Roof Design Considerations

Information Sheet

GAF MATERIALS CORPORATION

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From North America's Largest Roofing Manufacturer™

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, GAFMC does have extensive experience in the practical aspects of roofing.

Our experience suggests that careful consideration of the following will provide a fundamentally sound basis for design and selection of GAFMC roofing systems.

Balanced Performance

All other factors being equal, the most desirable roofing systems tend to be the ones that provide balanced performance, addressing not just the need for a watertight roofing membrane, but any and all other factors that are necessary to preserve and enhance the rooftop environment and the building as a whole.

Basic Considerations

Most roofing applications are relatively straightforward. Balanced performance considerations include the physical durability of the roofing membrane, the energy savings associated with roofing insulation, and the drainage capabilities of the roof. The following design elements are typically considered:

- Membrane design/number of plies as a measure of durability and longevity;
- Insulation thermal resistance to save energy loss through the roof;
- Need to add or enhance roof drainage capabilities by means of tapered board or cellular concrete insulation system, or additional drain points.

Additional Considerations

However, some roofing applications are more complex. Balanced performance considerations may require that a significant portion of available funds be dedicated to additional factors that involve building elements other than the roof system. Not addressing the overall rooftop environment and building structure will often cause a roofing system to fail to live up to expectations, and lead to an accelerated roof replacement schedule. Although not an exhaustive list, the following additional design elements may typically require consideration:

- Replacement of damaged roof decking or structural components;
- Improvement of roof access;
- Removal of unused rooftop equipment and associated equipment mountings;
- Remounting of rooftop equipment to allow proper roofing and flashing technique;
- Matching of architectural elements such as special perimeter metalwork;
- Repair of deteriorated parapet and penthouse walls;
- Protection of roofing membrane by means of walkway pad system.
- Compliance with applicable building codes

Installed vs. Life Cycle Costs

Many factors enter into the establishment of a roofing budget and selection of a roofing system. One of the more sophisticated decision methods involves comparing the initial installed costs of various roofing systems to their projected total costs over a longer period of time. Often, the roofing system that has the lowest initial cost will cost more over time due to a shorter life expectancy and related additional costs of roofing replacement.

Installed Cost

Factors favoring the primary consideration of initial installed cost include:

- Limited availability of funds;
- Limited period of building ownership/anticipated sale;
- Limited period of building occupancy for tenants responsible for roof maintenance;
- Accounting practices and/or tax considerations.

Installed vs. Life Cycle Costs (continued)

Life Cycle Cost

Usually, however, installing the highest quality roofing system that satisfies budgetary restraints is recommended. Factors favoring the consideration of long-term ownership cost include:

- Longer life expectancy;
- Reduced need for repair;
- Lower incidence of water infiltration problems.

There are various computerized models available that will analyze installed cost compared to life cycle cost; the best of these models consider relative energy savings, time value of money, material disposal costs, and maintenance expenditures to provide the most accurate comparison.

Building Construction

Building construction can have a significant impact on roofing system selection and design. Building| construction can be generalized into two basic categories:

Rigid Construction

Rigid construction is primarily based on reinforced concrete, solid brick masonry and stone, and structural steel with solid masonry walls. Rigid construction is characterized by limited building movement, as well as limited movement between exterior walls and roof deck. Roof decks associated with rigid construction are most commonly cast-in-place concrete, precast concrete units, steel pan with insulating cellular concrete, poured gypsum, and wood plank.

Rigid construction lends itself to the following roof system design considerations:

- Higher load-carrying capacity with less deflection, allowing use of ballast or pavers as finish surface;
- Difficulty in mechanical attachment into deck, encouraging use of adhered roofing materials;
- Limited need to accommodate movement between roofing membrane and flashings.

Flexible Construction

Flexible construction is primarily based on structural steel with curtain walls, wood or steel framing, tilt-up wall panels, precast concrete, and engineered steel assemblies. Flexible construction is characterized by significant building movement, particularly between exterior walls and roof deck. Roof decks associated with flexible construction are most commonly steel deck, plywood and oriented strandboard, and cementitous wood fiber panels.

Flexible construction lends itself to the following roof system design considerations:

- Lower load-carrying capacity with more deflection, encouraging use of lightweight roofing materials;
- Ease of mechanical attachment into deck, ideal for use of mechanically attached roofing materials;
- More need to accommodate movement between roofing membrane and flashings.

Building Utilization

Building utilization can have a significant impact on roofing system selection and design. The most common building utilization considerations are as follows: extremes in internal temperature/humidity, positive internal pressure, rooftop traffic/abuse, rooftop-exhausted contaminants, and the use of the roof as recreational space.

Internal Temperature/ Humidity

Extremes in internal temperature/humidity are most often associated with cold storage/freezer buildings, swimming pool facilities, laundries, car washes, wet process manufacturing facilities, drying kilns, food processing plants, paper/pulp mills, and smelting/blast furnace facilities. What makes these building applications unusual is that the pronounced difference in vapor pressure between the building interior and the exterior which can cause a pronounced vapor drive through the roof assembly. This can result in a significant build up of condensation within the roof assembly, and severe deterioration of both the roof assembly itself and the structural deck.

Because of the uniqueness of the temperature and humidity conditions, GAFMC will not issue guarantees on these types of buildings.

Physical Abuse

Roofing installations that can be expected to experience a high degree of roof traffic due to equipment maintenance, vandalism or other unauthorized access, frequent hailstorms or high winds, and prolonged periods of temperature extremes or rapid fluctuations in temperature, will require a more durable roofing system.

Relevant design considerations include:
- Use of thicker membrane accessories or additional base plies;
- Use of a higher compressive strength insulation substrate;
- Application of a walkway system for areas of high traffic.

Contamination

Many roofing installations are exposed to oil, grease and chemical contamination in excess of normal airborne contaminants. These conditions are most often associated with restaurants, food processing plants, chemical and pharmaceutical plants, refineries, machining and manufacturing facilities, and airports. Most roofing materials are degraded by certain families of contaminants, and will become brittle, swell and soften, or dissolve, depending on the contaminant type, concentration and degree of exposure. Long-term exposure testing of roofing material and specific contaminant remains the preferred method of determining material resistance. Even then, unforeseen combinations of contaminants, environmental exposure effects, and variation in contaminant concentration prevent an absolute prediction in all but the most common situations.

Specialized Application

Relevant design/maintenance considerations include:
- Use of containment pans or equipment;
- Isolation of contaminated roof area with expectation of more frequent roof membrane replacement;
- Periodic cleaning of the roofing membrane;
- Limitation of rooftop spillage/exhaust of contaminating materials.

