



ANSI/SPRI VF-1 External Fire Design Standard for Vegetative Roofs

This standard was developed in cooperation with Green Roofs for Healthy Cities.

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This standard is for use by architects, engineers, roofing contractors and owners of low slope roofing systems. SPRI, its members and employees do not warrant that this standard is proper and applicable under all conditions.

1.0 Introduction

This design standard provides a method for designing external fire resistance for vegetative roofing systems. It is intended to provide a minimum design and installation reference for those individuals who design, specify, and install vegetative roofing systems. It shall be used in conjunction with the installation specifications and requirements of the manufacturer of the specific products used in the vegetative roofing system.

2.0 Definitions

The following definitions shall apply when designing a vegetative roofing system.

2.1 Ballast

In vegetative roofing systems; ballast consists of growing media, the trays or containers used to contain growing media, large stones, paver systems or lightweight interlocking pavers.

2.2 Border zone

The band around the edge of the vegetative plantings where no vegetation exists. It is frequently the perimeter of the roof area.

2.3 Firestops

Area capable of stopping the spread of flame.

2.4 Gravel stop

A low upward-projecting edge, usually formed from sheet or extruded metal, installed along the perimeter of a roof to prevent gravel or other small or lightweight aggregate from being blown or washed off. The gravel stop also serves as a point of termination for the roofing system.

2.5 Growing media

An engineered formulation of inorganic and organic materials including but not limited to heat-expanded clays, slates, shales, aggregate, sand, perlite, vermiculite and organic material including but not limited to compost worm castings, coir, peat, and other organic material.

2.6 Parapet

A parapet wall is a structure that rises above the roof edge to provide a wall of varying heights. The part of a perimeter wall that extends above the roof.

2.7 Penetration

A penetration is an object that passes through the roof structure and rises above the roof deck/surface. Penetrations consist of, but are not limited to, mechanical buildings, penthouses, ducts, pipes, expansion joints and skylights

2.8 Roof areas

For design and installation purposes, the roof surface is divided into the following areas:

2.8.1 Corners

The space between intersecting walls forming an angle greater than 45 degrees but less than 135 degrees.

2.8.2 Corner areas

The corner area is defined as the roof section with sides equal to 40% of the building height. The minimum length of a corner is 8.5 ft. (2.6 m).

2.8.3 Perimeter

The perimeter area is defined as the rectangular roof section parallel to the roof edge and connecting the corner areas with a width measurement equal to 40% of the building height, but not less than 8.5 ft. (2.6 m).

2.8.4 Field

The field of the roof is defined as that portion of the roof surface, which is not included in the corner or the perimeter areas as defined above.

- 2.9 Succulent
A plant with thick fleshy leaves and stems that can store water.
- 2.10 Grasses
Slow growing, narrow leaved plants. Grasses can be maintained by mowing.
- 2.11 Vegetative roofing system
A vegetative roofing system consists of vegetation, growing media, the trays or containers used to contain growing media, large stones, paver systems or lightweight interlocking pavers, drainage system, and waterproofing over a roof deck.

3.0 System requirements & general design considerations

- 3.1 Roof structure design or evaluation
The building owner shall consult with a licensed design professional such as an architect, architectural engineer, civil engineer, or structural engineer to verify that the structure and deck will support fully hydrated growing media, vegetation and other material or objects installed on the roof deck in combination with all other design loads.
- 3.2 Membrane requirements
The membrane specified for use in the vegetative system shall meet the recognized industry minimum material requirements for the generic membrane type, and shall meet the specific requirements of its manufacturer. When the membrane or system is not impervious to root penetration a root barrier shall be installed.
- 3.3 Slope
This Design Standard is limited to roof slope designs up to 2 in 12. For slopes greater than 2 in 12, a design professional experienced in vegetative roof design shall provide the design and the design shall be approved by the authority having jurisdiction.
- 3.4 Fire stops
 - 3.4.1 Walls**
Fire stop walls shall be of non-combustible construction complying with the applicable building code and extend above the roof surface a minimum of 36 in. (914 mm).
 - 3.4.2 Fire break roof areas**
Fire break roof areas shall consist of a class A (per ASTM E108 or UL790) rated roofing system for a minimum 6 ft. (1.8 m) wide continuous border.
- 3.5 Interior fire rating: steel decks: concrete decks
Interior fire resistance shall comply with the design fire penetration requirements based on use and occupancy and be determined to meet interior fire resistance requirements for the system installed beneath the soil media.
- 3.6 Exterior fire rating
Construct the roofing system inclusive of roof decks, vapor barriers, insulations, roofing membranes, flashings, roof drainage components, growing media and vegetation to conform to the designed fire resistance requirements as determined by the building code for the building considered.

