



GardenScape™ Application & Specification Manual



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Table of Contents

Content	Page
Roof Design	
General.....	4
Structural Loading Capacity.....	4
Wind Performance.....	5
Fire Resistance.....	5
Safety and Accessibility.....	5
Drainage and Slope.....	6
Vegetation-Free Zones.....	7
Roof Decks.....	8
Installation Specification	
Part 1 - General	
System Description.....	9
Regulatory Requirements.....	9
Delivery, Storage and Protection.....	9
Environmental Requirements & Restrictions....	9
Working Environment.....	10
Part 2 - Products	
Membrane.....	10
Flashing.....	10
Flashing Accessories.....	10
Fasteners.....	10
Adhesives & Sealants.....	10
Insulation.....	11
Insulation-High Traffic Applications.....	11
Recover Board.....	11
Other Accessories.....	11
GardenScape™ System.....	11
Part 3 – Execution	
Site Conditions.....	12
Preparation of Roofing Area-New & Tear Off...	12
Preparation of Roofing Area-Recover.....	12
Wood Nailer Installation.....	13
Base Sheet Installation.....	13
Recover Board/Insulation Installation.....	14
Membrane Installation.....	15
Flashing Installations.....	17
Traffic Protection.....	18
Field Quality Control.....	18
Cleaning.....	18
Insulation Attachment Table for FA Systems.....	19

Part 4 – GardenScapes™ Flashing/Details
Details GS-100 – 103..... 20
Detail GS 104..... 21

Part 5 – GardenScapes™ Application Process
Preparation..... 22
Safety..... 22
Tools..... 22
GardenScapes™ Materials..... 22
Preparing for a GardenScapes™ Installation.... 23
Installation of GardenScapes™ Dura-Gro™..... 23
Installation of Drain Box..... 24
Installation of Metal Edging..... 24
Installation of Start-Rite™ Growing Medium.... 25
Installation of GardenScapes Vegetation..... 25
Installation of Optional Paver Components..... 26
Stone Ballast / Paver..... 26
Traffic Protection..... 26

Part 6 - Inspection
Inspection..... 26
Plant Inspection..... 27

Part 7 - Flood Test
Flood Test..... 27

Part 8 – Post Water Test Considerations
Post Water Test Considerations..... 27

Part 9 - Maintenance
Maintenance..... 28
Maintenance Procedures..... 29

Part 10 – Post Occupancy Assessment
Post Occupancy Assessment..... 29
Post Construction – Best Practices..... 29

Part 11 – Seasonal Constraints
Considerations for seasonal limitations..... 30

Part 12 - Fertilization
Fertilization..... 30
Table of Organic & Mineral Fertilizers..... 31
Application of Fertilization..... 31

Part 13 – Quality Assurance
Quality Assurance..... 32
Vegetation Quality Assurance..... 32
General..... 32

Roof Design

General

Proper roofing system design and selection requires the consideration of many factors. Although our expertise is in roofing system design and materials manufacturing, and not in engineering, architecture, or specialized roof consulting, GAF does have extensive experience in the practical aspects of roofing.

Structural Loading Capacity

One of the most important factors in determining the suitability of a deck for a garden roof is the ability of the structure to hold the imposed loads.

Roof decks can be designed to support anticipated loads so structural loading capacity may not be an issue on new construction projects. However, not all existing structures are capable of supporting the added weight of garden roof components.

The 2 kinds of loads that are imposed on roofs are: dead and live loads. Dead loads comprise of permanent material, including those that are a part of, or below, the garden roof. Elements that will need to be accounted for in dead load calculations include, but are not limited to:

- Roof structure
- Deck
- Waterproofing membrane
- Saturated growing medium
- Plants (weight at maturity)
- Pipes
- Sprinkler system
- Roof top Equipment
- Gravel
- Benches
- Ceiling fans
- Suspended ceilings

Live loads are that which are variable on a structure. They are not continuous and are created by:

- Wind
- Rain
- Snow
- Retained irrigation water
- Seismic
- Temporary construction equipment
- Animals
- People

Loads during construction and during significant repairs can be larger than those being simply serviced or inspected due to accumulation of materials and the existence of construction equipment. Designers should make certain that the roof has the capability to accommodate the additional weight during and after installation.

Roofs that are going to be covered with vegetated systems must have their structural loading capacity, i.e. the amount of weight that the structure can withstand, calculated by a licensed structural engineer.

Wind Performance

Ideally, roofing systems should be capable of resisting forces generated by the maximum anticipated wind speed for a specific building.

- Factory Mutual Research Corporation
Testing based on method described in Approval Standards 4450 and 4470.
Measures resistance to upward pressure applied to the roof system.
FM Loss Prevention Data Sheet 1-35, January 2007
- American Society of Civil Engineers 7-02 Wind Design
A comprehensive analysis of wind forces acting on buildings. Requires detailed calculations to determine actual wind pressures at different regions of the roof.
Referenced by building codes.

Fire Resistance

Resistance by the roofing system to fire applied to the exterior roof surface is important. Typically, a UL Class A or B rating is required by building code. Occasionally, depending on the use of the building, special resistance to fire applied from within the building is required. This is normally expressed in the form of hourly ratings, and usually requires the use of a specialized roof assembly.

Consult your local building official for acceptability of your GardenScapes™ roofing system and local fire requirements.

Safety and Accessibility

All garden roofs require some form of access to the roof for maintenance purposes or for use by occupants. Safe access to the roof can take the form of a door, external stair case, external roof hatch, or roof ladder surrounded by vegetation free zones. Vegetation free zones should be installed in areas that require maintenance. A designated area should be positioned bordering the roof access point to assist with equipment and material loading.

Installation

Installation personnel can use the same means of access as designed for maintenance or occupants. Accessibility concerns during installation include the safety of workers and the method of transporting garden roof materials to the roof. Utilize means available for safe transportation of materials up to installation site (e.g. cranes, elevators, conveyance machines, and hoists).

Maintenances

Building systems (e.g. HVAC, window washing, and telecommunications equipment) as well as garden roof maintenance personnel will require a means of access to the roof, such as hatches, elevators and stairwells with doorways and/or permanent or portable ladders (for shorter structures).

These must be designed to meet local job site safety and building code requirements.

Use by Occupants

When designing garden roofs for use by building occupants or the general public, accessibility must conform to local building code safety requirements. Full access to a roof that has been “gardened” should only be made possible when the system has been designed and constructed for the purpose. (FLL 2002) These requirements may include:

- Guardrails.
- Lighting.
- Fire safety.
- Disabled access.

During construction and maintenance, safety anchors or handrails may be required to ensure that projects meet local safety standards. They should be designed to resist loads stipulated by local building codes. Handrails and safety anchors should be made of corrosion resistant materials such as stainless steel or hot dipped galvanized steel.

Safety anchors should be easily accessible for inspection and maintenance. It is preferable to design roofs with higher parapet walls to accommodate the anchors. All fasteners used to wall mount anchors should be located above the drainage plane of the roof and be made watertight in order to avoid jeopardizing the waterproofing assembly’s integrity. The higher the anchor, the less likely it is to cause a leak. In general, anchors should not be placed lower than 8” (203 mm) above the finished roof surface.

When handrails or safety anchors are secured to the deck rather than to walls, they must be designed with sufficient height to be flashed and made waterproof. When secured to the deck they may increase the cost of the waterproofing assembly and be a potential maintenance issue; in addition, safety lines are more likely to damage plant material. Extensive garden roof with low lying vegetation will allow for greater unrestricted safety line travel, minimizing the damage to plant material, than semi-intensive or intensive garden roofs.

Drainage and Slope

Providing positive roof drainage is important. Standing water can result in deck deflection and possible structural damage. Additionally, in the event of an opening through the roofing membrane, standing water can significantly worsen damage to the roof system, the building itself, and interior contents by providing a reservoir of water ready to leak through the membrane opening.

National building codes generally require a minimum 1/4"per 12" slope to drain in order to provide positive drainage and accommodate deck irregularities. Although existing buildings may or may not be required to achieve this degree of roof slope, providing positive slope to drain remains an important design consideration.

Drains

Drains used in garden roof application must perform the same functions as on traditional roofs. Additionally, they must also meet a number of additional criteria. Drains installed in a garden roof assembly should:

- Be made of deterioration resistant materials (i.e. plastic, brass, or stainless steel) and use corrosion resistant accessories
- Have underside slotted clamping rings to mechanically connect the drain body and waterproof membrane.

- Have debris collection basins to prevent clogging.
- Have inspection chambers with removable lids.
- Be set below the level of the field membrane.
- Be easily accessible for maintenance via vegetation-free zones, etc.
- Sized to accept the rainfall event as required by codes (e.g. a diameter of no less than 3" [75mm]).

Sloped Roofs

Garden roofs on structures with slopes greater than 10° (2:12) are more difficult to implement than on flat roofs since their design must account for the potential that critical planes in the garden roof profile may not resist shear stresses.

An engineered slope stability analysis by will be required for slopes greater than 10° (2:12)

Vegetation-Free Zones

Provide stone ballast or paver blocks to cover all border zones that are designated to be free of vegetation and growth media. Consult local code for details as well as FM Loss Prevention Data Sheet (L.P.D.S.) 1-35.

Perimeter and Corner Zones

Ensure border zones are free of vegetation and growth media.