Full utilization of the roof is increasing, particularly in urban areas where space is at a premium. Plaza deck roofing utilizing concrete pavers, and landscape or garden roofing, are two of the most common specialized roofing applications. Proper drainage and physical protection of the roofing membrane are critical considerations. Polymeric drainage boards and geotextile fabrics in multiple layers are commonly used to address these considerations. The performance of a flood test prior to the application of any materials above the roofing membrane is also critical; repair of the roofing membrane once the drainage, protection, and overburden layers have been installed is impractical and expensive, and is to be avoided at all costs.

Building Utilization (continued)

Specialized Applications (continued)

Every specialized roofing application has its own requirements. Design consideration for these applications is beyond the scope of this technical manual.

Fire Resistance

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

Reference to current GAFMC listings in the appropriate UL directory is recommended to verify roof assembly requirements for specific fire ratings. The following are general considerations to be followed when reviewing roof assemblies for fire ratings:

Construction Type and Deck Slope

- Non-combustible decks include steel, structural concrete, lightweight insulating concrete, gypsum concrete, and cementitious wood fiber.
- Combustible decks include wood, plywood and oriented strandboard.
- The greater the roof slope, the more directly a fire will act upon the roof surface, and the more difficult it will be for a roof system to achieve a specific fire rating.

Existing Roofing Over Non-Combustible Decks

- Determination of the UL classification of the existing roof is required.
- In many cases, all UL Class A, B or C roof systems with insulation installed over existing roofing will maintain their new UL Classification rating.
- All UL Class A, B or C roof systems without insulation installed over existing roofing require special evaluation based upon the existing roof system assembly.

Existing Roofing Over Combustible Decks

- Determination of the UL classification of the existing roof is required.
- All UL Class, A, B or C roof systems with insulation installed over existing UL Class A, B or C rated roofing will retain the lesser of the new or existing UL Classification ratings.
- In many cases, all combustible deck-rated UL Class A, B or C roof systems with insulation installed over existing roofing will maintain their new UL classification rating.
- All UL Class A, B or C roof systems without insulation installed over existing roofing require special evaluation based upon the existing roof system assembly.

Fire Resistance (continued)

The following are common fire codes and approvals typically used in conjunction with GAFMC roofing systems:

Underwriters Laboratories Class A,B,C

- Primary testing is based on ANSI/UL 790, which is similar to and meets all criteria of ASTM E-108. Tests for all decks measure flame spread on exterior surface of roof assembly.
- Additional testing for combustible decks is also based on ANSI/UL 790. Measures burn-through resistance from exterior through roof system-roof deck assembly.
- Ratings provided in Underwriters Laboratories Roofing Materials and Systems Directory as “Class A”, “Class B”, and “Class C” assemblies. Class A is the superior rating.
- Many GAFMC roofing systems are available with a Class A, B, or C rating.
- Roof deck-roof system assemblies must be constructed in exact accordance with the components listed for each rated assembly. No material substitutions are allowed.
- UL ratings are required by building codes for most building applications.

Underwriters Laboratories Hourly Ratings

- Testing based on ANSI/UL 253, which is similar to ASTM E-119. Measures burn-through resistance from interior through exterior of ceiling-roof deck-roof system assembly.
- Ratings provided in Underwriters Laboratories Fire Resistance Directory as “P-Number” assemblies.
- Ratings may be available with GAFMC roofing systems of 1 to 3 hours, depending on the deck and insulation configuration.
- Ceiling-roof deck-roof system assemblies must be constructed in exact accordance with the components listed for each P-Number assembly. No material substitutions are allowed.
- Hourly ratings are required by building codes for special building applications, and are usually not specified if not specifically required by code.
- Testing based on ASTM E-108. Measures flame spread on exterior surface of roof assembly.

Factory Mutual Research Class A, B, C

- Ratings provided in Factory Mutual Approval Guide, typically as part of a comprehensive roof system approval that also includes wind and hail resistance as other major test criteria.
- Many GAFMC roofing systems are available with a Class A rating.
- Roof deck-roof system assemblies must be constructed in exact accordance with the components listed for each rated assembly. No material substitutions are allowed.

ASTM E-108 Class ratings are required by building codes for most building applications, and are be provided as part of an overall FM roof system approval.

Wind Performance

Resistance by the roofing system to wind forces is an obvious requirement. Ideally, roofing systems should be capable of resisting the forces generated by the maximum anticipated wind speed for a specific building. One widely accepted method for specifying wind performance is to require an FM 1-60, 1-90, or higher rated system as appropriate for a specific building based upon location, exposure, etc. In general, additional securement of the roofing insulation can accommodate most requirements.

The following are general considerations to be followed when reviewing roof assemblies for wind ratings: (note: ASCE -7 is an alternative reference to Factory Mutual Loss Prevention Data Sheets.)

Location

- Coastal and mountainous locations generate higher wind speeds and, therefore, greater wind-related forces.
- Reference Factory Mutual Loss Prevention Data Sheet 1-28 for wind speed map.

Terrain

- Surrounding terrain that provides shielding or otherwise disturbs wind flow reduces wind energy that reaches the roof system.
- Refer to FM LPDS 1-28 for full descriptions of the following four defined terrain exposures:
    - Exposure A- Urban areas surrounded by higher buildings.
    - Exposure B- Suburban areas surrounded by buildings and vegetation of similar height.
    - Exposure C- Open areas without significant obstructions to wind.
    - Exposure D- Coastal areas directly exposed to large bodies of water.

Height

- Increased building height exposes roof systems to higher wind uplift forces that are present with higher roof locations.
- Refer to FM LPDS 1-29 for design tables that correlate wind uplift forces to geographic location, surrounding terrain and building height.

Construction Type

- Building with porous deck types will allow internal air pressure to affect the underside of the roof system, effectively increasing the overall forces being applied to the roof system.
- The installation of an air barrier over porous decks can effectively seal the deck and reduce the internal air pressures from reaching the roof system.
- The installation of an air barrier or other means of addressing the following combination of building conditions is required:
    - Air-permeable deck, i.e., steel, wood, and cementitious wood fiber, and excessive internal pressurization of building.
    - Air-permeable deck, i.e., steel, wood, and cementitious wood fiber, and openings in perimeter walls that exceed 25% of the wall area, such as aircraft hangers, distribution centers, etc.

Roof Regions

- Wind pressures are increased in the corners of the roof, and have increased pressures acting along the remaining roof perimeter. The remaining field area of the roof normally experiences significantly lower wind pressures than either the corner or perimeter areas.
- Refer to FM LPDS 1-28 for guidelines regarding roof areas.

Roof Slope

- Roof slopes in excess of 10% begin to create an additional ridge area of higher wind pressure, and create separate windward and leeward conditions.
- Refer to FM LPDS 1-28 for guidelines regarding roof areas.