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3.7 Wind design

The vegetative roofing system shall be designed for wind resistance before beginning the design process for fire resistance. Vegetative roofing systems shall be designed to the requirements of SPRI RP 14, "Wind Design Standard for Vegetative Roofing systems" or other design standards as approved by the authority having jurisdiction.

4.0 Vegetative roof design options

Fire-resistant vegetative roof designs include, but are not limited to, the generic systems described below. Other systems, when documented or demonstrated as equivalent to the provisions of this standard, are permitted to be used when approved by the authority having jurisdiction (See Commentary Section 4.0). When there is a conflict between this standard and the wind design requirements the design with the more conservative requirement shall be used.

4.1 Generic fire resistive vegetative systems

4.1.1 Succulent based systems

Systems where the vegetative portion of the roof is planted in growing media that is greater than 80% inorganic material, and the vegetation consists of plants that are classified as succulents. Non-vegetative portions of the rooftop shall be systems that are classified ASTM E108, Class A.

4.1.2 Grass based systems

Systems where the vegetative portion of the roof is planted in growing media that is greater than 80% inorganic material, and the vegetation consists of plants that are classified as grass. Non-vegetative portions of the rooftop shall be systems that are classified ASTM E108, Class A.

4.2 Fire protection for roof top structures and penetrations

For all vegetative roofing systems abutting combustible vertical surfaces, a Class A (per ASTM E108 or UL790) rated roofing system shall be achieved for a minimum 6 ft. (1.8 m) wide continuous border placed around rooftop structures and all rooftop equipment.

4.3 Spread of fire, protection for large area roofs

A firestop as described in Section 3.4 shall be used to partition the roof area into sections not exceeding 15,625 ft² (1,450 m²), with each section having no dimension greater than 125 ft. (39 m). Incorporate the border zones into expansion joints or roof area dividers wherever possible.

4.4 Fire hydrants

Access to one or more fire hydrants shall be provided.

4.5 Border zones

Border zones are required when terminating at a fire barrier wall.

5.0 Maintenance

Maintenance shall be provided as needed to sustain the system keeping vegetative roof plants healthy and to keep dry foliage to a minimum; such maintenance includes, but is not limited to irrigation, fertilization, weeding. Excess biomass such as overgrown vegetation, leaves and other dead and decaying material shall be removed at regular intervals not less than two times per year. Provision shall be made to provide access to water for permanent or temporary irrigation. The requirement for maintenance shall be conveyed by the designer to the building owner, and it shall be the building owners responsibility to maintain the vegetative roofing system.

Commentary to VF-1

This Commentary consists of explanatory and supplementary material designed to assist designers and local building code committees and regulatory authorities in applying the requirements of the preceding standard.

The Commentary is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at them.

The sections of this Commentary are numbered to correspond to the sections of the VF-1 standard to which they refer. Since it is not necessary to have supplementary material for every section in the standard, there are gaps in the numbering of the Commentary.

C1.0 Introduction

Green roofs, also known as vegetative roofs, eco-roofs, and rooftop gardens fall into two main categories: intensive is primarily defined as having more than 6 inches of growing media, greater loading capacity requirements, and greater plant diversity, and extensive, defined as having less than 6 inches of growing media, less loading capacity requirements and fewer options for plants.

Vegetative roofs are complex systems consisting of many parts critical to the functioning of the system. To name a few of the components that are generally found in the system, but the system is not limited to these products: insulation, waterproofing membrane, protection mats/boards, root barrier, drainage layer, filter fabric, growing media, and vegetation. A vegetative roof may consist of more than just growing media and vegetation, but include such things as walkways, water features, stone decoration, and benches.

