



*Member of the FM Global Group*

# **Approval Standard for Cementitious Panel Roof Decks**

**Class Number 4472**

**October 2016**

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# Foreword

The FM Approvals certification mark is intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of Approval Standards is to present the criteria for FM Approval of various types of products and services, as guidance for FM Approvals personnel, manufacturers, users and authorities having jurisdiction.

Products submitted for certification by FM Approvals shall demonstrate that they meet the intent of the Approval Standard, and that quality control in manufacturing shall ensure a consistently uniform and reliable product. Approval Standards strive to be performance-oriented. They are intended to facilitate technological development.

For examining equipment, materials and services, Approval Standards:

- a) must be useful to the ends of property conservation by preventing, limiting or not causing damage under the conditions stated by the Approval listing; and
- b) must be readily identifiable.

Continuance of Approval and listing depends on compliance with the Approval Agreement, satisfactory performance in the field, on successful re-examinations of equipment, materials, and services as appropriate, and on periodic follow-up audits of the manufacturing facility.

FM Approvals LLC reserves the right in its sole judgment to change or revise its standards, criteria, methods, or procedures.

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## 1 INTRODUCTION

### 1.1 Purpose

- 1.1.1 This standard states Approval requirements for cementitious panels for use as roof decking in Class 1 insulated roof construction.
- 1.1.2 Approval criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and an Audit program.

### 1.2 Scope

- 1.2.1 Cementitious panel roof deck components, incorporated in a complete roof deck assembly, which exhibit low fire spread below the deck, adequate simulated wind uplift resistance, minimum heat damage potential and adequate strength during the Approval examination will qualify as a Class 1 assembly.
- 1.2.2 This standard applies to any component intended for use as a cementitious panel roof deck. Weatherability is not a part of the Approval evaluation. Roof cover performance is evaluated in accordance with FM Approval Standard for Class 1 Roof Covers (4470), Class 1 Panel Roofs (4471) or Class 1 Steep Slope Roof Covers (4475).
- 1.2.3 The performance of a cementitious panel roof deck depends in part on all components in the roof system makeup, and on how they interact. It is therefore necessary to evaluate the roof assembly as a whole when measuring the fire spread potential on the underside of the roof and its windstorm resistance classification.
- 1.2.4 This standard is intended to evaluate only those hazards investigated, and is not intended to determine suitability for the end use of a product.

### 1.3 Basis for Requirements

- 1.3.1 The requirements of this standard are based on experience, research and testing. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists was also considered
- 1.3.2 The requirements of this standard reflect tests and practices used to examine characteristics of Class 1 cementitious panel roof decking for the purpose of obtaining Approval. Cementitious panel roof decks having characteristics not anticipated by this standard may be FM Approved if performance equal, or superior, to that required by this Standard is demonstrated, or if the intent of the standard is met. Alternatively, cementitious panel roof decks which meet all of the requirements identified in this standard may not be FM Approved if other conditions which adversely affect performance exist, or if the intent of this standard is not met.

## 1.4 Basis for Approval

Approval is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

### 1.4.1 Examination and tests on production samples shall be performed to evaluate

- The suitability of the product;
- The performance of the product as specified by the manufacturer and required by FM Approvals; and as far as practical,
- The durability and reliability of the product.

### 1.4.2 An examination of the manufacturing facilities and audit of quality control procedures is made to evaluate the manufacturer's ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. These examinations may be repeated as part of FM Approvals' Surveillance Audit program.

## 1.5 Basis for Continued Approval

Continued Approval is based upon:

- Production or availability of the product as currently FM Approved;
- The continued use of acceptable quality assurance procedures;
- Satisfactory field experience;
- Compliance with the terms stipulated in the Approval report;
- Satisfactory re-examination of production samples for continued conformity to requirements; and
- Satisfactory Surveillance Audits

Also, as a condition of retaining Approval, manufacturers may not change a product or service without prior authorization by FM Approvals.

## 1.6 Effective Date

The effective date of an Approval standard mandates that all products tested for Approval after the effective date shall satisfy the requirements of that standard. Products FM Approved under a previous edition shall comply with the new version by the effective date or else forfeit Approval.

The effective date of this standard is September 30, 2017 for compliance with all requirements.

## 1.7 System of Units

Units of measurement used in this Standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Appendix A lists the selected units and conversions to SI units for measures appearing in this standard. Conversion of U.S.

customary units is in accordance with the American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)/American Society for Testing Materials (ASTM) SI 10-2010, "American National Standard for Metric Practice."