Parapet Walls

- Parapet walls in excess of 3 ft. in height can reduce and even effectively eliminate corner regions from the roof, but tend to widen the perimeter region.
- Refer to FM LPDS 1-28 for guidelines regarding the effect of parapet wall on roof regions

The following are common uplift tests and levels of performance typically used in conjunction with GAFMC roofing systems:

Factory Mutual Research Wind Ratings

- Testing based on method described in Approval Standards 4450 and 4470.
- Test deck size is typically 12' x 24' or 5' x 9'.
- Measures resistance to upward pressures applied to the roof system.
- Ratings equate to design pressures by a 2:1 factor of safety:

1-60	=	30 psf design pressure.
1-75	=	37.5 psf design pressure.
1-90	=	45 psf design pressure.
1-105	=	52.5 psf design pressure.
1-120	=	60 psf design pressure.

- Higher ratings are available in 15 psf increments.

Underwriters Laboratories Wind Ratings

- Testing based on UL 580.
- Sample size is 10' x 10'.
- Measures resistance to a combination of negative pressure applied to the top surface of the roof system and oscillating positive pressure applied to the underside of the roof deck.
- Ratings provided in Underwriters Laboratories Roofing Materials and Systems Directory as "Roof Deck Constructions". Class 15, Class 30, Class 60, and Class 90 ratings are provided.

Underwriters Laboratories Wind Ratings

- UL Wind Class ratings are primarily utilized for testing metal roof and deck panels.
- UL Wind class ratings are not required by building codes.
- GAFMC roofing systems have not been evaluated by this test method.

American Society of Civil Engineers 7-98 Wind Design

- A comprehensive building load standard; section 6 means to analyze wind forces acting on buildings. Requires detailed calculations to determine actual wind pressures at different regions of the roof.
- Referenced by building codes.

Energy Efficiency

Thermal transmission standards have been established by building codes for most buildings. Roof insulation installed above the roof deck is a practical means of achieving the necessary energy efficiencies. In addition, the use of white-colored reflective membranes can reduce the heat load on air conditioning equipment, as well as providing a moderating effect on the temperature in proximity to the building.

Thermal transmission measurements and comparisons are referenced in various ways. The following is a description of common terminologies:

K-Value

- Thermal Conductivity – the number of BTU's (energy) that pass through a 1 inch thickness of a 1 square foot sample of homogenous material in one hour with a temperature difference between the two surfaces of 1°F.
- Units of Thermal Conductivity are expressed as: (BTU) (inch)/(h) (sq. ft.) (F).
- Thermal Conductivity only applies to a 1-inch thickness of a material, and as such is a qualitative physical property not directly suitable for determining insulation requirements.

C-Value

- Thermal Conductance – The number of BTU's (energy) that pass through a given thickness of a 1 square foot sample of material in one hour with a temperature difference between the two surfaces of 1°F.
- The C-Value is the reciprocal of the R-Value.
- Units of Thermal Conductance are expressed as: (BTU)/(h) (sq. ft.) (F).
- Thermal Conductance applies to an actual thickness of a material, and as such is a quantitative physical property that can be used for determining insulation requirements, but normally is not.

U-Factor

- Thermal Transmittance – The number of BTU's (energy) that pass through a 1 square foot sample of a total material assembly in one hour with a temperature difference between the two surfaces of 1°F.
- The U-Factor is the reciprocal of the summation of all R-Values for all materials in an assembly.

U-Factor (continued)

- Units of Thermal Transmittance are expressed as: (BTU)/(h) (sq. ft.) (F).
- Thermal Transmittance applies to an actual total material assembly, and as such is a quantitative physical property that can be used to represent the overall thermal performance of a system.

R-Value

- Thermal Resistance – The number of degrees difference between two surfaces (energy difference) that is required to obtain an energy flow of 1 BTU through a 1 square foot sample of a given material thickness in one hour.
- The R-Value is the reciprocal of the C-Value.
- Units of Thermal Resistance are expressed as: (F) (sq. ft.) (h)/(BTU).
- Thermal Resistance applies to an actual thickness of a material, and as such is a quantitative physical property that can be used for determining insulation requirements.

Based upon Model Energy Code guidelines, the following minimum roof insulation R-Values are suggested for various geographic building locations for typical building usage (refer to the Model Energy Code or local/state energy code for additional information):

- Alaska, Southern Canada
  R = 25 to 40
- New England, Upper Great Plains, Great Lakes, Mountain States
  R = 20 to 25
- Mid-Atlantic, Great Northwest, Lower Great Plains
  R = 14 to 18
- West Coast, Southwest, Deep South
  R = 12 to 17
- Gulf Coast, South Atlantic, Hawaii, Northern Mexico
  R = 10 to 14

The determination of potential energy savings based upon different types and thicknesses of roof insulation is a relatively complicated analysis that is beyond the scope of this manual. The following is a general description of one commonly used analysis method:

NRCA Energy Manual Method

Generalized Analysis

- Calculate total R-Value of roof assembly by adding the R-Values of each individual roof and deck component.
- Convert total R-Values (summer and winter) to U-Values.
- Determine energy savings in therms, BTU's, KWH, as appropriate for fuel type. This calculation considers U-Value, climate, roof size, and furnace/boiler/refrigeration efficiencies.
- Multiply calculated energy savings by local energy costs to obtain financial value of energy savings.

NRCA Energy Manual Method (continued)

- Different values will be required for summer and winter conditions due to differences in air layers immediately above the roof surface and immediately below the roof deck.
- Climate considerations and mechanical efficiencies are provided in tabular form for most major cities and typical equipment types.
- Performing calculations for two or more insulation thicknesses or types will allow for a reasonably accurate comparison of the cost of additional insulation to the value of energy savings.

Roof Drainage

Why Roofs Should Drain

- Standing water can result in deck deflection and possible structural damage.
- Water on the roof can promote vegetation, fungi and bacterial growth.
- In the event of an opening in the roof 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 gravitate through the membrane opening.
- Required by model building code.
- To prevent premature deterioration of roof membrane and flashing assemblies.

How to Obtain or Improve Drainage

- Provide structural slope in the deck assembly.
- Install a tapered insulation system. For recommendations on tapered roof insulation to provide slope for drainage, contact the GAFMC Technical Hotline at: 1-800-766-3411.
- Install tapered lightweight insulating concrete.
- Add additional drains.
- Use crickets, saddles and sumped drains.