A vegetative roof may cover the whole roof or share a portion of the surface with a conventional roofing system. They are versatile systems with many strong attributes including stormwater management, reduction of the heat island effect, and aesthetics to name a few.

VF-1 is a minimum standard. Manufactures and /or designers requirements that exceed the standards minimum requirements can be incorporated into specifications for vegetative roof fire resistance.

While the standard is intended as a reference for designers and roofing contractors, the design responsibility rests with the “designer of record.”

C2.1 Ballast

Ballast includes the growing media and the trays and containers that are used to contain growing media. The type of growing media used as ballast in vegetative roofs can influence the fire performance of the system. Stones, pavers, and concrete surfaces are often used as ballast and are non-combustible.

C2.5 Growing media

Inorganic materials used as growing media are not combustible, however media with high concentrations of organic material can support combustion. Soils with high percentages of organic material can negatively affect the fire resistance of a system. Currently data is unavailable on specific growing media blends, but it is known that media with high loadings of organic material such as peat moss can burn.

Sources for growing media specifications are as follows:

From ASTM

C549-06	Standard Specification for Perlite Loose Fill Insulation
C330-05	Standard Specification for Lightweight Aggregates for Structural Concrete
C331-05	Standard Specification for Lightweight Aggregates for Concrete Masonry Units
C332-07	Standard Specification for Lightweight Aggregates for Insulating Concrete

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Test Methods for classifying material

C117-04	Standard Test Method for Materials Finer than 75- μm (No.200) Sieve in Mineral Aggregates by Washing
C136-06	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
D5975-96 (2004)	Standard Test Method for Determining the Stability of Compost by Measuring Oxygen Consumption. US Composting Council: "TMECC" Test Methods for the Examination of Composting and Compost.

C2.7 Penetration

Penetrations may consist of, but are not limited to, mechanical buildings, penthouses, ducts, pipes, expansion joints and skylights. These penetrations may be combustible or fire may have a major impact on their performance. For these reasons, penetrations need to be protected from fire exposure.

C2.11 Vegetative roofing system

Vegetative roofing systems will go over both loose-laid, mechanically fastened, and fully adhered roofing systems. However, when a mechanically attached roofing system is used special precautions need to be taken to prevent damage to the membrane due to the fastener and plates below the membrane and impact damage and wear that can occur at these locations. Mechanically attached systems should not be used unless approved by the membrane supplier of vegetative roofs, and all precautions from the supplier are followed.

There are several types of vegetative roofing systems as noted below, and they can be interchanged without affecting the fire performance of the system.

Ballasted vegetative roofing system

A ballasted vegetative roofing system consists of vegetation; ballast as defined in 2.1, provides waterproofing and includes a membrane or membrane and substrate materials installed over a structural deck capable of supporting the system. Membranes are permitted to be loose laid, mechanically attached or partially adhered to the roof deck or supporting insulation.

Protective vegetative roofing system

A protected vegetative roofing system consists of vegetation, growing media, ballast as defined in 2.1, a fabric that is pervious to air and water, insulation, and includes a membrane that provides waterproofing and substrate materials installed over a structural deck capable of supporting the system. Membranes are permitted to be loose laid, mechanically attached or partially or fully adhered to the roof deck or supporting insulation.

Vegetative roofing system using a fully adhered roof membrane system

A vegetative roofing system using a fully adhered membrane system consists of vegetation, growing media, ballast as defined in 2.1, and includes a membrane that provides waterproofing and is fully adhered to attached insulation, or adhered directly to a roof deck.

C3.2 Membrane requirements

List of ASTM references for generic roofing types

EPDM	ASTM D-4637
PVC	ASTM D-4434
TPO	ASTM D-6878
HYPALON/CPE/PIB	ASTM D-5019
KEE	ASTM D-6754
SBS	ASTM D-6164, 6163, 6162
APP	ASTM D-6222, 6223, 6509
BUR	As defined by the standards referenced in the International Building code Fully adhered hot-applied reinforced waterproofing system ASTM D 6622

Building height

Special consideration shall be given when the building height is greater than 150 ft. (45.7 m). Vegetative roofs can be designed using reference 1, consultation with a wind design engineer, or wind tunnel studies and fire design experience of the specific building and system.