Rooftop Structures, Penetrations and Joints

Provide a minimum of 1.5 ft. wide (or per code requirement) continuous border zone (free of vegetation and growth media) surrounding all rooftop equipment, penetrations, skylights, solar panels, antenna supports, expansion joints and interior parapet walls. Consider wider vegetation free zones in cases where HVAC intake or exhaust could be expected to affect or be affected by plant growth; (e.g., where taller plants may restrict intake or high velocity exhaust emissions could cause plant damage.

Provide a minimum 3 ft. wide (or per code requirement) continuous border zone around rooftop structures, including but not limited to mechanical and machine rooms, penthouses, and adjacent façade walls.

Provide 3 ft. wide (or per code requirement) continuous border zone strips to partition the roof area into sections not exceeding 15,625 ft² with each section not exceeding 125 ft in length. Incorporate the border zones into expansion joints or roof area dividers wherever possible.

Ref: See FM Loss Prevention Data Sheet (L.P.D.S.) 1-35, Jan. 2007 for addition information.

Roof Decks

It is the responsibility of the engineer, architect, building owner or roofing contractor to determine the fitness of a deck for a specific roofing system installation.

- **Structural Steel**
 - Minimum 22 gauge (standard FM-approved steel decking is 22 ga. in thickness).

- **Structural Concrete**
 - Minimum 2500 psi compressive resistance
 - Minimum 2" (51 mm) thick for precast, minimum 4" (102 mm) thick for poured-in-place.
 - Cannot be wet or frozen. If the deck is determined to be wet, it must be allowed to dry.
 - For insulated decks, wood nailers of equivalent thickness to the roof insulation must be provided at perimeters and projection openings to act as an insulation stop and to provide for the nailing of the flanges of metal flashing.
 - Ridges and other irregularities require grinding to provide a smooth and even substrate surface.
 - When applying insulation directly to the deck in hot asphalt, prime with asphalt/concrete primer, ASTM D41, at a rate of 1 gal/square and allow the primer to dry prior to the application of the roofing system.
 - **Poured-in-place decks:**
 - Must be properly cured prior to application of the roofing system; twenty eight (28) days is normally required for proper curing. Curing agents must be checked for compatibility with roofing materials. Prior to the installation of the roof assemblies, GAF recommends the evaluation of the surface moisture and the deck's dryness through the use of ASTM D-4263 or a hot bitumen test.
 - **Pre-cast concrete decks:**
 - Usually manufactured as planks or slabs and constructed of steel reinforced Portland cement and solid aggregate; often they are made with hollow cores to minimize weight.
 - All deformed panels must be replaced.
 - Joints must be filled with masonry grout to correct imperfections between slabs and feathered to provide a slope not greater than 1/8" per ft. for fully adhered insulated assemblies.
 - If the joints cannot be grouted and finished smooth, then a leveling course of lightweight insulating concrete minimum 2" (51mm thick) must be applied. Do not seal joints between the slabs; leave open to permit venting and drying of the roof fill from below.
 - **Pre stressed concrete decks:**
 - GAF recommends a minimum 2" (51 mm) cellular lightweight concrete fill be installed over all pre-stressed concrete decks prior to installation of the roof system and/or insulation because variations in camber and thickness of pre-stressed concrete members may make securement of the roof system difficult.
 - Provisions must be made for the curing or drying of the fill installed over the top of the pre-stressed deck members. Do not seal joints between the slabs, leaving open to permit venting and drying of the roof fill from below.

- **Wood Planking–Minimum**
 - 1" nominal thickness
 - Tongue & groove or splined edges required.
 - All boards must have a bearing on rafters at each end and be securely fastened.
 - Lumber should be kiln dried.
 - Preservatives or fire retardants used to treat decking must be compatible with roofing materials.
 - Decking should be kept dry and roofed promptly after installation.

Installation Specification

GardenScapes™ System Components

Part 1 – General

1.01 System Description

- A. Fully adhered heat-welded thermoplastic sheet roof membrane system

1.02 Regulatory Requirements

- A. Conform to all applicable building and jurisdictional codes, including roof assembly wind uplift and fire resistance requirements.
- B. Follow your local jurisdiction requirements for disposing of used and expired adhesives and sealants.

1.03 Delivery, Storage and Protection

- A. Deliver products to site in original containers with seals unbroken and labeled with manufacture's name, product brand name and type.
- B. Store materials in weather protected environment, clear of ground and moisture, in accordance with GAF's instructions.
- C. All materials stored outside shall be raised above ground or roof level on pallets, and covered with a tarpaulin or other waterproof material. Factory-installed plastic wrapping is not an adequate covering. Extreme heat conditions may require special storage requirements. Contact GAF Contractor Services for suggestions.
- D. Follow GAF's directions and requirements for protection of materials prior to and during installation.
- E. Materials that are wet or damaged to the extent that they will no longer serve their intended purpose shall not be used. All roof insulation that has been wet is considered damaged, even if later dried out. Remove all damaged materials from the jobsite.

1.04 Environmental Requirements & Restrictions

- A. Do not apply roofing materials during inclement or threatening weather.
- B. Do not expose materials vulnerable to water or sun damage in quantities greater than can be weatherproofed during the same day.
- C. High or gusting winds make the installation of materials difficult.
- D. Material installation during periods of high ambient temperatures, typically above 90°F, can result in poor installation quality due to condensation on the membrane surface and excessively fast adhesive drying rates.
- E. Material installation during periods of low ambient temperatures, typically below 40°F, can result in poor installation quality due to increased material stiffness and vulnerability to damage and excessively slow adhesive drying rates. To avoid these problems:
 - 1. Store accessory materials in a warming box.
 - 2. Use as soon as possible.
 - 3. Allow adhesive to properly cure.
 - 4. Use a weighted lawn roller over membrane.
 - 5. Do not install fully adhered systems until the temperature is 40°F and rising.
 - 6. Adjust welder settings to insure proper welds for applicable ambient conditions.
 - 7. See "Seasonal Constraints" section for best planting times.

1.05 Working Environment

- A. Provide a safe working environment, including, but not limited to, adequate fall protection, restriction of unauthorized access to the work area, and protection of the building and its occupants.
- B. Safe work practices should be followed, including, but not limited to, keeping tools in good operating order, providing adequate ventilation if adhesives are used, and daily house-keeping to remove debris and other hazards.

Part 2 – Products

2.01 Membrane

- A. EverGuard® TPO (smooth reinforced) thermoplastic polyolefin membrane.
- B. EverGuard® TPO Fleece-Back thermoplastic polyolefin membrane

2.02 Flashing

- A. EverGuard® membrane flashings to be of same type, thickness and color of roofing membrane except where EverGuard® Fleece-Backed membrane is used with smooth reinforced membrane flashings.
- B. EverGuard® TPO Fleece-Back membranes are optional flashing membranes for all EverGuard® TPO roofing systems, respectively. These membranes may be a solution when a contaminated substrate is encountered.

2.03 Flashing Accessories

- A. EverGuard® pre-formed flashing accessories to be of same type as roofing membrane.
 - 1. EverGuard® laminated metal flashings to be a minimum of 25 mils of non-reinforced TPO membrane laminated to 25 ga. galvanized steel sheet metal.
 - 2. Pre-formed Vent Boots with stainless steel clamping bands.
 - 3. Pre-formed Universal Corners for reinforcement of inside and outside corners.
 - 4. Pre-formed Expansion Joint Covers for roof-roof and roof-wall expansion joints.
 - 5. Membrane Flashing Strips for miscellaneous applications.
 - 6. UN-55 Detailing Membrane for flashing of miscellaneous penetrations in lieu of preformed accessories.
 - 7. EverGuard® TPO Cover Strip for stripping in of flat metal edges.
 - 8. EverGuard® 6" RTS strip.

2.04 Fasteners

- A. DRILL•TEC™ membrane fasteners and plates, insulation fasteners and plates, and flashing fasteners and termination bars. Refer to the Insulation Attachment Table at the end of this section for the correct type, length and diameter.

2.05 Adhesives and Sealants

- A. EverGuard® TPO bonding adhesives, sealants and caulking.
 - 1. EverGuard® Bonding Adhesive (solvent-based).
 - 2. EverGuard® H2O Bonding Adhesive (low VOC).
 - 3. EverGuard® 2-Part Pourable Sealant for use in coated metal sealant pans.
 - 4. EverGuard® Caulking for use in sealing termination bars and penetration clamping bands.
 - 5. EverGuard® TPO Cut Edge Sealant.
 - 6. Roofing asphalt. ASTM D-312, Type III or Type IV.
 - 7. EverGuard® Water Block for use in sealing behind termination bars and at drain flanges as a water cut-off.
 - 8. EverGuard® TPO primer.

2.06 Insulation

- A. EnergyGuard™ foam insulation of the following types. Minimum 1” thickness. Board size to be 4’ x 8’ panels for mechanical attachment, and 4’ x 4’ for adhered attachment and tapered systems.
1. EnergyGuard™ & EnergyGuard™ Ultra polyisocyanurate insulation w/ glass-based facer meeting or exceeding the requirements for ASTM C-1289 (min. 16 psi compressive strength).
 2. EnergyGuard™ extruded polystyrene insulation meeting or exceeding the requirements for ASTM D-578, Type X (minimum 15 psi compressive strength).
 3. EnergyGuard™ expanded polystyrene insulation with plastic facer meeting or exceeding the requirements for ASTM D-578, Type II (minimum 15 psi compressive strength).