Drainage Requirements

- Proper and adequate drainage is required and is the responsibility of those involved in the design and construction of the roof substrate and supporting structure. GAFMC recommends at least $^1/_4$" per ft. slope with proper grading to and placement of outlets. Guarantees will not cover leaks or damages in areas of a roof that pond water. GAFMC defines "ponding" as water that does not drain or dissipate from the roof surface within 48 hours after precipitation ends. Ponding can also result from other water sources, including improperly piped air conditioning condensate and steam condensate lines.

About Roof Drains

- A roof will drain free of water only as rapidly as drains and leaders will allow. When interior roof drains are used, they should be properly located and sufficient in number and size to drain all accumulated water from the surface of the roof in accordance with the local code. Special consideration should be given to the location of the drains and/or scuppers and gutters to insure their usefulness when deflection of the decking may reasonably be expected to occur after its installation.
- Roof drains designed to lengthen the period of drainage by metering the flow of water to storm sewers and constructing drainage of the roof in conformance with certain codes are at best hazardous to the overall performance of a roofing system. Anything that reduces good, immediate drainage of a roof presents a hazard.

About Roof Drains (continued)

- The size and locations of drains will vary with the slope of the deck, the roof surface (smooth or gravel), and the intensity of the possible maximum rainfall in the areas in which the building is to be erected. Many roof problems can be traced to improper spacing of drains, insufficient size of drains and leaders, inadequate gutter and valley drainage, and lack of scuppers and overflow drains.

- Drains should be appropriate size to allow for rapid removal of water according to local codes, maximum expected rainfall and ANSI requirements.

- Always recess drain heads below roof surface level to allow immediate water runoff. Drains and drain flashing shall be set a minimum of 1" (25 mm) below the roof level and located at least 18" (46 cm) away from all walls. Where the building has parapet walls, it is often necessary to form crickets with a definite high point between proposed drains and a definite low point at the drain location. Tapered insulation should be used at all drain edges to sump drains.

- Drains should not be less than 3" (2.6 cm) in diameter. When the location of drains has been determined, the actual roof areas draining to each outlet should be computed.

- Drains should be located to avoid forcing water to flow beyond a sharp turn. Intermediate drains should be located at not over 75 ft. (22.86m) to 50 ft. (15.24 m) intervals for steep roofs.

- Outlets should always be provided with suitable strainers to prevent debris from clogging the outlet or leader. Strainers should be made of a corrosion resistant material.

- Leaders: The cross sectional area of a leader should be uniform for its entire length. Tapered leaders may cause choking or backing up of water flow. The cross sectional area of the leader should be no less than the cross sectional area of the drain outlet.

- Provisions should be made to prevent leaders from freezing below the roof line.

- Overflows are a safety factor and should be installed above every drain/scupper. When they are eliminated to satisfy architectural requirements, if allowable by local building codes, adequate provisions should be made to increase the size of the drains and leaders. Overflows should be installed in accordance with local building codes and below the counter flashing.

- Gutters should be larger, never smaller, than the leader. When leaders are spaced more than 50 ft. (15.24 m) apart, the size of the gutter should be increased 1" (25 mm) for every additional 20 ft. (6.10 m) between leaders. When leaders are spaced less than 50 ft. (15.24 m) apart, a gutter the same size as the leader can be used providing the leader is not less than 4" (10 cm).

- The outside edge of the gutter should be at least 3/4" (19 mm) lower than the roof level or eave so that water will not back up or stand on the roof in case the leader becomes clogged.

Additional Roof Drainage Factors

- Uncontrolled roof drainage at the perimeter, over the roof edge, can lead to damage and discoloration of the exterior building wall.
- Control roof drainage within individual roof areas to accommodate drainage flow. Provide overflow drains or scuppers for all enclosed roof areas.
- Control roof drainage from higher roof levels by collecting drainage from drip edge conditions in gutters. This allows redirection of drainage towards drain points of lower roof levels. Install splash blocks beneath all downspouts.

Expansion Joints

The function of an expansion joint is to minimize the effect of stresses and movements of building components and to prevent these stresses from adversely affecting the building.

Where to Use Expansion Joints

- The design, location, and use of building expansion joints must be considered at the time of original building design and are the responsibility of the architect, engineer and owner.
- Although requirements may vary depending on structural and climatic conditions, expansion joints are strongly recommended:
    - every 200 linear feet (61 m) of building length;
    - where steel framing, structural steel, or deck materials change direction or elevation;
    - where separate wings of “L”, “U”, “T”, or similar configurations exist;
    - where the type of deck material changes, i.e., where precast concrete and steel decks abut;
    - within the roofing system whenever control, expansion or contraction joints are provided in the deck material or deck system;
    - where additions are connected to existing buildings;
    - at junctions of canopies, exposed overhangs or loading docks;

Expansion Joint Recommendations

- Must be continuous along the break in the structure and not terminated short of the end of the roof deck.
- Should never be bridged with insulation or roofing membrane.
- Construction ties must be removed in order for expansion joints to function properly.
- Extend expansion joints at least 8” (20.3cm) above the roof surface on curbs and use either Metalastic® flexible expansion joint covers or metal caps or covers.
- Locate expansion joints so that normal drainage flow patterns are not blocked; joints can also be positioned at the high points of the roof so that drainage is away from them.
- Where possible, position walkways and roof access points to limit roof traffic over expansion joints; provide protective coverings for expansion joints at locations of repeated roof traffic.
- Area dividers or “control” joints are not considered expansion joints. They can be installed where expansion joints have not been provided for in the original building design or where stresses have developed in the roof system. Contact our Technical Helpline for recommendations regarding area dividers.

Roof Decks

GAFMC does not manufacture or install structural roof decks. Acceptance of the deck for application of the roof system is the responsibility of the architect and/or designer. Acceptance of a roof deck by GAFMC as satisfactory to receive roof materials only refers to the top deck surface.

The minimum roof deck requirements which follow are provided as supplementary guides for the roof designer and erector; new or unusual decks not included in this manual must be approved in writing by a GAFMC Contractor Services Manager in order to be eligible for a roofing system to receive a GAFMC guarantee.

Design and Construction Considerations

- Must be adequately smooth and level to provide support and maximum contact surface for roofing materials.
- Must be dry (free of moisture in any form), clean, free of debris, sharp projections and depressions. All depressions, holes, deformations, etc. shall be made smooth prior to application of roofing materials.
- Must be constructed in accordance with the deck manufacturer's requirements and specifications, by a qualified/certified deck installer.
- Do not install electrical conduit or piping immediately above or on the roof deck because roof systems cannot be properly installed on/or over these types of items and, when hidden, they can be a future safety hazard.
- Must support maximum loads which may be imposed during and after construction; maximum deflection should not exceed 1/240th of the span at midspan.
- Must provide positive drainage unless other provisions are planned; see section on drainage.
- On slopes $^{1}/_{2}$" per foot or greater ($^{3}/_{4}$" or greater for torch applied systems), provisions must be made for insulation stops and or backnailing of the membrane.
- Must be designed to accommodate structural expansion and contraction; see section on expansion joints.
- Must be designed in accordance with insurance and code requirements.
- Do not use the space directly below the deck as a plenum without enclosing the conditioned or return air in ducts. If, because of design considerations, the bottom of the deck is to be used as a plenum, contact GAFMC Contractor Services for further recommendations.
- GAFMC shall not be responsible for damage to the roofing system caused by moisture entrapment under the roofing system from the deck or any other source.