Other factors

There are other factors that affect the design of the vegetative roof for wind and fire. These include, but are not limited to, building height, building location, pressurized buildings, large openings, eaves and overhangs.

C3.5 Exterior fire rating

Building codes are specific as to the requirements for the roofing system fire resistance based on designated occupancy. Roofing systems may be required to obtain ASTM E 108 Class A, B or C. Data exists that supports the Classification of succulent based systems as Class A fire resistance. Other systems may be tested for fire resistance as installed, but the vegetation needs to be maintained in order to continue to sustain fire resistance. Provisions need to be made so the vegetation installed on the roof will have sustainable resistance to the spread of flame as required by the building code.

C3.6 Wind design

Vegetative roofs are not recommended where the basic wind speed is greater than 140 mph (225 kph). However, they can be designed using reference 1, consultation with a wind design engineer, or wind tunnel studies of the specific building and system. The “authority having jurisdiction” is the only source for approval of designs not covered in this document. ASCE 7 gives guidance on how non-standard conditions should be evaluated.

C4.0 Vegetative roof design options

The Design Options of Section 4 were developed to provide a barrier to prevent the spread of fire from the vegetative section of the roof to other parts of the building. These design options were developed from European experience, forest fire prevention, and roofing experience. Vegetative “Green Roofs” have an excellent history of resisting fire damage.

Some vegetation, such as succulents, are very fire resistive. Local code officials may consider waiving the barrier requirements when fire resistive vegetation is installed.

ASTM E-108 and UL 790 can be used to test vegetative roofing systems. Modifications of the test standards may be able to provide a meaningful test for selected conditions. However, with all the plant types that could be used in a roof design, the varying weather conditions that occur through the year, and the effects of seasons generate many variables that limit the potential to classify a roof construction. For this reason, if the roof is being

designed with little or no maintenance planned; fire rated barriers are required.

Given that wind standards may often require greater areas of non-vegetative roof, the wind standard will most often determine the size of the perimeter area or border zones.

C4.2 Fire protection for roof top structures and penetrations

Pavers are often used as Class A or non-combustible separators. Care should be taken when installing pavers to avoid damaging the membrane. Some manufacturers require a separation material between the paver and the membrane.

C4.3 Spread of fire, protection for large area roofs

Spread of flame for Class A fire is limited to 6 ft. (1.8 m), if there is a 6 ft. break separating vegetative areas using Class A material or non combustible material the flame spread is not expected to ignite the nearby area. The dimensions chosen for large area roof limitations are based on FLL and FM requirements, they also coincide with the International Building Codes Area limitations for Assembly buildings.

C5.0 Maintenance

The building owner needs to properly maintain a vegetative roof. One of the important ways of preventing fires is to keep the roof adequately watered. The need for water will vary greatly due to climate and types of plants chosen. Designers should be aware that plantings are to be specific for the roof being installed and that rooftops are at best hostile places for vegetation. Removal of dead foliage should occur on a regular interval, for most roofs and that may be at least once a month. The moisture level of the growing media should be checked weekly. By regularly removing excess biomass that could become fuel for a fire on the rooftop, the risk of fire spreading beyond the 6 foot (1.8 m) Class A fire rated separation setback to combustible vertical surfaces is minimized.

Best management practices for maintenance include regular weeding, fertilization, and removal of dead/dormant vegetation in accordance with the recommendations of the green roof provider. Specific directions for the proper maintenance of the vegetative cover should be furnished by the green roof provider.

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References

1. Kind, R.J. and Wardlaw, R.L., Design of Rooftops Against Gravel Blow-Off, National Research Council of Canada, Report No. 15544, September 1976.
2. FM Global: Property Loss Prevention Data Sheets 1-35 Green Roof Systems
3. FM Global: Approval Standard for Vegetative Roof Systems Class Number 4477 Draft April 2009
4. FLL Standard "Guideline for the Planning, Execution and Upkeep of Green-Roof Sites", Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V. – FLL, Colmantstr, Bonn, Germany.