2.07 Insulation – High Traffic Applications

- A. EnergyGuard foam insulation of the following types. Minimum 1” thickness. Board size to be 4’ x 8’ panels for mechanical attachment, and 4’ x 4’ for adhered attachment and tapered systems.
1. EnergyGuard™ & EnergyGuard Ultra polyisocyanurate insulation w/ glass-based facer meeting or exceeding the requirements of ASTM C-1289 (min. 25 psi compressive strength).
 2. EnergyGuard™ extruded polystyrene insulation meeting or exceeding the requirements for ASTM D-578, Type IV (minimum 25 psi compressive strength).
 3. EnergyGuard™ expanded polystyrene insulation meeting or exceeding the requirements for ASTM D-578, Type IX (minimum 25 psi compressive strength).

2.08 Recover Board

- A. EnergyGuard™ Perlite insulation, minimum 1/2", ASTM C-728B. High density wood fiber insulation, minimum 1/2", ASTM C-208, Class E.
- C. EnergyGuard foam recover board of the following types. Board size to be 4’ x 8’ panels for mechanical attachment and 4’ x 4’ for adhered attachment and tapered systems.
1. EnergyGuard™ and EnergyGuard™ Ultra 1/2” poly isocyanurate recover board insulation with glass-based facer meeting or exceeding ASTM C-1289 (min. 16 psi compressive strength).

2.09 Other Accessories

- A. Subject to compliance with requirements, provide the following products not available from GAF:
1. Wood Nailers: New wood nailers shall be pressure-treated for rot resistance, #2 or better lumber. Asphaltic or creosote-treated lumber is not acceptable.
 2. Roofing Nails: Galvanized or non-ferrous type and size as required to suit application.
 3. Temporary Sealant: Polyurethane foam sealant or similar to provide watertight roofing seal.
 4. Air/Vapor Barrier: Polyethylene sheeting, minimum 6 mil for TPO only.
 5. Air/Vapor Barrier: Asphalt impregnated Kraft paper composite (Permate by BMCA).
 6. Fire Barrier: Silicone-treated fiberglass-faced gypsum panels, minimum 1/4” thick (Dens-Deck® or Dens-Deck® Prime, by Georgia-Pacific or SecureRock™ by USG).
 7. Urethane Adhesive: Membrane and/or insulation adhesive of acceptable type from approved manufacturer. Requires special approval from GAF Contractor Services.

2.10 GardenScapes™ System

- A. GardenScapes™ garden roof system components are designed to be used in conjunction with each other. Do not substitute other components.
1. DuraGro™ 4-in-1 Drainage Foundation System: Includes separation mat/water retention mat, drainage core and filter fabric.
 2. Start-Rite™ Growing Medium: Regionally blended includes activated carbon and growth agent for fuller, healthier sedum growth.
 3. Sedum: Regional vegetation suited for project location climates.
 4. Accessories: Full-line of stainless steel edging, corners, attachment plates and heavy duty plastic module drain boxes (from 4” – 12” high).

Part 3 – Execution

3.01 Site Conditions

- A. Obtain verification that the building structure can accommodate the added weight of the new roofing system.
- B. Confirm the adequacy of the new roofing system to provide positive slope to drain. Eliminate ponding areas by the addition of drainage locations or by providing additional pitch to the roof surface.
- C. All defects in the roof deck or substrate shall be corrected by the responsible parties before new roofing work commences. Verify that the deck surface is dry, sound, clean and smooth, free of depressions, waves, or projections. GAF is not responsible for determining the acceptability of the deck.
- D. Protect building surfaces against damage and contamination from roofing work.
- E. Where work must continue over completed roof areas, it is the general contractor's responsibility to protect the finished roofing system from damage. When no general contractor is involved, the roofing contractor is responsible for protecting finished roofing surfaces from damage.
- F. Deck preparation is the sole responsibility of the building owner or roofing contractor. All defects in the roof deck or substrate shall be corrected before roofing work commences.
- G. Prepare substrate surfaces thoroughly prior to application of new roofing materials. This is particularly important for recover and re-roofing applications. Preparation includes, but is not limited to, removal of existing flashings, replacement of wet/damaged existing roofing materials, removal of loose aggregate, removal of abandoned equipment, supports and penetrations, replacement of damaged decking, etc. Providing a smooth, even, sound, clean and dry substrate minimizes the likelihood that underlying deficiencies will cause premature deterioration or even failure of the new roofing system.

3.02 Preparation of Roofing Area – New and Tear-off Applications

- A. Remove all existing roofing materials to the roof decking, including flashings, metal edgings, drain leads, pipe boots, and pitch pockets, and clean substrate surfaces of all asphalt and adhesive contaminants.
- B. Confirm quality and condition of roof decking by visual inspection, and by fastener pull-out testing.
- C. Secure all loose decking. Remove and replace all deteriorated decking.
- D. Remove abandoned equipment and equipment supports.
- E. Confirm that height of equipment supports will allow the installation of full-height flashings.

3.03 Preparation of Roofing Area – Recover Applications

- A. Remove all stone ballast, loose gravel, and debris from the roof surface.
- B. Remove blisters and ridges from the roof membrane.
- C. Cut membrane away from all perimeter and penetration securements.
- D. Remove all existing flashings, including metal edgings, drain leads, pipe boots, and pitch pockets, and clean substrate surfaces of all asphalt and adhesive contaminants. If the wall/curb flashings are in good condition and tightly adhered to the substrate, new TPO flashing materials may be installed over these to a height of 18"; new PVC flashing materials may be installed over a separator layer of polymat or insulation board.
- E. The building owner must have a moisture survey performed to ascertain the condition and suitability of the existing roofing materials to receive a cover system. GAF will not be responsible for damage to the roofing system if it results from moisture in the existing roofing system. Remove and replace all existing roofing materials that contain moisture.
- F. Confirm quality and condition of roof decking by visual inspection if possible, and by fastener pull-out testing. Remove and replace all deteriorated decking.
- G. Remove abandoned equipment and equipment supports.
- H. Raise equipment supports to allow the installation of full-height flashings.
- I. Recover installation over coal tar pitch roofs is not acceptable.

3.04 Wood Nailer Installation

A. Acceptable Material

1. Solid Blocking: Pressure-treated wood, #2 Grade or better, nominal 5/4" x 4" minimum; stagger multiple layers.
2. Shim Material: Pressure-treated plywood, 1/2" x width to match solid blocking.

B. Existing Nailers

Anchor to resist 250 lb. per ft. load applied in any direction.

1. DRILL•TEC™ HD screws 18" on center attachment to structural wood, steel decks. Minimum 1" thread embedment.
2. DRILL•TEC™ spikes 18" on center attachment to concrete decks. Minimum 1" shank penetration.
3. DRILL•TEC™ Polymer screws 12" on center attachment to gypsum concrete, cellular concrete, cementitious wood fiberdecks. Minimum 1-1/2" thread embedment.
4. 3 anchors per length of wood nailer minimum.

C. New Nailers

Anchor to resist 250 lb. per ft. load applied in any direction.

1. DRILL•TEC™ HD screws 18" on center attachment to structural wood, steel decks. Minimum 1" thread embedment.
2. DRILL•TEC™ spikes 18" on center attachment to concrete decks. Minimum 1" shank penetration.
3. DRILL•TEC™ Polymer screws 12" on center attachment to gypsum concrete, cellular concrete, cementitious woodfiber decks. Minimum 1-1/2" thread embedment.
4. 3 anchors per length of wood nailer minimum.

D. Shim Material

Secure simultaneously with overlying solid wood nailer.

1. Shim material must be continuous; spaced shims are not acceptable.

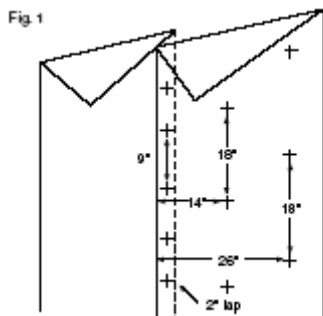
3.05 Base Sheet Installation

A. General

1. Fiberglass base sheet shall typically be installed over all nailable substrates other than gravel-surfaced built-up roofing whenever insulation, recover board, or fire barrier board is installed in hot asphalt.
2. Nailable base sheet shall be applied over substrates that are not suitable for asphalt adhesion.
3. Install base sheet so that wrinkles and buckles are not formed.
4. Overlap base sheet a minimum of 2" for side laps and 6" for end laps.

B. Mechanical Securement - Nailable Base Sheet

1. Secure nailable base sheet to the deck. Use appropriate type and length of approved fastener for structural deck type, and install required number of fasteners in accordance with Figure 1.
2. Pre-drilling is required for concrete decks, and may be required for gypsum concrete and cementitious woodfiber decks.
3. Install fasteners such that the fastener plate is pulled flush with the venting base sheet surface and lies flat on the deck surface.



3.06 Recover Board/Insulation Installation

A. General

1. Insulation board shall be installed as required.
2. A recover board overlay must be installed over expanded or extruded polystyrene insulation for all membrane applications adhered in solvent-based bonding adhesive. The use of an overlay board with the joints taped is required for all membrane applications adhered in hot asphalt over polystyrene insulation. Perlite is only acceptable as a recover board when the membrane is installed in hot asphalt.
3. The use of extruded and expanded polystyrene insulations is limited to a maximum roof membrane temperature of 165°F.