## 1.8 Applicable Documents

The following standards, test methods, and practices are referenced in this standard:

### FM Approvals LLC

- *Approval Standard for Single-Ply , Polymer Modified Bitumen Sheet, Built-Up Roof (BUR) and Liquid Applied Roof Assemblies for use in Class 1 and Noncombustible Roof Deck Construction, FM Standard 4470*
- *Approval Standard for Class 1 Panel Roofs, FM Standard 4471*
- *Approval Standard for Class 1 Steep Slope Roof Covers, FM Standard 4475*
- *Approval Standard for Flexible Photovoltaic Modules, FM Standard 4476*
- *Approval Standard for Vegetative Roof Systems, FM Standard 4477*
- *Approval Standard for Class 1 Fire Ratings of Insulated Wall or Roof/Ceiling Panels, Interior Finish Materials or Coatings and Exterior Wall System, FM Standard 4880*
- *American National Standard for Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures, ANSI/FM Standard 4474*
- *Test Method for Determining the Pull Out Resistance of Fasteners used to Secure Above Deck Components to Cementitious Panel Decking, FM Standard 4472*
- *Test Method for Determining the Pull Out Resistance and the Pull-Over Resistance of Fasteners used to Secure Cementitious Panel Roof Decking, FM Standard 4472*
- *Test Method for Determining Side Lap Securement Resistance when used with Cementitious Panel Roof Decking, FM Standard 4472*
- *Test Method for Determining Live Load Deflection of Cementitious Panel Roof Decking, FM Standard 4472*
- *Test Method for Determining the Susceptibility to Heat Damage of Roof Insulation*

### FM Global

- *Wind Design, FM Global Property Loss Prevention Data Sheet 1-28*
- *Roof Deck Securement and Above-Deck Roof Components, FM Global Property Loss Prevention data Sheet 1-29*

National Fire Protection Association (NFPA)

- *Standard Method of Fire Tests for Determining the Heat Release Rate of Roofing Assemblies with Combustible Above-Deck Roofing Components, NFPA 276*

## 1.9 Definitions

For purposes of this standard, the following terms apply:

<i>Structure</i>	The building framework to which the roof deck is fastened.
<i>Span</i>	The distance between roof deck supports, measured center to center.
<i>Deck</i>	The structural component of the roof assembly to which the roof system is secured.
<i>Cementitious Panel Roof Deck</i>	A factory fabricated roof deck consisting of fibers (typically wood or fiberglass) and cementitious binder. Panels are supplied in various thickness with tongue and groove or butt side and end joints.
<i>Interlocking</i>	A mechanical securement achieved by joining adjacent panels of cementitious panel deck along the specially designed joints.
<i>Insulation Multi-Layer Insulations</i>	A material applied to reduce the flow of heat. Roof insulations installed in two or more layers with all joints offset between the upper and lower layers.
<i>Fasteners</i>	A mechanical securement device used alone or in combination with a stress distributor to secure various components of a roof assembly.
<i>Roof Cover</i>	The exterior surface of a roof assembly.
<i>Roof System</i>	An assembly of interacting roof components (NOT including the roof deck) designed to weatherproof, and normally, to insulate the building's top surface.
<i>Roof Assembly</i>	An assembly of interacting roof components (including the roof deck) designed to weatherproof, and normally, to insulate the building's top surface and to support anticipated loads.
<i>Rated Load</i>	The rated load is equal to two times the service load. The rated load is equal to the rating requested for FM Approval (i.e. the rated load is 90 psf [4.3 kPa] for a Class 1-90 rating).
<i>Mechanically Fastened</i>	Mechanically fastened describes roof covers, insulations or base sheets that have been attached to the substrate at defined intervals using fasteners with or without stress distributors.
<i>Fully Adhered</i>	Fully adhered describes components that have been bonded to the substrate using a compatible adhesive throughout the entire surface of the roof.
<i>Partially Adhered</i>	Components that have been bonded to the substrate using a compatible adhesive applied in spots or ribbons across the surface of the roof.

<i>Service Load</i>	The uplift load resulting from a windstorm that a roof assembly must resist. The service load is used for bending stress calculations and is equal to one half of the rated load, measured in psf (kPa).
<i>Live Loads</i>	Loads such as those caused by moveable objects such as equipment, materials, , or personnel.
<i>Wind Uplift</i>	The force generated by wind on a roof system or components in a roof system. Wind that is deflected around and across the surfaces of a building causes a drop in air pressure immediately above the roof surface (negative pressure); the air in the building will flow beneath the roof deck (positive pressure), and the combined uplift pressures tend to lift the roof upward. Wind uplift may also be caused by the introduction of wind underneath the roof edges where it can cause the roof assembly to pull away from the substrate. Roof loss by wind can be minimized, or prevented, by proper installation and adequate attachment.
<i>Minor Delamination</i>	In wind uplift testing, an area measuring approximately 1% of the test sample. For a 12 x 24 ft (3.7 x 7.3 m) test = an area of 3 ft <sup>2</sup> (0.28 m <sup>2</sup> ); for a 5x9 ft (1.5 x 2.7 m) Test = an area of 0.5 ft <sup>2</sup> (0.05 m <sup>2</sup> ), whereby two adhered components which are intended to be in contact are not in contact.

## 2 GENERAL INFORMATION

### 2.1 Product Information

Class 1 Cementitious Panel Roof systems are usually comprised of a cementitious panel roof deck, insulation, and a roof covering. They are often constructed by securing rigid insulation to the top surface of the deck with adhesive or fasteners. A weatherproof covering is then installed above the insulation. Other components such as vapor retarders may be used as well.