Steel Decks

- Should have a G-90 galvanized finish on all panels
- Can be categorized into 3 configurations:
  1) narrow rib, 1" (25mm) flute opening or smaller;
  2) intermediate rib, 1"-1 $^{3}/_{4}$" (25mm - 44mm) flute opening;
  3) wide rib, 1 $^{3}/_{4}$" – 2 $^{1}/_{2}$" (44mm - 64 mm) flute opening.
- Must be a minimum uncoated thickness of 22 gauge (0.8mm).
- Must comply with the gauge and span requirements in the current Factory Mutual FM Approval Guide and be installed in accordance with Loss Prevention Data Sheet 1-28 or specific FM approval.
- 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.
- Insulation boards thick enough to span the flutes of the steel deck as recommended by the insulation manufacturer are required and must be secured to the steel deck with approved DRILL-TEC™ mechanical fasteners to meet at least an FMRC 1-60 uplift resistance rating. Insulation should be installed over steel decks with long sides continuous, either parallel or at right angles to steel deck ribs. The board edges that are parallel with the steel deck ribs must rest firmly on the bearing surface of the steel deck. The joints of parallel courses of insulation should be staggered.

Steel Decks (continued)

- When two layers of insulation are to be installed, solidly mop the second layer of insulation to the first layer. As an alternate to asphalt, both layers of insulation can be mechanically fastened simultaneously.
- When reroofing over steel decks, surface corrosion shall be removed, repairs to holes or severely corroded areas made, loose or inadequately secured decking shall be fastened, and irreparable or otherwise defective decking shall be replaced.

Loadmaster Decks

- Must be installed by a Loadmaster approved contractor according to Loadmaster's specifications.
- The metal deck used in the Loadmaster system must be no lighter than 25 gauge.
- Only specifications using white granule surfaced Ruberoid® SBS products are acceptable over this deck.

Poured Structural Concrete Decks

- Poured in place structural concrete decks consist of Portland cement, water, and aggregate.
- These decks typically vary from 4" to 12" (10.2cm to 30.5 cm) in thickness.
- Must be poured over removable forms or must provide for bottom side drying. Poured in place structural concrete decks that are poured over non-vented metal decks or pans that remain in place can trap moisture in the deck under the roof system and are not acceptable.
- The underside of the concrete decks, either the vented metal forms or exposed concrete, must remain unobstructed to the escape of water vapor. Materials that retard the flow of vapor must not be installed directly below the deck. Foil-faced insulation secured to the bottom of the deck, spray-on fireproofing, or paint, which obstructs the venting of the concrete, are just three examples of the unacceptable deck assemblies.
- It is the responsibility of the engineer, architect, building owner or the roofing contractor to determine the fitness of a deck for direct membrane application to a concrete deck.
- Treat cracks greater than 1/8" (3mm) in width in accordance with the deck manufacturer's recommendations.
- 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, GAFMC recommends the evaluation of the surface moisture and deck's dryness through the use of ASTM D-4263 or hot bitumen test.
- Cannot be wet or frozen. If the deck is determined to be wet, it must be allowed to dry.
- Sumps for the roof drains should be provided in the casting of the deck.
- 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.
- For non-insulated decks, nailers must be flush with deck surfaces.
- When applying roofing or insulation directly to the deck, prime with asphalt/concrete primer, ASTM D41, at a rate of 1 gal/square (0.4L/m^2) and allow the primer to dry prior to the application of the roofing system.
- Decks with broomed or textured surfaces are not acceptable for direct application of a non-insulated roofing system.

Precast Concrete Decks

- Precast concrete decks are 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 their weight.
- It is the responsibility of the engineer, architect, building owner or the roofing contractor to determine the fitness of a deck for direct membrane application to a concrete deck.

Precast Concrete Decks (continued)

- If the deck is determined to be wet, it must be allowed to dry.
- All deformed panels must be replaced.
- Joints must be filled with a masonry grout to correct imperfections between slabs and feathered to provide a slope not greater than 1/4" per foot (2.1 cm/m), for non-insulated assemblies or 1/8" per foot (1.0 cm/m) for insulated assemblies.
- Fill depressions with masonry grout and treat cracks greater than 1/8" (3 mm) width in accordance with the deck manufacturer's recommendations.
- If the joints cannot be grouted and finished smooth, then a leveling course of lightweight insulating concrete (minimum 2" (5.1 cm) thickness) must be applied. Do not seal joints between the slabs; leave open to permit venting and drying of roof fill from below.
- When applying roofing or insulation directly to the deck, prime with asphalt/concrete primer, ASTM D41, at a rate of 1 gal/square (.4 L/m^2) and allow the primer to dry prior to the application of the roofing system. Hold back bitumen at the joints approximately 4" (10.2 cm) to prevent bitumen drippage.

Prestressed Concrete Decks

- GAFMC recommends a minimum 2" (5.1 cm) cellular lightweight concrete fill be installed over all prestressed concrete decks prior to installation of the roof system and/or insulation because variations in camber and thickness of prestressed concrete members may make securement of the roof system difficult.
- It is the responsibility of the engineer, architect, building owner or the roofing contractor to determine the fitness of a deck for direct membrane application to a concrete deck.
- If the deck is wet, it must be allowed to dry.
- Lightweight fills can also be poured to provide slope in the deck to facilitate drainage.
- The 2" (5.1 cm) minimum fill thickness at low points allows for mechanical attachment of the base sheet to the deck.
- Provisions must be made for the curing or drying of the fill installed over the top of the prestressed deck members.

Poured Gypsum Decks

- Gypsum concrete decks are formed by pouring gypsum concrete over reinforcing galvanized steel mesh. Formboards are left exposed or a rated finished ceiling is suspended below. Poured in place gypsum concrete slabs dry out and cure from the underside and adequate heat and ventilation below the slab are needed to permit the escape of moisture.
- Generally the poured gypsum decks encountered are existing decks; contact our Technical Helpline for recommendations regarding roofing over newly installed poured gypsum decks.
- Must be smooth and free from deflections or ridges.
- An average fastener withdrawal resistance as recommended by the fastener manufacturer must be obtained; however, at no time should the withdrawal be less than 40 lbs. (178 N) per fastener.
- If either surface–wet or frozen, a poured gypsum deck is not suitable to receive a roof.
- GAFMC will not be responsible for splits in a GAFMC membrane that are caused by cracking of the gypsum deck, regardless of the cause.
- When reroofing over old, dry, poured gypsum decks, a GAFGLAS® # 75 Base Sheet may be used in lieu of the Stratavent® Eliminator™ Nailable Base Sheet.
- If proper mechanical attachment cannot be achieved, please contact our Technical Hotline for assistance with installation recommendations.

