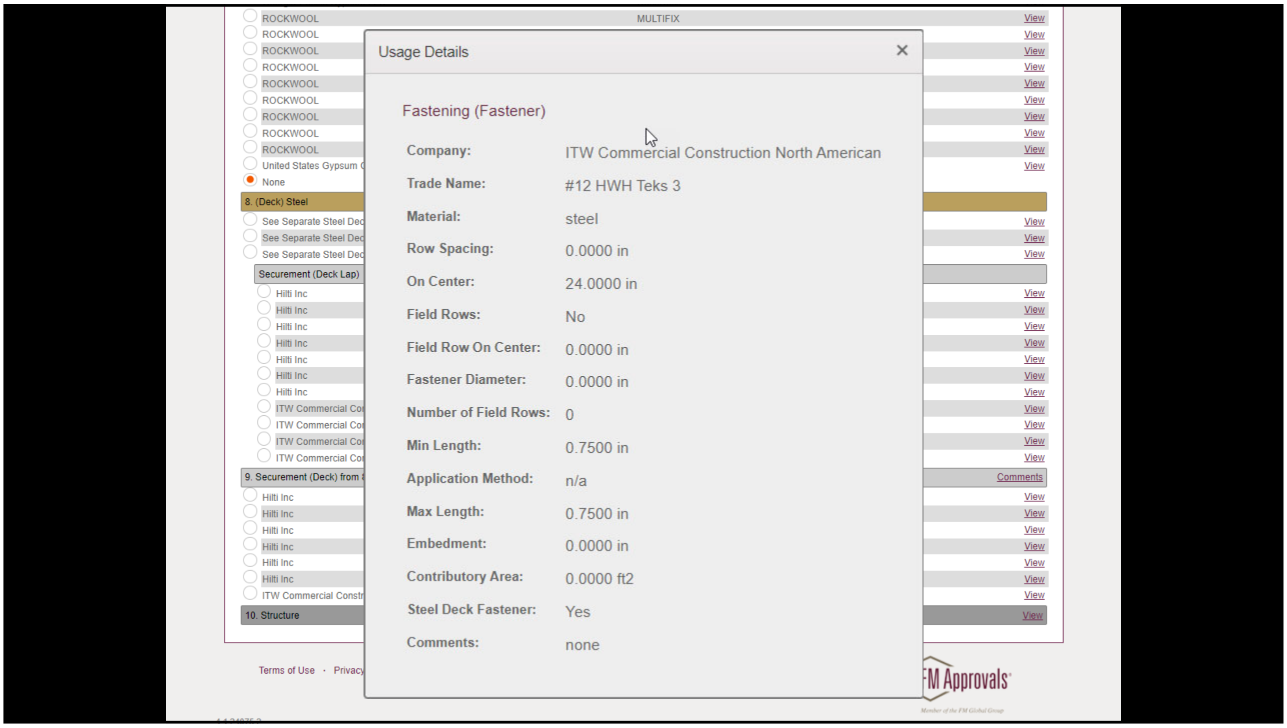

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Steel roof deck considerations

- Be cautious of deck overstress with using mechanically-attachment membrane systems
  - Thicker deck
  - Reduced deck spans
  - Higher yield strength steel
- Roof deck to structure (e.g., joists) attachment is dictated by the roof assembly’s wind uplift classification
  - Many classifications require specific mechanical fasteners
- Be cautious of “acceptance” of steel roof decks

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Radio frequency radiation

Rooftop cell phone transmitters

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CRCA Advisory Bulletin

JUNE 2023

Radiofrequency Radiation and Electromagnetic Fields

The increased number of cellular antennas and other communication equipment that generates radiofrequency radiation (RF) and electromagnetic fields (EMF) may be exposing roofers and other contractors to harmful levels of radiations when working on rooftops, sides of buildings and other locations where RF generating antennas are located. This bulletin will focus on radiation types, safety limits and mitigating exposure.

With the ever-increasing use and development of communication technology, there is an increased risk for those working in and around communication devices and equipment that emit radiofrequency electromagnetic fields (EMF) such as smart meters, cell phone towers and equipment using 5G technology. Roof areas are often prime locations for this type of equipment and anyone accessing these roof areas for any reason should be aware of the Occupational Health and Safety requirements and the Safety Code 6. Consult with provincial and/or federal authorities having jurisdiction for further information/guidance for most stringent requirements.

What is Radiofrequency (RF) Radiation?

There are two types of radiation – ionizing radiation and non-ionizing radiation. Both are forms of electromagnetic energy, but ionizing radiation has more energy than non-ionizing radiation. Ionizing radiation, like x-rays or gamma rays, has enough energy to cause chemical changes by breaking chemical bonds. Sources of this type of radiation can be found in hospitals, nuclear energy plants, and nuclear weapons facilities. Non-ionizing radiation causes molecules to vibrate, which generates heat. RF radiation is a type of non-ionizing radiation and is the energy used to transmit wireless information. RF radiation is invisible and power levels of equipment and amount of RF radiation can fluctuate without warning.