### 2.2 Approval Application Requirements

To apply for an Approval examination the manufacturer, or its authorized representative, should submit a request to [information@fmapprovals.com](mailto:information@fmapprovals.com).

The manufacturer shall provide the following preliminary information with any request for Approval consideration:

- A complete list of all models, types, sizes, and options for the products or services being submitted for Approval consideration;
- A complete set of manufacturing drawings for each thickness and profile, anticipated marking format, brochures, sales literature, spec. sheets, installation instructions, and maintenance procedures; and
- The number and location of manufacturing facilities;
- The wind uplift ratings desired, or expected, for example, Class 1-60, 1-75, etc.;



- All details of the above-deck roof system for use with the deck.

All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

### **2.3 Requirements for Samples for Examination**

- 2.3.1** Following authorization of an Approval examination, the manufacturer shall submit samples for examination and testing based on the Approvals requested. Sample requirements will be determined by FM Approvals following review of the preliminary information.
- 2.3.2** Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.
- 2.3.3** The manufacturer shall submit samples representative of production. Any decision to use data generated using prototypes is at the discretion of FM Approvals. It is the manufacturer's responsibility to provide any specialized tools or equipment needed to properly evaluate their product for Approval.

### 3 GENERAL REQUIREMENTS

#### 3.1 Review of Documentation

3.1.1 During the initial investigation and prior to physical testing, the manufacturer's specifications and details shall be reviewed to assess the ease and practicality of installation and use. The Approval investigation shall define the limits of the Approval.

#### 3.2 Markings

3.2.1 Marking on the product or, if not possible due to size, on its packaging or label accompanying the product, shall include the following information:

- name and address of the manufacturer or marking traceable to the manufacturer;
- date of manufacture or code traceable to date of manufacture or lot identification;
- trade name, model number, size, etc., as appropriate.

When hazard warnings are needed, the markings should be universally recognizable.

3.2.2 The product trade name, model number or model type identification shall correspond with RoofNav, the manufacturer's catalog designation and shall uniquely identify the product as FM Approved. The manufacturer shall not place this trade name or model number identification on any other product unless covered by a separate agreement with FM Approvals.

3.2.3 Labels or markings denoting FM Approval shall be applied by the manufacturer only within and on the premises of manufacturing locations that are under the FM Approvals Surveillance Audit Program.

3.2.4 The Approval Mark shall be displayed visibly and permanently on the product and/or packaging as appropriate and in accordance with the FM Approvals Certification Mark Usage Guidelines. The manufacturer shall not use this mark on any other product unless such product is covered by a separate report.

3.2.5 All markings shall be legible and durable.

#### 3.3 Test Sample Production

All products submitted for testing shall be representative of production run material. The need to monitor the manufacture of the test specimens shall be at the sole discretion of FM Approvals.

#### 3.4 Calibration

All examinations and tests performed in evaluation to this Standard shall use calibrated measuring instruments traceable and certified to acceptable national standards.

## 4 PERFORMANCE REQUIREMENTS

This standard is intended to evaluate each cementitious panel roof deck for its performance as it relates to allowable live load deflection, combustibility from below the deck, wind uplift resistance, ability to maintain an adequate securement of the above deck components; and to obtain satisfactory performance of the cementitious panel roof covering system as a whole.

Tests or evaluations of alternate products or assemblies may be waived if considered less critical than those previously tested or evaluated.

Confirming tests may be required, at the discretion of FM Approvals, depending on design features and results of any foregoing tests.

Following a test failure, a re-test of an identical or similar assembly shall be at the discretion of FM Approvals and with a technical justification of the conditions or reasons for the failure. When a test specimen fails to meet the Approval acceptance criteria for a given classification/rating, two successful test specimens of the same or similar construction must meet the Approval acceptance criteria to qualify for the given classification/rating. For each failed specimen, two successful test specimens are required. Any test specimen that fails more than three times is no longer considered a candidate for FM Approval.

Prior to testing, roof assemblies shall be permitted to cure for a maximum period of 28 days.

### 4.1 Allowable Live Load Deflection

The cementitious panel roof deck must provide sufficient strength and stiffness so that above deck components will not deflect excessively and separate under construction or live loads.

Live load deflection is a function of the span of the deck and the stiffness of the deck which is a function of the moment of inertia (I) of the deck profile. Under a static point load of 300 lb (1334 N) the deck shall not deflect more than 1/240 of the span (L) when the 300 lb (1334 N) static load is applied at mid-span of a two span arrangement or at the mid-span of a single span arrangement when the deck is designed to be installed in a single span arrangement.