Lightweight Insulating Poured-in-Place Concrete Decks (LWIC)

- Lightweight aggregate insulating concrete roof decks are poured-in-place in a slurry comprised of Portland cement, perlite or vermiculite aggregate and water. Cellular concrete is comprised of Portland cement, water and a preformed foaming agent which produces a closed cell network throughout the concrete.
- Individual concrete deck manufacturers may incorporate polystyrene insulation boards into the deck design to provide additional slope and/or insulating value to the completed deck system.
- Lightweight insulating concrete decks are required to have a minimum thickness of 2" (5.1cm), a minimum compressive strength of 125 psi (87,900 kg/m^2) and a density of 22 pcf (352 kg/m^2). Individual deck manufacturer's standards apply when their specifications exceed these GAFMC minimum thickness, compressive strength, and density requirements.
- Where the Mean January Temperature (reference current ASHRAE Fundamentals Handbook) is below 40°F (4.4°C), lightweight insulating concrete decks must be poured and roofed between April 1st and October 31st; this type of deck is unacceptable in Alaska.
- The lightweight insulating deck/fill must be installed by an applicator approved, in writing, by the deck manufacturer.
- The roof system shall be installed as soon as possible following deck curing to prevent damage from exposure to precipitation; the maximum drying time before installation of the roof system shall be the maximum time required by the deck manufacturer.
- LWIC should not be poured during rainy periods; deck areas which have frozen before they have cured must be removed and replaced. Decks which receive precipitation prior to installation of the roof membrane must be checked for moisture content and dryness.
- Aggregate based lightweight insulating concrete decks require bottom side venting as provided. Solid metal decking and structural concrete decks are among those not acceptable to receive and aggregate based lightweight insulating concrete mix.
- Cellular lightweight insulating concrete decks can be installed over non-slotted, or slotted, galvanized metal decking designed for cellular LWIC or structural concrete.
- Topside or perimeter venting is required. Use one way pressure release vents with all specifications installed over these decks at a rate of one vent for each 10 squares (1000 ft^2)(92.90m^2).
- On new lightweight insulating concrete decks, use a STRATAVENT® Eliminator™ Nailable as the base sheet. It is also required for all twelve, fifteen, and twenty year Guarantee specifications. Over dry, old decks with less than 20% moisture content, GAFGLAS® #75 Base Sheet may be used as the base sheet for five and ten year specifications.
- Mechanically attach the GAFGLAS® base sheet using the DRILL-TEC™ Base Sheet Fastener. Using Plates with the DRILL-TEC™ Base Sheet Fastener, nail the two inch side lap on 9" centers; in the field of the sheet, stagger nail on 18" centers, in two rows located approximately 12" from each sheet edge. This is not a FMRC Approved installation pattern. Refer to the current FMRC Approved Guide for formally approved systems.
- Lightweight insulating concrete decks are acceptable only on slopes up to 1" per foot (8.3 cm/m).
- Do not attach insulation directly to lightweight concrete decks. Over old, dry decks, additional board insulation may be solidly mopped to an approved mechanically attached base sheet.

Wood Decks-Plank and Heavy Timber

- Wood boards must be at least 1" nominal thickness and have a nominal width of 4"-6". Tongue and groove or shiplap lumber is preferred to square edge material since subsequent shrinkage or warping of square edge planks may cause ridging of the roof system above adjacent boards.
- All boards must have a bearing on rafters at each end and be securely nailed.
- Lumber should be kiln dried.

Wood Decks- Plank and Heavy Timber (continued)

- Preservatives or fire retardants used to treat decking must be compatible with roofing materials.
- Decking should be kept dry and roofed promptly after installation.
- Knotholes or large cracks in excess of 1/4" (6 mm) should be covered with securely nailed sheet metal.
- When light metal wall ties or other structural metal are exposed on top of the wood deck, cover them with a heavy ply of a roofing sheet, such as Stratavent® Eliminator™ Nailable, Base Sheet, extending 2"-6" (5.1 cm - 15.2 cm) beyond the metal in all directions. Nail in place before applying the base ply.
- Attach an acceptable base sheet through flat metal caps or use nails with attached 1" (25 mm) square or round metal caps that have a minimum withdrawal resistance of 40 pounds each (178 N).
- Tape and staple fastening systems may be used on wood decks when they comply with local building codes and agencies.

Wood Decks- Plywood

- Plywood sheathing shall be exterior grade, minimum 4 ply, not less than 15/32" (12 mm) thick.
- Preservatives or fire retardants used to treat decking must be compatible with roofing materials.
- Must be installed over joists not greater than 24" (61 cm) o.c.
- Must be installed so that all four sides of each plywood panel bear on and are secured to joists and cross blocking; the plywood must be secured in accordance with the American Plywood Association (APA) recommendations. "H" clips are not acceptable.
- Panels must be installed with a 1/8" to 1/4" (3 mm - 6 mm) gap between panels and must match vertically at joints to within 1/8" (3 mm).
- Decking should be kept dry and roofed promptly after installation.
- Knotholes or large cracks in excess of 1/4" (6 mm) should be covered with securely nailed sheet metal.
- When light metal wall ties or other structural metal are exposed on top of the wood deck, cover them with a heavy ply of roofing sheet, such as Stratavent® Eliminator™ Nailable, extending 2"-6" (5.1 cm - 15.2 cm) beyond the metal in all directions. Nail in place before applying the base ply.
- Attach an acceptable base sheet through flat metal caps or use nails with attached 1" (25mm) square or round metal caps that have a minimum withdrawal resistance of 40 pounds (178 N) each.
- Tape and staple fastening systems may be used on wood decks when they comply with local building codes and agencies.

Oriented Strand Board (OSB) Decks

- Only products with the Structural 1 APA rating should be used as a decking material.
- Weyerhaeuser's Struc-One oriented strand board is an acceptable substrate to receive a GAFMC roofing assembly. It must be a minimum of 1/2" (13 mm) thick. See plywood deck section for applicable requirements.

