FM Approvals

ANSI American National Standards Institute

**ANSI/FM 4477-2021**
**REVISION OF ANSI/FM 4477-2016**
**APPROVED SEPTEMBER 27, 2021**

# American National Standard for Vegetative Roof Systems

**September 2021**

# Foreword

NOTE: This foreword is introductory only and is not part of American National Standard FM 4477.

This standard is intended to verify that the product as described will meet minimum specific stated conditions of performance, safety and quality, useful in determining the potential suitability for end-use conditions of these products. It describes minimum performance requirements for materials that are intended for use in roof assemblies by evaluating the ability of the materials and, in turn, the system components to withstand simulated wind uplift resistance.

This American National Standard has been developed according to the essential requirements of due process for standards development of the American National Standards Institute (ANSI). FM Approvals is an ANSI-accredited standards developer (ASD).

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ANSI regulations require that this American National Standard shall be revised, reaffirmed or withdrawn within five years of the date of publication.

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# TABLE OF CONTENTS

## 1.1 PURPOSE

This standard states the test requirements for vegetative roof systems that are used with a roof assembly.

## 1.2 SCOPE

1.2.1 This standard applies to all vegetative roof systems that are intended to be installed over a single-ply, polymer-modified bitumen sheet, built-up roof, or liquid applied roof cover assembly.

1.2.2 The standard is intended to evaluate only those hazards investigated, and is not intended to determine suitability for the end use of a product.

1.2.3 This standard evaluates vegetative roof systems for their performance in regard to fire from above and below the structural deck, foot traffic and root barrier resistance.

## 1.3 BASIS FOR REQUIREMENTS

The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists was also considered.

## 1.4 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 *Standard for Use of the International System of Units (SI): The Modern Metric System*, BSR/IEEE/ASTM SI 10.

## 1.5 APPLICABLE DOCUMENTS

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

| | |
|---|---|
| **ANSI (American National Standards Institute)** | Procedure for Investigating Resistance to Root or Rhizome Penetration on Vegetative Roofs, ANSI/SPRI VR-1 2018 |
| **ASTM International (American Society for Testing and Materials)** | Standard Test Method for Determining Water Migration Resistance Through Roof Membranes, ASTM D7281<br>Standard Test Methods for Fire Tests of Roof Coverings, ASTM E108 |
| **NFPA (National Fire Protection Association)** | Standard Method of Fire Tests for Determining the Heat Release Rate of Roofing Assemblies with Combustible Above-Deck Roofing Components, NFPA 276 |

## 1.6 DEFINITIONS

For purposes of this standard, the following terms apply:

| | |
|---|---|
| **Adhesive** | Adhesive is used in roof construction to adhere roof coverings to roof coverings as in lap construction. It is also used to bond roof coverings to the substrate below or to adhere insulation to the substrate. Depending on the use, the adhesive could be in either a liquid form, semi liquid form or a solid form as in a seam tape or as in hot asphalt which is solid until heated. |
| **Deck** | The deck is the structural component of the roof assembly to which the roof system is secured. |
| **Delamination** | Separation of the plies in a roof membrane or system in any laminated roofing material or component, e.g., laminated layers of rigid insulation or the felt plies in a built-up roof or separation of any membrane from the substrate to which it is adhered. |
| **Drainage/Retention Panel** | Drainage panels are used to allow for proper drainage of water from the overlying saturated growth media and to retain water to provide the root system with access to moisture during dry periods. |
| **Fasteners** | A fastener is a mechanical securement device used alone or in combination with a stress distributor to secure various components of a roof assembly. |
| **Filter Fabric** | The filter fabric is used to retain growth media and prevent fine particles from being washed out of the growth media into the underlying drainage panel. |
| **Fully Adhered –** | Fully adhered describes roof components that have been bonded to the substrate using a compatible adhesive throughout the entire surface of the roof. |
| **Growth Media (Engineered Soil)** | Made up of mineral soil and organic soil, the material that supports and nourishes the roof vegetation; it provides water and nutrients to the plants, as well as anchorage for the root system. |
| **Hardscape** | Materials and features, such as stone ballast (roof gravel), concrete pavers, gravel stops, curbs, and grating used for bordering or enclosing vegetative roof system areas and intended to support foot traffic. |
| **Heat Weld** | A process of bonding overlapping edges of separate sheets or sections of polymer modified bitumen or thermoplastic roofing membranes by the application of heat and pressure to form a watertight seam. |
| **Insulation** | Insulation is any of a variety of materials designed to reduce the flow of heat, either from or into a building. |
| **Mechanically Fastened** | Mechanically fastened describes roof covers or base sheets that have been attached to the substrate at defined intervals using fasteners with or without stress distributors. |
| **Modular systems** | Trays with growing medium which may include vegetation that are constructed offsite and then are installed on the roof. |
| **Moisture Retention Mat** | A moisture retention mat is used to provide moisture to the growth media and the plant roots. The moisture retention mat is designed to allow for unimpeded root penetration. |
| **Protection Board (Cover Board)** | A board stock placed over an insulation layer. |
| **Protection Fabric** | Protection fabric is used to protect the root barrier and waterproofing membrane from damage due to growth media aggregate, hardscape materials, drainage panel edges, and damage during installation of the vegetative roof system. |
| **Roof Assembly** | A roof assembly is a system of interacting roof components (including the roof deck) designed to weatherproof and, normally, to insulate a building's top surface. |
| **Roof System** | A system of interacting roof components (not including the roof deck) designed to weatherproof and, normally, to insulate a building's top surface. |