#### 4.1.1 Conditions of Acceptance for Allowable Live Load Deflection (*Calculation Method*)

The moment of inertia (I) is determined by the manufacturer. The manufacturer shall supply calculations used to determine the Moment of Inertia. The moment of inertia shall be used in the following equations to determine the allowable span (L). The deck thickness used to determine the moment of inertia shall be the design thickness requested for FM Approval. Substitute the calculated (I) into the equations below to determine the allowable span. For a single span condition, the load is applied at mid-span. For a multi span condition, the load is applied at the mid-span of one span of the two span condition.

U.S. Customary Units

	One Span Condition	Two Span Condition
Equation	$D = \frac{PL^3}{48EI}$	$D = 0.015 \left( \frac{PL^3}{EI} \right)$
Reduced Equation	$L = \sqrt{0.00067(EI)}$	$L = \sqrt{0.00093(EI)}$

Where:

D = deflection = L/240, (in.)

P = load = 300 lb concentrated load distributed over a 12 in. wide section of deck

L = span (in.)

I = moment of inertia (in.<sup>4</sup> per foot of width)

E = modulus of elasticity (psi) – value for calculation as provided by manufacturer

International System of Units (SI)

	One Span Condition	Two Span Condition
Equation	$D = \frac{PL^3}{48EI}$	$D = 0.015 \left( \frac{PL^3}{EI} \right)$
Reduced Equation	$L = \sqrt{0.00015(EI)}$	$L = \sqrt{0.00021(EI)}$

Where:

D = deflection = L/240, (mm)

P = load = 1334 N concentrated load distributed over a 305 mm wide section of deck

L = span (mm)

I = moment of inertia (mm<sup>4</sup> per 305 mm of width)

E = modulus of elasticity (N/mm<sup>2</sup>) – value for calculation as provided by manufacturer

**4.1.2 Conditions of Acceptance for Allowable Live Load Deflection (Test Method)**

When it is not possible to calculate the live load deflection of the cementitious panel roof deck due to material properties or other reasons, the deflection of the deck shall be determined by testing in accordance to *Test Method for Determining Live Load Deflection of Cementitious Panel Roof Decking*.

- 4.1.2.1** Under a static concentrated load of 300 lb (1334 N), applied at midspan over a 1 ft<sup>2</sup> (0.09 m<sup>2</sup>) area, the deck shall not deflect more than 1/240 of the span.

## 4.2 Side Lap Securement

Individual deck panels must interlock or be fastened together securely at their side joints in a manner which will limit the differential deflection between adjacent panels under anticipated loads. Testing for securement of adjacent panels shall be in accordance with *Test Method for Determining Side Lap Securement Resistance when used with Cementitious Panel Roof Decking*.

### 4.2.1 Conditions of Acceptance for Side Lap Securement

Deck panels shall be capable of securement to adjacent panels by Approved means. The means employed shall resist a concentrated load of 300 lb (1334 N) applied downward to the underlying panels, over 6 x 3 in. (152 x 76 mm) area, located 1/2 in. (13 mm) from the panel joint. The test shall be conducted on both sides of the joint connection, in accordance with *Test Method for Determining Side Securement Resistance when used with Cementitious Panel Roof Decking*.

4.2.1.1 Differential deflection between adjacent panels shall not exceed 1/4 in. (6.4 mm).

## 4.3 Combustibility From Below the Roof Deck

To qualify as Class 1, each cementitious panel roof deck assembly shall satisfy the performance criteria described below to reduce the potential for internal fire spread.

Testing for combustibility from below the roof deck shall be in accordance with *Standard Method of Fire Tests for Determining the Heat Release Rate of Roofing Assemblies with Combustible Above-Deck Roofing Components*, NFPA 276 or in accordance with *Approval Standard for Class 1 Fire Ratings of Insulated Wall or Roof/Ceiling Panels, Interior Finish Materials or Coatings and Exterior Wall System*, FM Standard 4880.

### 4.3.1 Conditions of Acceptance for Combustibility from below the Roof Deck

4.3.1.1 The roof assembly when subjected to the *Standard Method of Fire Tests for Determining the Heat Release Rate of Roofing Assemblies with Combustible Above-Deck Roofing Components* NFPA 276 (Construction Materials Calorimeter Test) shall not exhibit fuel contribution rates in excess of the values shown in the following table.

<i>Time Interval</i>	<i>Maximum Fuel Contribution Rate</i>	
	<i>Btu/ft<sup>2</sup>/min</i>	<i>(kW/m<sup>2</sup>)</i>
<i>minute</i>		
3	410	(77.6)
5	390	(73.8)
10	360	(68.1)
Avg. (30 min)	285	(54.0)

4.3.1.2 There shall be no dropping of flaming particles into the furnace or uncontrolled flaming on the top exterior surface of the sample.

4.3.1.3 The roof assembly, when evaluated in accordance with *Approval Standard for Class 1 Fire Ratings of Insulated Wall or Roof/Ceiling Panels, Interior Finish Materials or Coatings and Exterior Wall System*, FM Standard 4880 shall meet the fire performance requirements of FM Standard 4880.