Cementitious Structural Woods Fiber Decks

- Cementitious structural wood fiber decks are manufactured from wood fibers bonded together with cementitious binders.
- Must be protected from the weather during storage and application; any decking which becomes wet or is deformed should be removed and replaced with new decking.
- Should not be installed over high humidity occupancies.
- Must have a minimum design load as recommended by the deck manufacturer.
- All structural wood fiber deck panels must be anchored against uplift and lateral movement.
- Install a mechanically attached base sheet prior to installation of insulation or roofing membranes; an average fastener withdrawal resistance as recommended by the fastener manufacturer must be obtained.

Cementitious Structural Woods Fiber Decks (continued)

- Installation of fill material such as lightweight insulating concrete over these decks is acceptable only when installed in accordance with the lightweight deck manufacturer's recommendations and a deck certification from the manufacturer is issued.

Asphalt/Perlite Fill Decks

- Generally these decks are not considered a suitable substrate. Please contact our Technical Helpline for information on this type of deck.

Parapet Walls

Most common wall types are suitable substrates for the installation of GAFMC membrane flashing.

Brick/Block Masonry

- Standard-finish brick and concrete block with standard tooled mortar joints.
- Split-face block, textured block and brick, and deeply tooled mortar joints require a cementitious parge coating to provide a smooth and even substrate surface.

Structural Concrete

- Steel trowel, wood float or removable form finish.
- Ridges and other irregularities require grinding to provide a smooth and even substrate surface.

Stucco/ Exterior Finish Insulating System (EFIS)

- Stucco finish and EFIS systems are not acceptable substrates.

Plywood

- Minimum 4 ply, 15/32" (12mm) thickness, exterior grade.
- Tongue and groove edges or full blocking required.

Orient Strand Board (OSB)

- Minimum 1/2" (13mm) exterior grade.
- Tongue and groove edges or full blocking required.

Sheet Metal

- Minimum 24 gauge steel or 0.032" (0.8 mm) aluminum.
- Corrugated panels require an overlay of 15/32" (12mm) plywood, or moisture resistant gypsum panels.

Gypsum Panel

- Minimum 1/2" (13mm) thickness.
- Moisture resistant gypsum panels.
- Underlying substrate must allow securement of flashing at prescribed spacing.

Water Vapor Transfer

For projects where there is a significant difference in vapor pressure between building interior and exterior, the volume of water vapor flow is much greater, and control of water vapor transfer into and through a roof system becomes an important consideration. Without adequate control provisions, a vapor retarder, the roof insulation can become saturated with water, with a corresponding reduction in insulation thermal performance. Structural deck damage and/or condensation into the building interior may also occur.

Vapor flow is referenced in various ways. The following are of common terminologies:

Permeance

- The time rate of vapor transmission through a flat material or construction induced by vapor pressure difference between two specific surfaces, under specified temperature and humidity conditions.

- Units of Permeance are expressed as: (gr)/(h) (sq. ft.) (in. Hg).

Permeance (continued)

- The Permeance, or perm rating, of a material is a performance evaluation specific to a sample of material, and not a specific property of the material.
- In general, the perm rating of a vapor retarder should be < 0.5 perms.

Relative Humidity

- Relative humidity is the ratio of the pressure of water vapor present in air to the pressure of fully saturated water vapor at the same temperature.
- Relative Humidity is expressed as a percentage.

Dew Point Temperature

- The temperature at which air becomes saturated with water vapor (100 percent relative humidity) and condensation begins to occur.
- Dew Point Temperature is expressed as degrees F or C.

Temperature and Relative Humidity

A number of basic considerations factor into the need and location of a vapor retarder:

Vapor flows based upon a difference in vapor pressure between two locations, and flows from higher to lower pressure regions.

- Normally, the higher the temperature, the higher the vapor pressure.
- In determining the need for a vapor retarder for most typical conditions, the exterior winter temperature and the interior winter relative humidity are the most critical factors.
- Temperature information is readily available from the National Weather Service.
- Relative humidity information is typically available from the building HVAC design professional or the building operations manager. Relative humidity can also be field measured.

Vapor Retarder Location

- Vapor retarders are intended to be installed as close to the warm side of the roof assembly as possible. Normally, this places the vapor retarder directly on the structural deck or directly over a minimal layer of insulation. Note: the vapor retarder is not considered a part of the GAFMC roofing system.
- A sufficient amount of insulation must be installed over the vapor retarder so as to raise the dew point location above the level of the vapor retarder.
- Determining the need and location of the vapor retarder is the responsibility of the design professional.

Sealing Perimeter and Penetrations

- Vapor retarders shall be completely sealed at all perimeter and penetration locations.
- Sealing methods shall be selected in accordance with type of vapor retarder being installed.
- Air leakage into the roof system at perimeter and penetrations will significantly reduce the effectiveness of the vapor retarder by allowing moist air to penetrate into the roof assembly where it can condense and cause roof deterioration.

Building Usage

- Normal building usage such as offices, schools, retail, warehousing, etc. will not normally require the use of a vapor retarder except when located in the most northern climates.
- Building usage such as swimming pools, food processing, paper manufacturing, foundries, etc. that result in increased internal temperatures and humidity conditions will likely require the use of a vapor retarder except when located in the most southern climates.
- These generalizations are not intended to substitute for actual vapor flow calculations based upon specific building and climatic conditions.

The Case for the Use of a Vapor Retarder

- A vapor retarder can protect the long term thermal resistance of insulation sandwiched between the vapor retarder and the membrane.
- A vapor retarder provides a good safeguard against vapor migration in case a building's use changes from a "dry" use to a "wet" use.

The Case Against the Use of a Vapor Retarder

- The vapor retarder, together with the roofing membrane, may seal within the roof sandwich entrapped moisture that can eventually destroy the insulation, help split or wrinkle the membrane or, in gaseous form, blister it.
- In the event of a roof leak through the membrane, the vapor retarder will trap the water in the insulation and release it through punctures, breaks, or poor seals in the vapor retarder that may be some lateral distance from the roof leak, thus making leak discovery more difficult. A large area of insulation may be saturated before the punctured roof membrane can be repaired.
- A vapor retarder is a disadvantage in summer, when vapor migration is generally downward through the roof (hot, humid air can infiltrate the roofing sandwich through the vents, or through diffusion through the roof membrane; it may condense on the vapor retarder itself).
- A vapor retarder may be the weakest horizontal shear plane in the roofing sandwich. Failure at the vapor retarder/insulation interface can result in splitting of the membrane. At the least, the vapor retarder introduces an additional component whose shear resistance may be critical to the membrane's integrity.

Insulation

The function of roof insulation is to provide insulating value and it has economic benefits: increased comfort, smaller heating/cooling equipment requirements, lower operating expenses, and a reduced consumption of expensive fuel supplies. Insulation must also provide a smooth, dry, clean and firmly attached substrate to receive the roof membrane.