B. Placement

1. Butt insulation boards together with a 1/4" maximum space between adjoining boards. Fit insulation boards around penetrations and perimeter with a 1/4" maximum space between board and penetration.
2. Install insulation boards in pieces a minimum of 2' x 2' in size. Every piece shall be properly secured to the substrate.
3. Insulation boards installed in multiple layers shall have the joints between boards staggered a minimum of 6" between layers.
4. Insulation boards installed over steel decking shall have boards placed perpendicular to deck flutes with edges over flute surface for bearing support.
5. Insulation shall be tapered to provide a sump area a minimum of 36" x 36" at all drains.
6. Insulation boards that are wet, warped or buckled shall not be installed and must be discarded. Insulation boards that are broken, cracked, or crushed shall not be installed unless the damaged area is first removed and discarded.
7. Insulation boards that become wet or damaged after installation must be removed and replaced.
8. Install no more insulation than can be properly covered by the end of each day with roofing membrane.

C. Mechanical Securement

1. This application method is suitable for all deck and insulation types. For GardenScapes™ roof systems, GAF does recommend a second layer of insulation be adhered to the mechanically attached first layer of insulation.
2. Use appropriate type and length of approved fastener for structural deck type. Install required number of fasteners per insulation type and board size in accordance with the Insulation Attachment Table.
3. Pre-drilling is required for concrete decks, and may be required for gypsum concrete and cementitious woodfiber decks.
4. Install fasteners such that the fastener plate is pulled slightly below the insulation board surface.
5. Use fastener of correct length as required by the Insulation Attachment Table. The use of any fastener greater than 8" in length must be pre-approved by GAF Contractor Services.

D. Adhered Securement-Asphalt

1. Use ASTM D-312, Type III or Type IV asphalt.
2. Apply asphalt at the rate of 25 lbs. per 100 sq. ft. over the entire surface to which the insulation is to be adhered.
3. Asphalt application rates of up to 60 lbs. per 100 sq. ft. may be required if the substrate surface is rough or porous, such as an existing flood coat and gravel surfacing.

4. Apply asphalt at its EVT temperature to obtain a proper bond, typically within the range of 425-475° F degrees.
5. Walk in the insulation boards after installation to ensure a proper bond.
6. Maximum board size: 4' x 4'.
7. Hot asphalt application requires priming of concrete and gypsum decks and existing asphaltic roofing systems.

E. Adhered Securement-Adhesive

1. Depending on foam adhesive type, apply adhesive in full 1/4" - 1/2" thick coverage or in 3/4"-1" continuous beads according to the manufacturer's instructions.
2. Adhesive beads shall be evenly spaced at the rate required for the insulation board size and type of roofing system being installed.
3. Apply adhesive when the air and surface temperature is at least 40°F.
4. Additional adhesive beads must be installed in corner/perimeter roof areas for EverGuard™ Fully Adhered and TriPosite™ systems according to manufacturer's instructions.
5. Walk in the insulation boards after installation to ensure a proper bond.
6. Maximum board size: 4' x 4'.

3.07 Membrane Installation

A. Placement

1. Place roof membrane so that wrinkles and buckles are not formed. Any wrinkles or buckles must be removed from the sheet prior to permanent securement.
2. Full-width rolls shall be installed in the field and perimeter regions of the roof.
3. Overlap roof membrane a minimum of 3" for side laps of fully adhered systems that utilize smooth backed reinforced membrane. Membranes are provided with a lap line along the side laps; the black line is for mechanically attached system overlaps and the red line is for adhered and ballasted systems overlap.
4. Install membrane so that the laps run across the roof slope lapped towards drainage points.
5. All exposed sheet corners shall be rounded a minimum of 1".
6. All cut edges of reinforced TPO must be sealed with EverGuard® TPO Cut Edge Sealant.
7. Overlap roof membrane a minimum of 3" for end laps of EverGuard® TPO membranes. End laps for EverGuard Fleece-Back Membranes are made by butting adjacent sheets and heat welding an 8" wide EverGuard TPO reinforced membrane flashing strip over the joints.

B. Supplemental Securement

1. Roof membrane must be mechanically secured at the perimeter, at the base of internal walls and curbs, and at all penetrations with DRILL•TEC™ Membrane Fasteners and Plates at a 12" on center maximum spacing. Membrane may be heat welded to coated metal flanges.
Note: a minimum of 4 fasteners per penetration is required.
2. Alternatively, membrane may be extended vertically 3" up walls and curbs and secured to the wall/curb substrate within 2" of the plane of the roof with DRILL•TEC™ Membrane Fasteners and inverted Termination Bar at a 12" on center maximum spacing. This detail is required to be used for all pressurized buildings.
3. Mechanically attach membrane with screws and plates to the roof deck at locations of deck angle changes in excess of 5 angle degrees (1" in 12").
4. Fasteners must be installed to achieve the proper embedment depth. Install fasteners vertical to the deck, or horizontal to the wall/curb without lean or tilt.
5. Install fasteners so that the plate is drawn down tightly to the membrane surface. Properly installed fasteners will not allow the plate/termination bar to move (under driving), but will not cause wrinkling of the membrane (overdriving).

C. Cold Bonding Adhesive-Smooth Reinforced Membrane

1. Use appropriate bonding adhesive for substrate surface, applied with a solvent-resistant roller, brush or squeegee. When using EverGuard™ TPO adhesives, use any one of the following substrates: polyisocyanurate insulation (w/o foil facer), high density wood fiberboard, Dens-Deck®, Dens-Deck® Prime, Dens Guard®, SecureRock™ cured structural concrete absent of curing and sealing compound, untreated OSB, untreated CDX plywood, Type X gypsum board, and dry, sound masonry absent of curing or sealing compounds.
2. Fully adhere membrane sheets with bonding adhesive at the rate of 60 sq. ft. of finished, mated surface area per gallon for solvent-based bonding adhesives, and at the rate of 100 sq. ft. of finished, mated surface area per gallon for water-based bonding adhesive. Coverage rates will vary depending on substrate. Porous substrates may require double application of adhesive. Apply bonding adhesive to both the underside of the membrane and the substrate surface. Allow solvents or water in adhesive to flash off.
3. Prevent seam contamination by keeping the adhesive application a few inches back from the seam area.
4. Adhere approximately one half of the membrane sheet at a time. One half of the sheet's length shall be folded back in turn to allow for adhesive application.
5. For solvent-based adhesives, mate membrane to the substrate coated with adhesive once the bonding adhesive has flashed off and is tacky to the touch. Water-based adhesives must be allowed to dry completely; install membrane within one hour of drying.
6. Roll membrane to ensure complete bonding between adhesive and membrane.

D. Cold Bonding Adhesive-Fleece-Backed Membrane

1. Use appropriate bonding adhesive for substrate surface, applied with a solvent-resistant roller, brush or squeegee. When using EverGuard™ TPO adhesives, use any one of the following substrates: polyisocyanurate insulation (w/o foil facer), high density wood fiberboard, Dens-Deck®, Dens-Deck® Prime, Dens-Guard®, SecureRock™, cured structural concrete or gypsum absent of curing and sealing compound, untreated OSB, untreated CDX ply-wood, Type X gypsum board, and dry, sound masonry absent of curing or sealing compounds. Fleece-Back TPO membranes may be adhered to lightweight insulating concrete with water-based bonding adhesive.
2. Fully adhere membrane sheets with bonding adhesive at the rate of 60 sq. ft./gal. for solvent-based bonding adhesives, and at the rate of 100 sq. ft./gal. for water-based bonding adhesive. Coverage rates will vary depending on substrate. Apply bonding adhesive to substrate surface only.
3. Roll membrane into adhesive as soon as practical; do not allow to dry or string.
4. Broom or roll membrane to ensure complete bonding between adhesive and membrane.

E. Field Seaming

1. Fabricate field seams using a current-generation automatic hot air welding machine and a 10,000 watt volt-age-controlled generator minimum. Outdated welding equipment and inadequate/fluctuating electrical power are the most common causes of poor seam welds.
2. Equipment Settings- The correct speed and temperature settings for automatic welders are determined by preparing test welds at various settings. The welds are tested by application of pressure, causing the seam to peel apart. A satisfactory weld will fail by exposing the scrim reinforcement called a "film tearing bond." A deficient weld fails by separating between the two layers of the membrane.
3. Adjustments to Equipment Settings- Many factors will affect the settings: thicker membranes, lower air temperatures, and overcast skies will generally require a slower speed than would be required with thinner membranes, higher air temperatures, and sunny skies. The slower speed provides additional heat energy to compensate for heat-draining conditions. The test weld

- procedure should be conducted at the beginning of every work period (i.e., morning and afternoon) and following a change in weather (i.e., air temperature, wind speed, cloud cover.)
4. Membrane laps shall be heat-welded together. All welds shall be continuous, without voids or partial welds. Welds shall be free of burns and scorch marks.
 5. Weld width shall be a minimum 1-1/2" in width for automatic machine welding. Weld width shall be a minimum 2" in width for hand welding.
 6. All cut edges of reinforced TPO membrane must be sealed with EverGuard® TPO Cut Edge Sealant.
 7. Fleece-backed membrane end laps shall be covered with 8" wide strips of smooth reinforced membrane, welded to each side of the butt joint.