| | |
|---|---|
| **Root Barrier** | A membrane designed to provide protection to the underlying waterproofing membranes from root penetration into the lap seams, as well as to provide protection from microorganisms in the growth media. |
| **Stress Distributor/Plate** | A stress distributor/plate is metal or plastic disk or bar designed to distribute a concentrated load over a larger surface area. |
| **Waterproofing Membrane (Roof Cover)** | The exterior surface of a roof assembly designed to protect the building components from the weather, over which the vegetative roof system is installed. |
| **Wind Blanket** | Organic or inorganic material placed over growth media and vegetation to minimize erosion and aid in the stabilization of the root systems in newly planted vegetation. The wind blanket may or may not be held in place with anchoring devices. They may be permanent, temporary, or intended to biodegrade over time. |

# 2. GENERAL INFORMATION

## 2.1 PRODUCT INFORMATION

Vegetative roof systems can be either a module system or constructed on site. They consist of several component layers beginning with the roof assembly and ending with the vegetation. Component layers that may be found in a vegetative roof system are the roof assembly and waterproofing membrane, insulation, root barrier, protection fabric, drainage panel, filter fabric, moisture retention mat, growth media, modules, and vegetation. Securements are used to hold the various components of the roof assembly together and generally consist of a combination of adhesives, welds and/or mechanical fasteners, whereas the vegetative roof system is loose laid, similar to a ballasted system.

# 3. GENERAL REQUIREMENTS

## 3.1 REVIEW OF DOCUMENTATION

During the initial investigation and prior to physical testing, the manufacturer's specifications and details shall be reviewed.

## 3.2 CALIBRATION

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

### 3.3 MARKINGS

3.3.1 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;
- model number, model type, and/or product name, as appropriate.

When hazard warnings are needed, the markings shall be universally recognizable and permanent.

3.3.2 The product trade name, model number, or model type identification shall correspond with the manufacturer's catalog designation. The manufacturer shall not place this trade name or model type identification on any other product unless covered by a separate agreement.

3.3.3 All markings shall be legible and durable.

### 3.4 MANUFACTURER'S INSTALLATION INSTRUCTIONS

The manufacturer shall provide the user with printed instructions to demonstrate proper installation procedures to be followed by installers.

### 3.5 TEST SAMPLE PRODUCTION

All products submitted for testing shall be representative of production run material.

## 4. PERFORMANCE REQUIREMENTS

This standard is intended to evaluate vegetative roof systems as part of a finished roof assembly for its performance as it relates to fire from above and below the structural deck, foot traffic, and root barrier resistance.

Tests of alternate constructions are permitted to be waived if considered less critical than those previously tested.

In some cases, the finished roof assembly includes additional items in conjunction with the vegetation, such as wind blankets. It may be necessary that these items be tested as part of the finished roof assembly, even if these items are specified to be "temporary" by the manufacturer.

Prior to ASTM E 108, *Standard Test Methods for Fire Test of Roof Coverings* testing, roof assemblies are required to be conditioned for a minimum period of 28 days. No watering of the sample will be allowed during the conditioning period to simulate drought conditions. A minimum ambient temperate of 70° F (22.2° C) shall be maintained. The test sample shall be subjected to natural sunlight for the duration of the 28 day period in greenhouse conditions or otherwise exposed to natural sunlight while protected from natural precipitation. The test sample vegetation shall be maturely developed and exhibit a minimum 90% coverage rate of the test sample. All other testing shall be conducted after a cure period of not more that 28 days.

## 4.1 COMBUSTIBILITY FROM ABOVE THE ROOF DECK

Testing for combustibility from above the roof deck shall be in accordance with ASTM E 108, *Standard Test Methods for Fire Test of Roof Coverings*.

4.1.1 Conditions of Acceptance for Combustibility from Above the Roof Deck – Spread of Flame Test

4.1.1.1 For Class A, the maximum flame spread of the sample materials shall not exceed 72 in. (1830 mm).

4.1.1.2 For Class B, the maximum flame spread of the sample materials shall not exceed 96 in. (2440 mm).

4.1.1.3 For Class C, the maximum flame spread of the sample materials shall not exceed 156 in. (3960 mm).

4.1.1.4 The vegetative roof deck sample shall contain the growth media and vegetation. All other components of the vegetative roof systems may be included in the roof deck sample.

4.1.1.5 There shall be no excessive lateral flame spread which is defined as flames extending to the two lateral edges of the exposed vegetation roof covering beyond 12 in. (305 mm) from the ignition source.

4.1.1.6 There shall be no portion of the vegetative or roof covering material blown, or falling, off of the test deck in the form of flaming or glowing brands that continue to glow after reaching the floor.