## 4.4 Wind Uplift Resistance

Cementitious panel roof deck may be subject to wind damage if not properly secured. Portions of the roof deck where damage is possible are the securement of the deck to the structure, the securement of deck side

laps, the securement of above deck components to deck and overstressing the deck. These areas of concern are addressed through the following testing and evaluation. Guidelines for wind design are outlined in FM Global Loss Prevention Data Sheet 1-28. Guidelines for installation of above deck roof components are outlined in FM Global Loss Prevention Data Sheet 1-29.

#### **4.4.1 Pull Out Resistance for Deck Fasteners**

Pull Out Resistance Testing of the fasteners used to secure the cementitious panel roof deck to the building structure is conducted to verify the capacity of the fastener to resist pull out from the substrate. The securement of the deck to the structure must ensure that the deck remains in place during the design windstorm. Testing for Pull Out Resistance shall be in accordance with *Test Method for Determining the Pull Out Resistance of Fasteners used to Secure Above Deck Components to Cementitious Panel Roof Decking*.

##### **4.4.1.1 Conditions of Acceptance for Pull Out Resistance for Deck Fasteners**

The required pull out resistance of fasteners shall not be less than the calculated load that the fastener securing the deck to the structure must resist for the desired wind uplift rating.

#### **4.4.2 Pull Over Resistance for Deck Fasteners**

Pull Over Resistance Testing of the fasteners used to secure the cementitious panel roof deck to the building structure is conducted to verify the strength of fastener/deck combinations. The securement of the deck to the structure must ensure that the deck remains in place during the design windstorm. Testing for Pull Over Resistance shall be in accordance with *Test Method for Determining the Pull Over Resistance of Fasteners used to Secure Above Deck Components to Cementitious Panel Roof Decking*.

##### **4.4.2.1 Conditions of Acceptance for Pull Over Resistance**

The required pull over resistance of fasteners shall not be less than the calculated load that the fastener/deck must resist for the desired wind uplift rating.

#### **4.4.3 Fastener Pull Out Resistance for Above Deck Component Fasteners**

Pull Out Resistance Testing for above deck component fasteners is conducted to verify that the above deck fasteners will remain securely anchored during the design windstorm. Testing for Pull Out Resistance shall be in accordance with *Test Method for Determining the Pull Out Resistance of Fasteners for use in Cementitious Panel Roof Decking*.

##### **4.4.3.1 Conditions of Acceptance for Pull Out Resistance for Above Deck Components**

The required pull out resistance of fasteners securing above deck components shall not be less than the calculated load that the fastener/deck must resist for the desired wind uplift rating.

#### **4.4.4 12 x 24 ft (3.7 x 7.3 m) Simulated Wind Uplift Pressure Test**

Testing for wind uplift resistance shall be in accordance with ANSI/FM Approvals 4474, *Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Positive and/or Negative Differential Pressures*. The test shall include the 12 x 24 ft. (3.7 x 7.3 m) Simulated Wind Uplift Pressure Test. The minimum rating required for Approval is Class 1-60. The maximum rating available is Class 1-990. Ratings between Class 1-60 and 1-990 are available in increments of 15. The rating assigned to the assembly shall be the maximum simulated uplift resistance pressure which the assembly maintains for one (1) minute without failure. In addition, the assembly must maintain the service wind load for one (1) minute without visible cracking or creasing of the insulation or coverboard.

- Multiple cracks or creases in the same insulation or cover board, which would impair performance is indicative of catastrophic failure, shall not be permitted.
- Crack or crease length in the same insulation or cover board, in excess of one half the minimum board dimension; e.g., 24 in. (1220 mm) for a 48 x 96 in. (1220 x 2440 mm) board shall not be permitted.

The 12 x 24 ft (3.7 x 7.3 m) Simulated Wind Uplift Pressure Test Procedure is used to determine the simulated wind uplift resistance of the following types of roof assemblies:

- Assemblies that utilize mechanical fasteners, adhesives, hot asphalt, heat welding, self-adhesive components or combination thereof, to secure insulations, a base ply, plies or a cap ply sheet, exterior coverings and other components, in single or multi-layered constructions, to one another and to the roof deck. Note: Adhesive securement of insulation and roof covers to the roof deck is not permitted if the deck does not have a continuous, flat top surface which allows for full contact between the deck and above deck components.
- Assemblies that utilize batten bars or rows of fasteners spaced less than or equal to 144 in. (3660 mm) on center with maximum in-row securement spacing of 48 in. (1220 mm).
- Assemblies that utilize an air retarder. For wind ratings of Class 1-90 and below, the assembly must also meet the service load (half of the rated load) without the air barrier in place. For wind ratings above Class 1-90, the assembly must perform to the rated level with and without the air barrier in place.

#### **4.4.4.1 Conditions of Acceptance for 12 x 24 Simulated Wind Uplift Pressure Test**

**4.4.4.1.1** All fasteners and stress distributors shall: a) remain securely embedded into, or through, the roof deck and other structural substrates to which they are being fastened to or through; b) not pull through, become dislodged, disconnected or disengaged from stress distributors, seams or substrates; c) not fracture, separate or break.