F. Membrane Surface Preparation

1. Membrane must be clean of dirt and contaminants, and free from dew, rain, and other sources of moisture. Factory-fresh membrane typically will not require cleaning prior to automatic welding, provided that welding is performed immediately after placement and securing of the membrane.
2. Membrane that has been exposed for over 12 hours or has become contaminated will require additional cleaning methods.
3. Light Contamination – Membrane that has been exposed overnight up to a few days to airborne debris, foot traffic, or dew or light precipitation can usually be cleaned with a white cloth moistened with EverGuard® TPO Cleaner. Be sure to wait for solvent to flash off prior to welding.
4. Dirt-Based Contamination – Membrane that is dirt-encrusted will require the use of a low-residue cleaner such as Formula 409 and a mildly abrasive scrubbing pad to remove the dirt. This must be followed by cleaning with a white cloth moistened with EverGuard® TPO Cleaner. Be sure to wait for cleaner to dry prior to welding.
5. Exposure-Based Contamination – Membrane that is weathered/oxidized will require the use of EverGuard® TPO Cleaner and a mildly abrasive scrubbing pad to remove the weathered/oxidized top surface layer. This must be followed by cleaning with a white cloth moistened with EverGuard® TPO Cleaner. Be sure to wait for cleaner to dry prior to welding. Unexposed membrane left in inventory for a year or more may need to be cleaned as instructed above.
6. Chemical-Based Contamination – Membrane that is contaminated with bonding adhesive, asphalt, flashing cement, grease and oil, and most other contaminants usually cannot be cleaned sufficiently to allow an adequate heat weld to the membrane surface. The membrane should be removed and replaced in these situations.

3.08 Flashing Installations

A. General

1. Flash all perimeter, curb and penetration conditions with coated metal, membrane flashing and flashing accessories as appropriate to site conditions.
2. All coated metal and membrane flashing corners shall be reinforced with preformed corners or unreinforced membrane.
3. Heat weld all flashing membranes, accessories and coated metal together to achieve a minimum 2" wide (hand welder) weld.
4. All cut edges of reinforced TPO membrane must be sealed with EverGuard® TPO Cut Edge Sealant.
5. When using bonding adhesive, be sure to use adhesive specific to membrane type.
6. Minimum flashing height is 8".
7. Refer to current EverGuard® Application and Specifications Manual for acceptable flashing details except as provided here in.

3.09 Traffic Protection

- A. Walkway paths should be installed at all roof access locations including ladders, hatchways, stairs and doors. Install walkways at other designated locations including roof-mounted equipment work locations and areas of repeated rooftop traffic.

3.10 Field Quality Control

- A. Inspect completed roof sections on a daily basis. It is the contractor's responsibility to probe all heat-welded seams and perform an adequate number of seam cuts to ascertain seam consistency.
- B. Immediately correct all defects, irregularities, and deficiencies identified during inspections.
- C. Remedial work shall be performed with like materials and in a manner consistent with the balance of the roofing installation so as to minimize the number of repair patches.
- D. Excessive patchwork will require replacement of the entire affected membrane section, from lap to lap.

3.11 Cleaning

- A. Remove bonding adhesive, bituminous markings and other contaminants from finished surfaces. In areas where finished surfaces are soiled by asphalt or any other source of soiling caused by work of this or other sections, consult manufacturer of surfaces for cleaning advice and conform to those instructions.
- B. Cut out and remove any sheet membrane contaminated with solvent-based adhesive, bituminous markings, and other contaminants from finished surface. Repair sheet damage by first cleaning the area with an all-purpose cleaner, then rinse off soapy residue. Reactivate membrane using the appropriate EverGuard® cleaner, wiping with a damp (not saturated) rag. Complete repair by installing a patch of like material to specific system requirements.

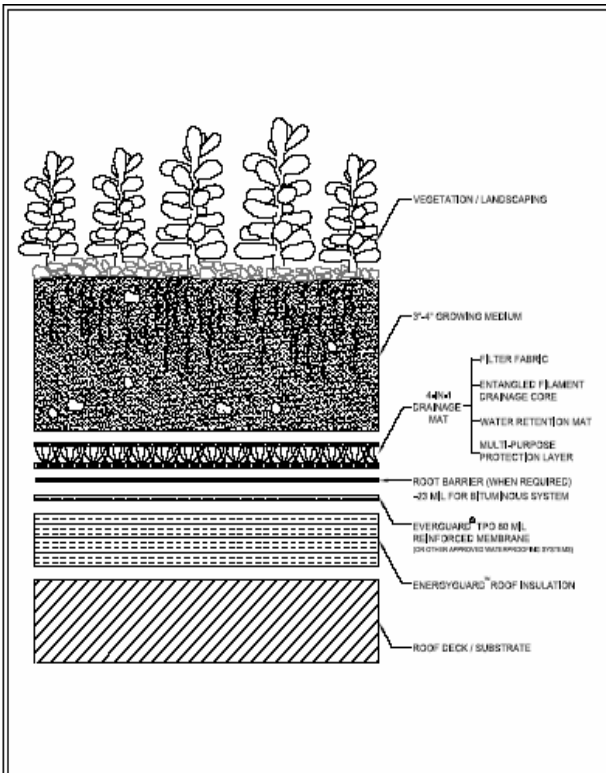
INSULATION ATTACHMENT TABLE FOR FULLY ADHERED SYSTEMS

NUMBER OF FASTENERS								
Insulation Type	Board Size	Thickness	Standard Attachment Fasteners/Board			FM Attachment Fasteners/Board		
			Field	Perimeter	Corner	Field	Perimeter	Corner
Isocyanurate	4x4	1" – 1.4"	8	12	15			
	4x4	1.5" – 1.9"	6	8	10	6 (8)	8 (12)	10 (14)
	4x4	2" minimum	4	6	8	4 (4)	6 (6)	8 (8)
	4x8	1" – 1.4"	16	24	28			
	4x8	1.5" – 1.9"	11	16	20	11 (16)	16 (24)	20 (28)
	4x8	2" minimum	8	12	15	8 (8)	12 (12)	15 (15)
EPS/XEPS ¹	4x4	1" – 1.4"	8	12	15			
	4x4	1.5" – 1.9"	6	8	10			
	4x4	2" minimum	4	6	8			
	4x8	1" – 1.4"	16	24	28			
	4x8	1.5" – 1.9"	11	16	20			
	4x8	2" minimum	8	12	15			
Gypsum Board	4x8	1/4" – 5/8"	16	24	28			
	4x8	1/2" minimum	16	24	28	16 (21)	24 (32)	28 (36)
Wood Fiber	4x4	1/2" minimum	6	8	10			
	4x4	1" minimum	4	6	8			
	4x8	1/2" minimum	8	12	10			
TYPE OF INSULATION FASTENERS								
Deck	Fastener		Plate		Penetration (minimum)			
Steel– all gauges	Drill•Tec HD (#14) or Standard (#12)		3" Galvalume		3/4" through the deck			
Wood – plank and sheathing	Drill•Tec HD (#14) or Standard (#12)		3" Galvalume		1" thread into/through the deck			
Structural Concrete	Drill•Tec HD (#14) or Drill•Tec Spike		3" Galvalume		1" thread/shank into the deck			
Insulating Concrete	Drill•Tec HD (#14)		3" Galvalume		3/4" thread through steel form			
Gypsum Concrete	Drill•Tec Polymer screw		3" Galvalume		1 1/2" thread into the deck			
Cementitious Wood fiber	Drill•Tec Polymer screw		3" Galvalume		1 1/2" thread into the deck			

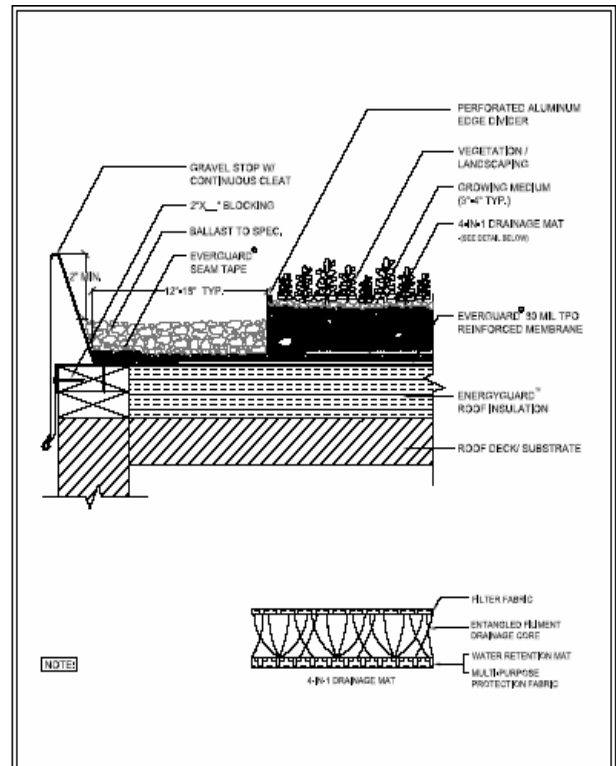
• Attachment requirements to meet determined uplift resistance are dependent on deck type, specific fastener, etc. refer to FM Loss Prevention Data Sheet 1-28
 • Numbers in FM section indicate I-90 attachment and numbers in () indicate FM I-90 fastener attachment patterns
 • ¹Water-based adhesive only fully adhering to EPS/XEPS insulation boards; no smooth PVC membrane direct to EPS/XEPS

Note: Alternately, system may be ballast applied. Refer to latest GAF EverGuard TPO Application & Specification Manual.