4.1.1.7 There shall be no portion of the roof deck that falls in the form of particles that continue to glow after reaching the floor.

4.1.2 Conditions of Acceptance for Combustibility from Above the Roof Deck – Intermittent Spread of Flame and Burning Brand Tests for Classes A, B or C.

4.1.2.1 There shall be no portion of the vegetative or roof covering material blown, or falling, off of the test deck in the form of flaming or glowing brands that continue to glow after reaching the floor.

4.1.2.2 There shall be no exposure of the deck or sustained flaming on the underside of the deck.

4.1.2.3 There shall be no portion of the roof deck that falls in the form of particles that continue to glow after reaching the floor.

## 4.2 COMBUSTIBILITY FROM BELOW THE ROOF DECK

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.

4.2.1 Conditions of Acceptance for NFPA 276:

4.2.2 The roof assembly, when subjected to NFPA 276, shall not exhibit fuel contribution rates in excess of the values shown in the following table.

| **Time Interval.** | **Max Fuel Contribution Rate** | |
|---|---|---|
| Min. | Btu/ft$^2$/min | kW/m$^2$/min |
| 3 min. | 410 | 77.6 |
| 5 min. | 390 | 73.8 |
| 10 min. | 360 | 68.1 |
| Avg. (30 min) | 285 | 54.0 |

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

## 4.3 FOOT TRAFFIC RESISTANCE TEST

Testing for foot traffic resistance of the drainage/retention panel shall be in accordance with Test Procedure, Appendix B.

4.3.1 Conditions of Acceptance for Foot Traffic Resistance

There shall be no signs of tearing or cracking of any vegetative roof system components causing one component to introduce itself into another component layer due to the material failure of any one layer.

## 4.4 ROOT BARRIER RESISTANCE TESTS

4.4.1 Testing for root barrier resistance of plastic materials with continuous heat welded seams shall be in accordance with *Standard Test Method for Determining Water Migration Resistance Through Roof Membranes*, ASTM D7281, ASTM International.

4.4.1.1 Conditions of Acceptance for Water Leakage Resistance

There shall be no signs of water leakage during the 7 day period. In addition, there shall be no signs of water leakage during or after the pressure cycles.

4.4.2 Testing for root barrier resistance of materials without continuous heat welded seams (example overlapping un-bonded seams) or testing for root barrier resistance of polymer-modified bitumen materials with continuous heat welded seams shall be in accordance with *Procedure for Investigating Resistance to Root or Rhizome Penetration on Vegetative Roofs,* ANSI/SPRI VR-1 2018.

4.4.2.1 Conditions of Acceptance for Root Barrier Resistance

There shall be no signs of root penetration through the root barrier or beyond the un-bonded area, if present, after the 2-year test cycle.

# APPENDIX A: UNITS OF MEASUREMENT

**LENGTH:**

in. - "inches"; (mm - "millimeters")

mm = in. x 25.4

ft - "feet"; (m - "meters")

m = ft x 0.3048

**HEAT:**

Btu - "British thermal units"; (J - "joules")

J = Btu x 1.0551 x 103

**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

**FORCE:**

lbs –‘‘pounds’’; (N –‘‘Newton’’)
N = lb x 4.448

# APPENDIX B: TEST PROCEDURE
# Determining the Foot Traffic Resistance

## B-1 INTRODUCTION

B-1.1 The Foot Traffic Resistance Test Procedure is designed to verify the ability of the vegetative roof components to resist foot traffic.

## B-2 DESIGN OF THE TEST APPARATUS (NOTE: ANY TEST APPARATUS CAPABLE OF MEETING THE TEST SPECIFICATIONS IS ACCEPTABLE).

B-2.1 The Tinius Olsen machine utilizes two screw threads to move the support platform in a vertical direction. Various test jaws can be inserted into the stationary portion to secure the test sample. The Tinius Olsen machine is connected to a computer with a data acquisition program which captures the data, creates graphs of the output and can average sets of data produced.

B-2.2 A 3 x 3 x 0.5 in. (75 x 75 x 13 mm) steel plate with rounded corners.

B-2.3 A 2 x 2 x 12 in. (50 x 50 x 305 mm) section of steel tubing.

## B-3 TEST SAMPLE

B-3.1 The size of the test sample shall be minimum 12 x 12 in. (305 x 305 mm).

## B-4 CONDUCT OF TEST

B-4.1 The test sample is placed on the movable crosshead of the Tinius Olsen machine. A 3 in. (76 mm) square steel plate with rounded corners shall be centered on the centerline of the 12 in. (305 mm) square horizontal panel. The 12 in. (305 mm) long tube steel is centered on the steel plate and the crosshead is moved into position to apply a compressive load through the tube steel and square plate onto the test sample.

B-4.2 A 200 lb (890 N) load shall be imposed on the plate. The superimposed load shall be reduced to zero and the sample cover reloaded a minimum of four additional times.

B-4.3 The specimen shall be visually examined to ensure that it continues to meet the Conditions of Acceptance (as defined in Section 4.3.1 of this standard).

## B-5 RESULTS

B-5.1 The test sample shall be given a passing rating if it meets the Conditions of Acceptance.