**4.4.4.1.2** All insulations and coverboards shall: a) not fracture, break or pull through, or over, fastener heads or stress distributors; b) not delaminate or separate from their facers or adjacent components to which they have been adhered; c) be permitted to deflect between points of mechanical securement provided that the insulation boards do not fracture, crack, or break.

EXCEPTIONS: Visible cracking or visible creasing of the insulation or coverboard, as indicated by the top surface of the roof cover, when less than or equal to one half the minimum board dimension, shall be permitted provided ultimate failure does not occur as noted in Section 4.4.

**4.4.4.1.3** All membranes shall: a) not tear, puncture, fracture or develop any through openings; b) not delaminate or separate from adjacent components.

EXCEPTIONS: 1) Mechanically fastened membranes shall be permitted to separate and deflect from adjacent components at locations where they are not fastened, 2) partially adhered membranes shall be permitted to separate and deflect from adjacent components at locations where adhesive placement was not intended, 3) tearing of membrane at fastener/stress distributors is allowed up to ultimate failure, 4) minor delamination is allowed provided it does not continue to grow in size by more than 50% from the end of one pressure level through the end of the following pressure level.

**4.4.4.1.4** All adhesives shall maintain full contact with all the surfaces of all components to which it has been applied to, or comes in contact with, without any separation, delamination, fracture, cracking or peeling of the adhesive or its bond.

EXCEPTIONS: Minor delamination is allowed, provided it does not continue to grow in size by more than 50% from the end of one pressure level through the end of the following pressure level.

- 4.4.4.1.5 All roof decks and their securements shall: a) maintain their structural integrity during the entire classification period; b) not fracture, split, crack or allow for fastener withdrawal.
- 4.4.4.1.6 All other components, including seams, base sheets, base plies, plies and cap plies, shall not tear, puncture, fracture, disengage, dislodge, disconnect, delaminate or develop any through openings.
- 4.4.4.1.7 The theoretical load per fastener (rated pressure x contributory area) does not exceed the pull out or pull over resistance of the fastener.
- 4.4.4.1.8 All above deck components shall meet the requirements outlined in the appropriate FM Standard (4454, 4470, 4471, 4475, 4476, 4477).

#### 4.5 Susceptibility to Heat Damage

The Susceptibility to Heat Damage Test procedure is used to assess the damage to roof insulation from exposure to radiant heat as a result of an interior building fire. Susceptibility to Heat Damage Testing is for insulations applied directly to decks other than concrete.

Testing for susceptibility to heat damage shall be in accordance with *Test Method for Determining the Susceptibility to Heat Damage of Roof Insulation*, FM Approvals, LLC.

##### 4.5.1 Conditions of Acceptance for Susceptibility to Heat Damage

The insulation shall not be decomposed, discolored, or otherwise damaged beyond a depth of 1/8 in. (3 mm), shall exhibit no significant curling, bowing or dimensional change, and shall sustain little or no visible damage when subjected to the Susceptibility to Radian Heat Damage Test.



## 5 OPERATIONS REQUIREMENTS

A quality assurance program is required to assure that subsequent Cementitious Panel Roof Deck(s) produced by the manufacturer shall present the same quality and reliability as the specific Cementitious Panel Roof Deck(s) examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the examination and tests, and is documented in the Approval Report.
- Continued conformance to this standard is verified by the Surveillance Audit.
- Quality of performance is determined by field performance and by periodic re-examination and testing.

### 5.1 Demonstrated Quality Control Program

5.1.1 The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- Existence of corporate quality assurance guidelines;
- Incoming quality assurance, including testing;
- In-process quality assurance, including testing;
- Final inspection and tests;
- Equipment calibration;
- Drawing and change control;
- Packaging and shipping; and
- Handling and disposition of non-conforming materials.

### 5.1.2 Documentation/Manual

There should be an authoritative collection of procedures/policies. It should provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

### 5.1.3 Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of two years from the date of manufacture.

### 5.1.4 Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the Approval Report, must be reported to, and authorized by, FM Approvals prior to implementation for production.

- The manufacturer shall assign an appropriate person or group to be responsible for, and require that, proposed changes to FM Approved or Listed products be reported to FM Approvals before implementation. The manufacturer shall notify FM Approvals of changes in the product or of persons responsible for keeping FM Approvals advised by means of FM Approvals' Revision Request, FM Approved Product/Specification-Tested Revision Report or Address/Main Contact Change Report.
- Records of all revisions to all FM Approved products shall be maintained.

## **5.2 Surveillance Audit**

- 5.2.1** An audit of the manufacturing facility is part of the Approval investigation to verify implementation of the quality assurance program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to insure a uniform product consistent with that which was tested and FM Approved.
- 5.2.2** These audits shall be conducted periodically but at least annually by FM Approvals or its representatives.
- 5.2.3** FM Approved products or services shall be produced or provided at or from the location(s) audited by FM Approvals and as specified in the Approval Report. Manufacture of products bearing the Approval Mark is not permitted at any other location without prior written authorization by FM Approvals.