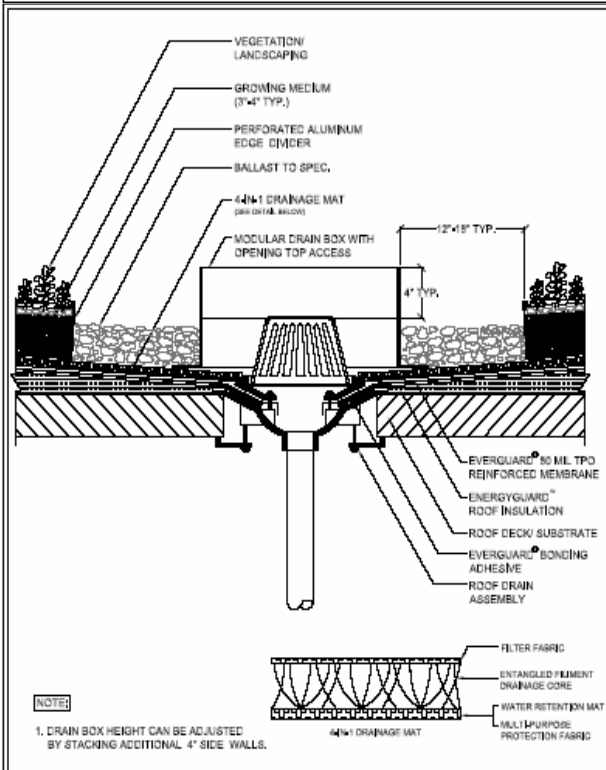
Part 4 - GardenScapes™ Flashing/Details



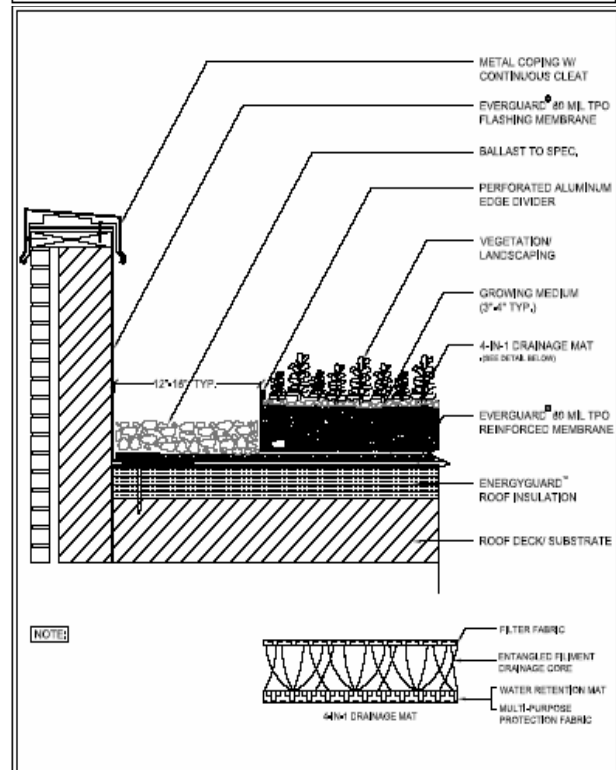
	GREEN ROOF SYSTEM	DRAWING # GS-100
	GardenScapes™	SCALE: N.T.S. 11-1407



	GRAVEL STOP COATED METAL EDGE DETAIL	DRAWING # GS-101
	GardenScapes™	SCALE: N.T.S. 11-1407



	ROOF DRAIN INSERT DETAIL	DRAWING # GS-102
	GardenScapes™	SCALE: N.T.S. 11-1407



	PARAPET WALL FLASHING DETAIL	DRAWING # GS-103
	GardenScapes™	SCALE: N.T.S. 11-1407

Part 5 - GardenScapes™ Application Process

5.01 Preparation

- A. Before you continue the installation of your GardenScapes™ Garden Roof system, do the following:
1. Read instructions thoroughly and understand how the whole system works.
 2. Understand the materials and know when and where to use each component, why each is necessary and the common mistakes to avoid.



5.02 - Safety

- A. Wear appropriate clothing.
1. Wear approved fall protection equipment as required. Common rooftop safety precautions should always be implemented.
 2. Beware of your surroundings and use common sense on your jobsite.
 3. Always follow local building codes.

5.03 - Tools

- A. HD scissors for cutting the drainage mat
B. Safety knives for opening bags or totes
C. Metal saw or good snips for cutting the retaining edge
D. Shovels for spreading the growing medium
E. Wheel borrows (depends on location of material)
F. Buckets for installing the drainage stone (unless bagged)
G. Metal rakes for leveling out media surface
H. Trowels (small hand shovels) for planting. (Assuming plug plantings)
I. Water and a hose with a nozzle or spray lance for watering after planting

5.04 - GardenScapes™ Materials

- A. DuraGro™ Exclusive 4-in-1 Drain Foundation mat. This all-inclusive mat takes the place of multiple components that make up other garden roof systems. Each roll covers 200 sq. ft.
B. Start-Rite™ Growing Medium. Specially formulated mix that is specific to region and includes 2 additives that help promote growth and aid in the filtration of the run off water.
C. Sedum. Grown specifically for GAF GardenScapes™ system installations, all vegetation is carefully maintained and shipped to ensure a quality installation.
D. Accessories. A full array of retainer edging, drain box edging, modular drain boxes as well as other additional components are available.
E. Root Barrier*. Only required when asphaltic waterproofing membranes are used.

5.05 - Preparing for a GardenScapes™ Installation

- A. Inspect the roofing membrane and all flashings. It is strongly recommended that the roof be flood tested with a minimum of 2” (51mm) for a 48 hour period. Plug drains and contain water as required. (Note: if your GardenScapes™ installation is to receive a GAF Diamond Pledge™ Guarantee, you must follow all inspection and test requirements. See Part 6.)
- B. Proceed with installation after a final satisfactory inspection is performed and any necessary repairs are made.
- C. Clean membrane with broom to ensure all debris is removed.
- D. Protect membrane that is left exposed during installation.



5.06 - Installation of GardenScapes™ DuraGro™ 4-in-1 Drainage Foundation

- A. Roll out the GardenScapes™ 4-in-1 water retention and separation layer in full sheet widths, lapping 6” (152 mm) on all side and end laps. Stagger all adjacent end laps a minimum 18” (458 mm) apart.
- B. Be sure that water retention (thicker mat) is installed directly to the roofing membrane and that the filter fabric (thinner material) faces up.
- C. Make sure all laps are parallel or perpendicular to the roof slope of the roof, such that the flow of water is never against the lap.
- D. Make sure the 4-in-1 water retention and separation layer is extended to the perimeter of all building edges, parapet walls, and curbs.
- E. Cut out the 4-in-1 water retention and separation layer to fit snugly around all roof top penetrations, drains, and curbs.



5.07 - Installation of Module Drain Box

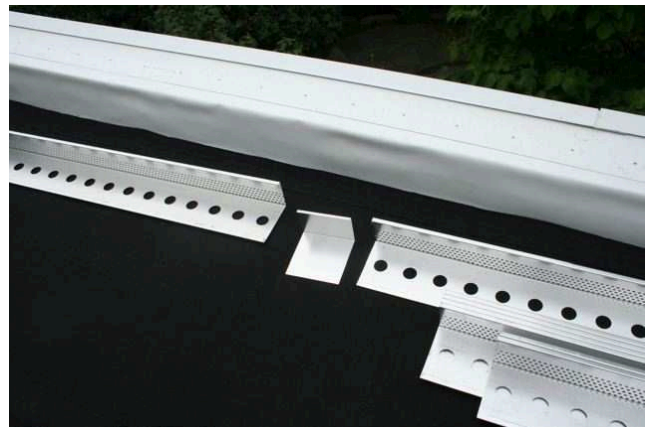
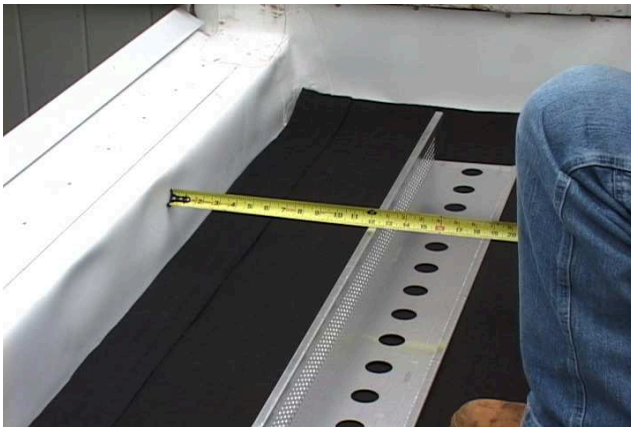
- A. Install GardenScapes™ drain boxes at all drains on the roof top.
- B. Add additional side sections if more height is needed around or over drain.



5.08 - Installation of Metal Edging

- A. Install GardenScapes™ gravel guard metal around the entire perimeter of the building, around all curbs, drains, and roof top penetrations (Modification to drain box edging may be required to fit with ballast. Use connector plates or a small section of straight edging to expand as needed). Ensure the larger drainage holes on the gravel guard are facing up (directly on 4-in-1 mat) at all times. The gravel guard must be a min. of 12” (305 mm) from the edge of the drain box, building perimeter, curbs or penetrations.
- B. Completely fill in the 12” (305 mm) area around the drain box, the building perimeter, curbs or penetrations with drainage gravel or pavers.

Note: Abide by all local codes for this dimension.