About Safety Code 6

Health Canada publishes Safety Code 6[1] which sets out recommended safety limits for human exposure to radiofrequency electromagnetic fields (EMF) in the frequency range from 3 kHz to 300 GHz. This range covers the frequencies used by communications devices and equipment that emit radiofrequency EMF such as: Wi-Fi, cell phones, smart meters, cell phone towers, those using 5G technology.

Safety Code 6 is reviewed on a regular basis to confirm that it continues to provide protection against all known potentially adverse health effects. If new scientific evidence were to show that exposure to radiofrequency EMF below the levels found in Safety Code 6 poses a risk, the Government of Canada would take steps to protect the health of Canadians.

[1] https://www.canada.ca/en/health-canada/services/health-risks-safety/radiation/occupational-exposure-regulations/safety-code-6-radiofrequency-exposure-guidelines.html

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Link

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June 2023

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How protect yourself from RF radiation
The risks associated with RF radiation increases with the number of devices present, the closer a worker is to the equipment/device(s), and the more time that is spent in the area. Workers can protect themselves by the following:

How protect yourself from RF radiation

The risks associated with RF radiation increases with the number of devices present, the closer a worker is to the equipment/device(s), and the more time that is spent in the area. Workers can protect themselves by the following:

- Complete a visual assessment of the area to determine if cellular antennas or other RF radiation generating antennas are present. If you are not sure, ask your supervisor, the building owner, or the property manager if RF-generating antennas are present where you need to work. The building owner or property manager should have the information, or know whom to contact for information about antennas, their locations, and the RF radiation levels.
- Look for warning signs posted near RF antennas; the signs should identify the hazard and tell you where to get more information.
- Contact the building owner/manager and the antenna licensee to have the equipment temporarily powered down or moved.

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Recognize the signage

Photos courtesy of Peter Shackford—Hettrick, Cyr & Associates, Inc.

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How protect yourself from RF radiation

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- Look for warning signs posted near RF antennas; the signs should identify the hazard and tell you where to get more information.
- Contact the building owner/manager and the antenna licensee to have the equipment temporarily powered down or moved.

If work needs to be performed within a potentially hazardous area:

- Check the site survey or roof plan for potential exposure levels
- Pre-plan work tasks and travel routes so you can limit trips through the RF field and time spent on tasks there – the goal is to get in and out as quickly as possible.
- Avoid standing directly in front of or close to an antenna. As a rule of thumb, stay 1.5 m (6 feet) away from a single antenna and 3 m (10 feet) away from a group of antennas.
- Use a personal RF monitor. The monitor will warn you if you are in an area where RF radiation is at a dangerous level. There are several handheld EMF personal safety monitors available on the market that measure exposure and allow workers to work in an exposed area for a limited time. Use personal monitors and protective clothing while work is being performed and if an alarm sounds, stop work and leave the area immediately.

the reader may take from such information.

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Some useful references

- CRCA Advisory Bulletin (Link)
- Health Canada's Safety Code 6 (Link)
- Federal Communications Commission (Link)
- Center for Construction Research and Training (Link)

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Link

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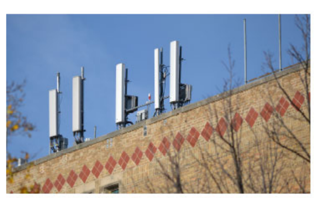
TOOLBOXTALKS

Radio frequency (RF) hazards

According to the Federal Communications Commission (FCC), radio waves and microwaves emitted by transmitting antennae are one form of electromagnetic energy that harm people. Harm from RF exposure will vary according to power levels, length of exposure time and distance from the antennae. Sources of RF energy on a rooftop often are not obvious and usually are not properly marked or defined as danger zones by warning signs. In many cases, antennae are hidden by building elements so workers may not be aware of their presence. Here are some important facts about RF energy and things that you can do to avoid it:

- High levels of RF may heat body tissue and increase body temperature, causing tissue damage because the body cannot cool quickly enough to prevent damage. This is called RF's thermal effects, and your eyes are the most vulnerable part of your body. Actual contact may cause a shock or burn.
- At lower, nonthermal levels of RF exposure, nervous system and immune system problems, kidney damage, neurological disorders and even some cancers may occur.
- Become familiar with what RF transmitters or antennae look like and the dangers of working near them. Be aware that warning signs for RF transmitters may not always be present on a roof.
- Your employer must inquire as to the presence of RF equipment and whether it may be shut down or shielded or other barrier device installed for the duration of the work period roofing workers will be in proximity to the transmitter.
- Symptoms of RF exposure often seem the same as physical exertion and can become heat exhaustion or heat stroke. Removing a worker from the area and cooling the body is important. Trained, professional medical care of the symptoms is critical.



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“Moisture” meter concerns



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These meters do not read moisture…
…they are reading relative conductivity, which can be correlated to specific materials in specific conditions when properly calibrated.

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Considerations

"Moisture" meters

- Read/understand the instruction manual
- Understand device sensitivity
- Understand proper operating conditions
- Proper calibration/recalibration is critical
- Don't overstate the meter's capability
- Verify job-specific results with gravimetric analysis

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Contractor-reported problems…

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Questions… and other topics

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