## **5.3 Installation Inspections**

Field inspections may be conducted to review an installation. The inspections are conducted to assess ease of application, and conformance to written specifications. When more than one application technique is used, one or all may be inspected at the discretion of FM Approvals.

## **5.4 Manufacturer's Responsibilities**

The manufacturer shall notify FM Approvals of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation.

**APPENDIX A: UNITS OF MEASUREMENT**

LENGTH:	in. - "inches"; (mm - "millimeters") mm = in. x 25.4 ft. - "feet"; (m - "meters") m = ft. x 0.3048
AREA:	in <sup>2</sup> - "square inches"; (mm <sup>2</sup> - "square millimeters") mm <sup>2</sup> = in <sup>2</sup> x 6.4516 x 10 <sup>2</sup> ft <sup>2</sup> - "square feet"; (m <sup>2</sup> - "square meters") m <sup>2</sup> = ft <sup>2</sup> x 0.0929
HEAT:	Btu - "British thermal units"; (J - "joules") J = Btu x 1.0551 x 10 <sup>3</sup>
HEAT RELEASE RATE:	Btu/min - "British thermal units per minute"; (kW - "kilowatts") kW = Btu/min x 0.0176
TEMPERATURE:	°F - "degrees Fahrenheit"; (°C - "degrees Celsius") °C = (°F - 32) x 0.556
MASS:	lb. - "pounds"; (kg - "kilograms") kg = lb. x 0.454
PRESSURE:	psi - "pounds per square inch"; (bar - "bar") kPa = psi x 6.895 bar - "bar"; (kPa - "kilopascals") bar = kPa x 0.01 bar = psi x 0.06895
LIQUID:	gal - "gallons"; (L - "liter") L = gal x 3.785 L - "liter"; (dm <sup>3</sup> - "cubic decimeters") L = dm <sup>3</sup>
FLOW RATE:	gal/min - "gallon per minute"; (L/min - "liters per minute") L/min = gal/min x 3.785

## APPENDIX B: SMALL SCALE TESTS

The following small scale tests are used to screen and/or compare the properties of individual roof components or roof components used in combination with other components that make up complete roof assemblies. The purpose of these tests is 1) to identify via small scale test procedures critical combinations of components to include in large scale tests 2) to determine if FM Approval may be extended to alternate components after full scale tests have been completed and 3) to assess physical characteristics necessary for the continued performance of a component when installed within a roof assembly. The decision to extend FM Approval to any components via small scale testing shall be at the sole discretion of FM Approvals. Alternate components must perform to an equal or higher level than the component qualified via large scale testing.

### B.1 Pull Through Tests for Roofing Membranes Using Tensile Loading

Pull through tests for roofing membranes using tensile loading shall be in accordance with *Test Procedure, Pull Through Tests for Roofing Membranes and Substrates Using Tensile Loading*, FM Approvals, LLC.

#### B.1.1 Results

- 1) The result shall be the highest force attained by the sample during the test.
- 2) The overall sample results shall be determined based on the average of three (3) tests. If the standard deviation of the three values divided by the mean is greater than 20%, additional testing shall be conducted until less than, or equal to, 20% is obtained. The results of all tests shall be used to determine the final average.

### B.2 Pull Through Tests for Roof Insulation Using Tensile Loading

Pull through tests for roof insulation using tensile loading shall be in accordance with *Test Procedure, Pull Through Tests for Roofing Membranes and Substrates Using Tensile Loading*, FM Approvals, LLC.

#### B.2.1 Results

- 1) The result shall be the highest force attained by the sample during the test.
- 2) The overall sample results shall be determined based on the average of three (3) tests. If the standard deviation of the three values divided by the mean is greater than 20%, additional testing shall be conducted until less than, or equal to, 20% is obtained. The results of all tests shall be used to determine the final average.

### B.3 6 x 6 Delamination Tests for Roofing Adhesives and Substrates Using Tensile Loading

6 x 6 delamination tests for roofing adhesives and substrates using tensile loading shall be in accordance with *Test Procedure, 6 x 6 Delamination Tests for Roofing Adhesives and Substrates Using Tensile Loading*, FM Approvals, LLC.

#### B.3.1 Results

- 1) The result shall be the highest force attained by the sample during the test.
- 2) The overall sample results shall be determined based on the average of three (3) tests. If the standard deviation of the three values divided by the mean is greater than 20%, additional testing shall be

conducted until less than, or equal to, 20% is obtained. The results of all tests shall be used to determine the final average.

#### **B.4 Membrane Delamination Tests for Roofing Membranes and Substrates Using Tensile Loading**

Membrane delamination tests for roofing membranes and substrates using tensile loading shall be in accordance with *Test Procedure, Membrane Delamination Tests for Roofing Membranes and Substrates Using Tensile Loading*, FM Approvals, LLC.