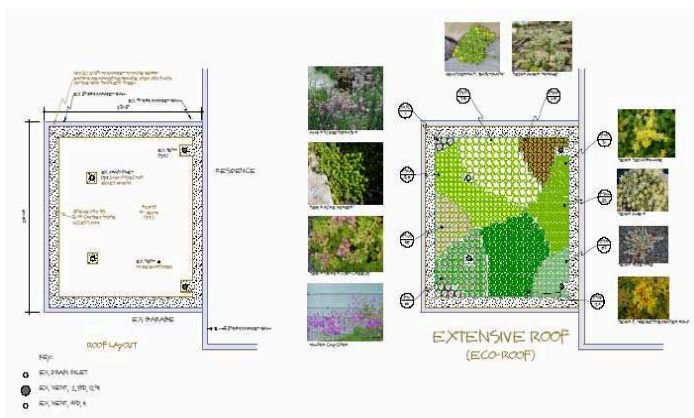
5.09 - Installation of Start-Rite™ Growing Medium

- A. Install the GardenScapes™ Start-Rite™ Growing Medium in a full and uniform application that will achieve minimum 4” (102 mm) coverage after compaction.
- B. Compaction of the growing media shall be performed with a minimum 200 lbs roller or hand compactor until a compression rate of a minimum 50% compaction is achieved as outlined in ASTM D-1557.
- C. After the GardenScapes™ Start-Rite™ growing medium is compacted, the additional soil is then installed and thoroughly watered. Fill in any settled areas with the growing media and re-wet to ensure an even surface.



5.10 - Installation of GardenScapes™ Vegetation

- A. Finally plant all GardenScapes™ Vegetation in accordance with the landscape architect/designer plans and instructions for the recommended soil types and climate of the regions.
- B. Water completed areas thoroughly.



5.11 - Installation of Optional Paver Components

- A. Walkways and vegetation-free zones are used to control the movement of users on accessible garden roofs and to allow for easy maintenance access to mechanical equipment and system components. A pathway should be dedicated to and designed to guide pedestrian traffic for maintenance purposes
1. Where pavers are being installed, they must be weather resistant.
 2. Pavers can be solid such as pre-cast concrete or a recycled rubber type.
 3. Pavers should be installed so that the top of the pavers are flush with the growing medium surface.
- B. Material Description
1. There is a wide range of products such as:
 - Pre-cast concrete pavers
 - Natural stone
 - Gravel
 - Wood
 - Fiberglass rocks
 - Recycled plastic decking
 - Concrete slabs

5.12 - Stone Ballast/Pavers

- A. Smooth and clean stone ballast, with rounded edges and corners, worn by water washing, typically referred to as river-washed stone. Subject to compliance with requirements, provide stone ballast in accordance with the following:
1. Size gradation of 3/4" to 1-1/2" diameter, No. 4 conforming to ASTM D448.
 2. Size gradation of 1" to 2-1/2" diameter, No. 2 conforming to ASTM D448.
- B. Heavyweight non-interlocking freeze/thaw resistant concrete pavers with smooth bottom surface finish. Approximate size of 18" x 18" to 30" x 30", approximate weight of 25 lbs./sq.ft.

5.13 - Traffic Protection

- A. Walkway paths should be installed at all roof access locations including ladders, hatchways, stairs and doors. Install walkway pads/rolls at other designated locations including roof-mounted equipment work locations and areas of repeated rooftop traffic.

Part 6 - Inspection

- A. GAF will inspect only those roofs where a guarantee is to be issued or where special inspection services have been agreed to be purchased prior to the start of the roof construction and the current charge for the guarantee or inspection service has been paid.
- B. GAF reserves the right to waive inspection of guaranteed roofs when, in its opinion, one is not necessary.
- C. Any inspection made by GAF is for its own use only and does not constitute a waiver of any of the terms and conditions of the guarantee.
- D. In order to be eligible for a GardenScapes™ roofing system guarantee, the following inspections and testing must be completed:
1. At the installation of the membrane & flashings, an interim inspection must be completed.
 2. Prior to water testing, all punchlist items must be remedied.
 3. A 48 hour water test must be performed and a test report sent to GAF. (See Part 7). If water entered the roofing system during this test, GAF must be notified for another inspection and GAF reserves the right to request a follow-up water test.
 4. After successful completion of the water test, the GardenScapes™ overburden system should be installed.
 5. A final inspection of the completed GardenScapes™ system must be performed by GAF prior to issuance of the roofing system guarantee.

6.01 – Plant Inspection

- A. Plants should be immediately removed from shipping packaging upon arrival and watered as needed. If the plants arrive before the site is ready for planting, then the plants should be laid out and cared for until installation is started.
- B. Inspections should be performed at the nursery and upon plant arrival at the site. Acceptance conditions should be outlined in the contract between the supplier and purchaser.
- C. Photographs may be included for project record and plant identification and placement.
- D. Inspections may be required to be conducted by several entities including, Nurserymen, Customs officials, State agriculture officials and/or Site inspectors.
- E. All plants should be tagged at their place of growth by the nursery. .

Part 7 - Flood Test

- A. Most roofing systems are designed to resist the passage of water that will have minimal amounts of hydrostatic pressure, such as flowing water. A distinction must be made between roofing systems and waterproofing systems with regard to the appropriateness and benefits of flood testing.
- B. Waterproofing systems are designed to stop the migration of water from the roof into the supporting structure under conditions of hydrostatic pressure, such as standing or ponding water.
- C. It is important to determine whether the garden roof has been designed to sustain loads resulting from standing water for extended periods of time, or whether it is expected that it will be necessary to withstand minimal amounts of hydrostatic pressure during its service life.
 - 1. **Flood Test:** *The process in which a controlled amount of water, usually 2” (51 mm), is temporarily retained (i.e. drains are closed) for a period of 24 to 48 hours over a horizontal surface to determine the effectiveness of the waterproofing system.*
 - 2. In some cases, temporary dams may need to be built to retain the water on the surface of the waterproofing material.
- D. **Note:** Extreme care must be taken to make certain that the weight of the water, including any water that may fall during the test period, does not exceed the structural capacity of the deck. Additionally, the height of the water should not exceed the height of the lowest flashing.
 - 1. Flood testing may overwhelm the capacity of various components (e.g. drains and vent pipes) to resist the passage of water under the obligatory significant hydrostatic loads. Such testing does not generally reflect the environment to which the roof will be exposed in service.
 - 2. Should there be a breach in the roof membrane system during the test, serious leakage and consequential damage will result from the large amount of water entering the building.
 - 3. If a leak is detected, it must be repaired immediately and documented to both contractor and roofing manufacturer.

Part 8 – Post Water Test Considerations

- A. After a waterproofing system has been installed and tested, the roofing contractor and/or the general contractor should assign a party to provide supervision and protection of the waterproofing membrane until the components of the garden roof are installed.
- B. Accessory items, such as electrical conduits, irrigation lines, piping, should not be attached to roofing membrane.
- C. Damage to a roof system caused by other trades is a major source of subsequent garden roof system problems. Construction traffic, staging, other trades’ work, debris and contaminants should be kept off finished waterproofing membrane.
- D. Damage can be difficult to find and leaks or point of water entry into the garden roof system can remain undetected for an extended period of time which may lead to future problems, such as, but not limited to, structural deterioration.
- E. Where construction damage is probable, the use of a temporary water-proofing system should be considered.

Part 9 – Maintenance

- A. Among the issues property owners need to consider in planning for inspection and maintenance of garden roofs are:
1. Plant condition. Are they healthy?
 2. Uncontrolled vegetation
 3. Weeds growing
 4. Disease or pest damage
 5. Moisture levels. Water plants if rainfall drought exceeds three to four weeks. Watering new garden roofs every other day until the plant roots are established is strongly recommended.
 6. Does the irrigation system work properly?
 7. Do dead plants need to be removed or replaced?
 8. Is there any root penetration or other physical damage to the roof membrane
 9. Are there any open flashing membrane seams or terminations?
 10. Signs of soil erosion and soil overflow at retention walls.
 11. Accumulation of fallen leaves, mud, soil, and weeds located in drains.
- B. The maintenance plan needs to outline the physical process for maintenance, but it also is important to assign responsibility for the removal of and care for growing medium and vegetation in the event of a leak.
- C. Additionally, maintenance plans should also establish a method to assign responsibility in the event of a leak.
1. Make sure that problems are investigated and repaired as quickly as possible.
 2. Inspect and clean drains a minimum of 4 times per year.
 3. Inspect sealant on sheet metal flashing components yearly and reseal as required.
 4. Ensure metal counter flashings are in place and are inspected after every major wind event.
 5. Utilize preventative maintenance from the project's outset, which should be reviewed by contractors and manufacturers to ensure that the maintenance meet warranty conditions.
 6. Provide a record of construction showing the name and phone numbers of designers, contractors and subcontractors.
 7. Require an "as-built" roof plan for future reference.
 8. Record all repairs to the roof.
 9. If the roof is not designed for accessibility, restrict access to minimize potential damage.
 10. Understand the terms and limitations of the warranty.
 11. Do not allow work on the roof that would nullify a warranty claim. Contact the original contractor and be certain that all work is approved by the contractor, manufacturer, and warranty holder before work is started.
 12. Review all roof maintenance requirements with who will work on the roof.
 13. Do not allow the use of large shovels, metal shovels or pointed shovels for the installation of new plants or maintenance of the landscaping. Alert contractors of the risk of damage to the membrane when using certain tools.
 14. Inspect deck soffits, the interior underside of the deck, periodically.
 15. Ensure that landscaping materials including growing medium are not installed above the predetermined height below the waterproofing flashings.
 16. Ensure that debris is removed regularly from the drainage basins.