##### **B.4.1 Results**

- 1) The result shall be the highest force attained by the sample during the test.
- 2) The overall sample results shall be determined based on the average of three (3) tests. If the standard deviation of the three values divided by the mean is greater than 20%, additional testing shall be conducted until less than, or equal to, 20% is obtained. The results of all tests shall be used to determine the final average.

#### **B.5 Membrane Peel Tests for Roof Membrane Seam or Cover Tape/Cover Strip Combination using Tensile Loading**

Membrane peel tests for roof membrane seam or cover tape/cover strip combination using tensile loading shall be in accordance with *Test Procedure, Membrane Peel Tests for Roof Membrane Seam or Cover Tape/Cover Strip Combination using Tensile Loading*, FM Approvals, LLC.

##### **B.5.1 Results**

- 1) The result shall be the highest force attained by the sample during the test.
- 2) The overall sample results shall be determined based on the average of three (3) tests. If the standard deviation of the three values divided by the mean is greater than 20%, additional testing shall be conducted until less than, or equal to, 20% is obtained. The results of all tests shall be used to determine the final average.

#### **B.6 Pull Through Tests for Fastener/Stress Plate or Batten Bar Combinations using Tensile Loading**

Pull through tests for fastener/stress plate or batten bar combinations using tensile loading shall be in accordance with *Test Procedure, Pull Out Tests for Fastener/Roof Deck Combinations and Pull Through Tests for Fastener/Stress Plate or Batten Bar Combinations using Tensile Loading*, FM Approvals, LLC.

##### **B.6.1 Results**

- 1) The result shall be the highest force attained by the sample during the test.
- 2) The overall sample results shall be determined based on the average of three (3) tests. If the standard deviation of the three values divided by the mean is greater than 20%, additional testing shall be conducted until less than, or equal to, 20% is obtained. The results of all tests shall be used to determine the final average.

#### **B.7 Insulation Breaking Load Test using Tensile Loading**

Insulation breaking load tests using tensile loading shall be in accordance with *Test Procedure, Test Method for Determining the Insulation Breaking Load using Tensile Loading*, FM Approvals, LLC.

**B.7.1 Results**

- 1) The result shall be the highest force attained by the sample during the test.
- 2) The overall sample results shall be determined based on the average of three (3) tests. If the standard deviation of the three values divided by the mean is greater than 20%, additional testing shall be conducted until less than, or equal to, 20% is obtained. The results of all tests shall be used to determine the final average.

- B.8** EN 13823, Building Products Excluding Floorings Exposed to the Thermal Attack by a Single Burning Item conducted in accordance with *Test Procedure, EN 13823, Reaction To Fire Tests For Building Products - Building Products Excluding Floorings Exposed To The Thermal Attack By A Single Burning Item*, FM Approvals, LLC
- B.9** ISO 11925-2, Reaction to Fire Tests - Ignitability of Building Products Subjected to Direct Impingement of Flame - Part 2: Single-Flame Source Test conducted in accordance with *Test Procedure, Reaction to Fire Tests - Ignitability of Building Products Subjected to Direct Impingement of Flame - Part 2: Single-Flame Source Test*, FM Approvals, LLC
- B.10** ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials conducted in accordance with *Test Procedure, Standard Test Method for Surface Burning Characteristics of Building Materials*, FM Approvals, LLC
- B.11** ASTM D1929, Standard Test Method for Determining Ignition Temperature of Plastics conducted in accordance with *Test Procedure, ASTM D1929-96 (Reapproved 2001)<sup>E1</sup>, Standard Test Method For Determining Ignition Temperature Of Plastics*, FM Approvals, LLC
- B.12** ASTM D240, Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter conducted in accordance with *Test Procedure, ASTM Oxygen Bomb Testing: ASTM D240-02 Heat Of Combustion Of Liquid Hydrocarbon Fuels By Bomb Calorimeter, ASTM D4809-00(2005) Heat Of Combustion Of Liquid Hydrocarbon Fuels By Bomb Calorimeter (Precision Method), ASTM D5468-02 Gross Calorific And Ash Value Of Waste Materials, ASTM D5865-04 Gross Calorific Value Of Coal And Coke, ASTM E711-87(2004) Gross Calorific Value Of Refuse-Derived Fuel By The Bomb Calorimeter*, FM Approvals, LLC
- B.13** ISO 1716, Determination of the Heat of Combustion conducted in accordance with *Test Procedure, ISO 1716, Reaction-to-Fire Tests for Building Products - Determination of the Heat of Combustion*, FM Approvals, LLC
- B.14** ISO 1182, Reaction to Fire Tests for Building Products - Non-Combustibility Test conducted in accordance with *Test Procedure, ISO 1182 Reaction To Fire Test For Building Products - Non-Combustibility Test*, FM Approvals, LLC.
- B.15** ASTM D638 - Standard Test Method for Tensile Properties of Plastics
- B.16** ASTM D1781 - Standard Test Method for Climbing Drum Peel for Adhesives
- B.17** ASTM D751 - Standard Test Methods for Coated Fabrics