9.01 – Maintenance Procedures

- A. **Irrigation.** The goal is to avoid damage due to drought. There is no way to predict the exact effort which might be necessary, since local weather conditions have a strong influence.
1. Within the first couple of weeks, periods without considerable rain or irrigation shouldn't be longer than two or three days depending on the temperature.
 2. After two weeks, when plants have started to grow into the Start-Rite™ medium, periods without rain or irrigation can be slowly extended.
 3. After 4 months, irrigation can be reduced to a minimum. Once plants have fully established, they can tolerate periods of drought lasting several weeks.
- B. **Weeding.** The goal is to avoid weeds reaching the roof and getting a chance to grow and spread seeds.
1. Garden roofs are a piece of nature and are built with natural materials. Although material suppliers try to eliminate weed seeds as much as possible, contamination cannot be avoided completely. Some seeds might even be airborne.
 2. For the first couple of months after installation, the garden roof should be checked weekly for weed growth. Pull all weeds by hand and put them in a plastic bag or container to avoid spreading seeds.
 3. After the initial phase, weeding should be done at least once a month. Monthly weeding is typically only necessary from March to October.
 4. Chemical weeding is not recommended and will void any vegetation warranty.
- C. **Pruning and Trimming.**
1. Prune and trim as needed to maintain proper appearance and plant health.
- D. **Feeding.**
1. Feed 6 oz per square with slow-release fertilizer in March or April each year after the year of installation.
- E. **Plant Replacement.**
1. Remove and replace dead plants immediately.
 2. Repeat the spreading of cuttings in areas where initially broadcasted sedum cuttings fail to grow.
- F. **Duration.**
1. Maintenance covered by the GardenScapes™ warranty contract will end two years after initial installation unless agreed upon between the property owner and the GardenScapes™ contractor.

Part 10 - Post Occupancy Assessment

- A. Post-occupancy evaluations tell how well a facility has met its desired goals in terms of its behavior, economics, social, and cultural contexts.
- B. A team with members from a variety of backgrounds (i.e. Environmental Engineering, Architecture, Agronomics, and Psychology etc) should conduct the inspection.
- C. While this is not a required step in the installation of your GardenScapes™ Roof System, it does provide a helpful indication for future projects.

10.01 - Post Construction *Best Practice*:

- A. Routine inspections
- B. Maintenance plan
- C. Anyone on roof should know of requirements of systems and the presence of monitors and sensors.
- D. Refer to ASTM E4200-06: Standard Guide for Selection, Installation, and Maintenance of Plants for Green Roof Systems.

Part 11 - Seasonal Constraints

11.01 Consideration must be given to seasonal limitations of plants.

- A. Note that changes to construction schedule may negatively impact plant survival and selection.
- B. The plant specifier must have a solid understanding of the vegetation's optimal planting period. He/She should consult with an educated garden roof professional or experienced Horticulturalist when choosing plants.
- C. Be certain that care is taken during plant selection that plants that do well at certain ground elevations, will also survive at a higher (i.e. roof height) elevation.
- D. Install garden roof vegetation in cool seasons to ensure a higher survival rate, befitting from natural precipitation to aid establishment.
- E. If installed during hot and/or dry periods, plants must be watered regularly to avoid damage.
- F. Planting should coincide with installation of Start-Rite™ growing medium to avoid erosion of medium.
- G. Proper maintenance for the first 2 years is critical for extensive garden roofs.
- H. Maintenance in many cases is ongoing and should be between the GardenScapes™ contractor and the property owner.

Part 12- Fertilization

- A. All garden roofs may not require scheduled fertilization, though it may be necessary during the initial establishment period (i.e. the first 2 years).
- B. The decision to leave out fertilization must be made early in the design phase.
- C. Specifying plants with high nutrient requirements will adversely affect the quality of water run-off. For example, Sedums are often selected for these kinds of projects because they do not deplete nutrient supply to the same extent as other plants, and therefore do not require additional fertilization.
 - 1. The use of fertilizer depends upon whether or not plant communities will be permitted to evolve naturally, adapting the gradual loss of nutrients.
- D. Over time, levels of organic material will diminish. The rate of decomposition will be affected by the climate in which the garden roof is located.
- E. Garden roofs in humid climates will experience growing medium decomposition and nutrient leaching, primarily nitrogen (N) and phosphorus (P), at an accelerated rate due to the elevated temperatures and increased rates of run-off.
- F. Generally, lost nutrients need to be supplemented through fertilization. This need can be diagnosed in two ways:
 - 1. Visually (by looking at leaf color, deficiency symptoms, growth difference between areas)
 - 2. Chemically (testing growing medium pH, salinity, etc. and through plant tests).
- G. Fertilizer is not needed if its omission does not lead to long-term nutrient depletion and does not negatively affect plant survival and growth.
- H. Table 12.01 on the next page compares the properties of organic and mineral fertilizers.
- I. Slow release fertilizers are better suited to the engineered properties of growing medium than liquid or gaseous fertilizers.
- J. Fertilization is necessary during the establishment period, but may not be required after the first 5 years unless plants show signs of deficiencies.

Table 12.01 Comparison of Organic and Mineral Fertilizers

	Organic	Mineral
Examples	Compost or Humus	N-P-K fertilizers
State	Liquid or Solid	Liquid, gaseous, or solid
Release	Slow	Quick or slow, depending on state
Application Method	via irrigation.	<i>Liquid:</i> Foliar sprays or via irrigation. <i>Gaseous:</i> subsurface injection. <i>Solid:</i> pellets inserted into the growing medium.
Frequency of Application	Yearly	Quarterly
Nutrient Content	Low-Medium	High
Effect on Soil Structure	Enhances soil structure	Does not affect soil structure
Effect on Water Retention	High	Low
Environmental Impact/Leaching	Low	High
Cost per unit	High	Low-Medium

12.02 – Application of Fertilization

- A. Fertilization can be applied directly (via broadcasting to root systems, foliar sprays, or by dissolving dry formulation in the irrigation system) or indirectly (when sections of a landscape are fertilized and other parts receive residual nutrients).
- B. Solid organic fertilizers usually take the form of compost or humus. They enhance soil structure and allow for greater water retention. This limits the occurrence of leaching, securing a continual supply of nutrients for plants and reducing contamination of receiving water bodies.
- C. Organic fertilizers can also be applied in liquid form that is distributed by an irrigation system. The efficiency of this method is dependent upon the composition and water retention capabilities of the growing medium.
- D. Key questions before applying fertilizer:
 - 1. Are the basic requirements of soil fertility fulfilled?
 - 2. Which nutrients are required (or not) for plant growth? In what quantity?
 - 3. Frequency at which nutrients need to be applied?
 - 4. Is fertilizer needed at planting time?
 - 5. Can the fertilizer negatively affect the waterproofing membrane or accessories?
- E. Liquid fertilizers deliver nutrients to plants quickly but their usefulness is associated to the composition of the growing medium. If the medium has a low water retention capacity, nutrients may pass quickly past the root system and from the roof into receiving water bodies.
- F. The only gaseous fertilizer is anhydrous ammonia. This product, which supplies nitrogen, is injected into the growing medium in liquid form and quickly vaporizes. During its evaporation, it is absorbed by water, growing medium, and plants. This method may have implications for air quality as it releases particulate matter and other air emissions.
- G. Solid, coated slow release fertilizers steadily discharge nutrients as they are in contact with water, while other water-insoluble forms are released gradually by microbial activity in the soil. They provide a continuous source for nutrients throughout the season rather than periodically saturating plants with fertilizer. This method may leach out of the media if the conditions are not conducive to nutrient uptake.
- H. Fertilizers should be applied carefully since a high concentration of nutrients can damage plants and adversely affect the quality of water runoff. The rate of application should be minimal.

Part 13 - Quality assurance

15.01 - Plant quality assurance programs

- A. Plant quality assurance programs as outlined in project specifications, include plant specific maintenance guidelines, inspections, and take warranty requirements into account. Disease and weed control is critical to assuring the continued quality of the garden roof system.
- B. Maintaining uninterrupted vegetation coverage reduces the space available for foreign plants to grow. Proper care will significantly reduce the chances of disease and weed propagation.
- C. Follow steps as outlined in the Maintenance section of this document.

13.01 - Vegetation Quality Assurance Best Practices:

- A. Include quality assurance requirements for maintenance, inspections, and warranties in the specifications. .
- B. Schedule final planting and warranty period maintenance.
- C. Experienced professionals should review installation throughout the process.
- D. Review contractor's performance, including maintenance.
- E. Establish a schedule of inspections for specified percent ground coverage and weeds.

General

GAF Materials Corporation (GAF) offers roof guarantees for a fee for all roofing system specifications published in this manual when installed by GAF Certified GardenScapes™ Roofing Contractors in accordance with the terms and conditions set forth in this manual, and the procedures for obtaining a guarantee are followed. All GAF and BMCA insulation, fasteners, pre-flashed details, expansion joint covers, cements, coatings, GardenScapes™ system components and accessory products as job appropriate are required for guarantees unless otherwise approved in writing by the Regional Contractor Services Manager prior to installation.

All guaranteed roofing systems must be flashed in accordance with GAF flashing requirements and details. GAF will be the sole judge as to whether or not a roofing guarantee will be issued to cover any proposed or completed roof. The issuance of a guarantee and/or the continued liability there under is partly contingent upon payment of established charges.

GAF has no obligation to issue a roofing guarantee on any roof. Any inspection prior to issuance is solely for the benefit of GAF. In the event that a roof system does not conform to GAF standards and a guarantee is not issued, no portion of the guarantee fee is refundable. GAF will not accept Notices of Award of Contract which indicate that the owner or architect has the option to accept or reject the guarantee upon completion of the roof.

GAF is not responsible for consequential damages in case of roof system failure. GAF has no control over a building's contents, type, quantity, positioning, or protection. A GAF guarantee cannot be withdrawn once it has been issued, although it may be cancelled subsequently by GAF for violation of its terms and conditions.