The selection of insulation type, thickness, and configuration is the responsibility of the architect, engineer, or owner. GAFMC reserves the right to accept or reject any roof insulation as an acceptable substrate for GAFMC roof systems. GAFMC insulations (GAFTEMP® Insulation or BMCA Insulation) must be used in roofing systems to be guaranteed by GAFMC.

Attachment

- The positive attachment of insulation over the substrate to which it is installed is essential. Insulation shall be attached according the requirements of the insulation manufacturer, trade associations, local codes and insurance underwriting agencies.
- Consult the current Factory Mutual Approval Guide and Factory Mutual Loss Prevention Data Sheet 1-28 and 1-29 for information on insulation attachment requirements.
- Do not install insulation in hot asphalt directly to a steel deck. The first layer of insulation must be mechanically attached to a steel deck.
- Install insulation to wood or wood fiber nailable decks by either mechanically fastening the insulation or by nailing a base ply to the deck following nailing recommendations for base plies and then installing insulation in a solid mopping of asphalt.
- On slopes of 1/2" (4.2 cm/m) or greater, consult the insulation manufacturer for recommendations regarding the installation of insulation stops.
- GAFMC is not responsible for damage to roofing membranes or flashing from movement or wind uplift due to inadequate attachment of the roof insulation. It is the responsibility of the design professional to determine wind uplift design forces and the means of attaching the roof system to resist those forces.

General Requirements

- Insulation must be approved by Factory Mutual and Underwriters Laboratories and be manufactured in board form to be used as a roof insulation.
- The minimum allowable thickness of insulation is 1/2" (13mm). Insulation must be able to withstand foot traffic without crushing. When installed over a metal deck, the insulation must be strong enough to span the flutes without breaking under typical rooftop traffic conditions.
- The maximum allowable thickness for a single layer of insulation is 3" (7.6 cm) unless approved in writing by GAFMC.
- Multi-layer insulation assemblies simultaneously attached with approved mechanical fasteners MUST not exceed 5" (12.7 cm) in total thickness without prior written approval from GAFMC. When insulation is installed in two or more layers, the joints MUST be staggered.
- Do not torch membranes directly to insulation.

Types of Insulation

The following insulations are acceptable for use in roofing systems to be guaranteed by GAFMC.

Perlite
(ASTM C728/FS HH-1-529)
BMCA Permalite® perlite insulation
BMCA Permalite® perlite recover board
BMCA Permalite® perlite tapered insulation
BMCA perlite tapered edge strips and cant strip

Fiber Board
(ASTM C208/FS LLL-1-535b, Class C)
BMCA High Density fiberboard insulation
BMCA Regular fiberboard insulation

Types of Insulation (continued)

Polyisocyanurate
(ASTM C1289/FS HH-1-972, Class 1)

Must utilize a Stratavent® Eliminator™ Perforated venting base sheet specification, have a layer of GAFGLAS® #75 Base Sheet mechanically fastened simultaneously, or have an overlay of a minimum 1/2" (13mm) of perlite or fiberboard.

GAFTEMP™ Isotherm isocyanurate insulation
GAFTEMP™ Isotherm tapered insulation

Perlite/Polyisocyanurate Composite
(FS HH-1-1972, Gen./FS HH-1-1972, 3)

GAFTEMP™ Isotherm composite insulation
GAFTEMP™ Isotherm tapered composite insulation

NOTE: The use of any of the following insulations in roof systems to be guaranteed by GAFMC requires approval in writing by a GAFMC Contractor Services Manager prior to installation.

Perlite/Polyisocyanurate/Perlite Composite
(FS HH-1-1972, Gen./FS HH-1-1972, 5)

Wood Fiber/Polyisocyanurate Composite
(ASTM C208/FS LLL-1-535b, Class C)
(ASTM C1289/FS HH-1-972, Gen.)

Cellular Foam Glass
(ASTM C552/FS HH-1-551E)
Must have an overlay of a minimum of 1/2" (13mm) of perlite or wood fiber.

Glass Fiber Board
(ASTM726/FS HH-1-526)

Expanded Polystyrene
(ASTM C578)
Must be a minimum of 1.5 lb. (80 kg/m^3) density. Requires an overlay of a minimum of 1/2" (13mm) perlite or wood fiber be mechanically fastened and the joints taped prior to application of roof membrane. (Not to be used under cutback cold adhesive applied roof systems.)

Perlite/Expanded Polystyrene Composite
(ASTM C728/FS HH-1-529)
(ASTM C578/FS HH-1-524C)

The polystyrene must be a minimum of 1.5 lb. (80 kg/m^3) density and the joints in the composite board taped. (Not to be used under cutback cold adhesive applied roof systems.)

Wood Fiber/Expanded Polystyrene Composite
(ASTM C208/FS LLL-1-535b, Class C)
(ASTM C578/FS HH-1-524C)

The polystyrene must be a minimum of 1.5 lb. (80 kg/m^3) density and the joints in the composite board taped. (Not to be used under cutback cold adhesive applied roof systems.)

Protected Membrane Roof Assemblies (PMRA)

- Protected Membrane Roof Assemblies, a roof assembly in which the insulation and ballast are placed above the roof membrane, can be constructed using GAFMC roofing membranes after addressing a number of basic design considerations.

- New construction or tear-off to an existing sound deck is required. The condition and structural integrity of the underlying deck is most important.

- In addition to the general requirements that the deck be smooth, dry, without any cracks over $^1/_4$" inch (6mm) wide, or holes larger than 1 inch (25mm) in diameter, the deck and underlying structure must be able to support ballast loads greater than 20 pounds per square foot (98 kg/m^2) or more depending on the specifics of the PMRA to be employed.

- It is the sole responsibility of the building owner to establish the ability of its building to support the ballasted roofing system plus snow loads, live loads, etc.

- Potentially severe wind conditions at the roof level must be anticipated by the building owner. Refer to the American Society of Civil Engineers Document 7-98 to establish potential winds hazards. In general, GAFMC PMRA specifications are limited to wind areas with a maximum expected wind of 90 mph as shown on the ASCE wind map and a maximum building height of 50 feet (15.24m) above ground level.

- Compliance to local codes and insurance requirements must be confirmed by the building owner.

- On some decks, such as steel decks, a minimum layer of insulation is required to be installed prior to the application of the roofing membrane. The possibility of moisture condensation occurring in this layer of insulation should not be overlooked, particularly in colder climates. Each PMRA job should be evaluated by the architect, design engineer, or owner to determine that the dew point is not in this layer of insulation and that a condensation problem will not develop.

- **The following GAFMC specifications are suitable for use in PMRA's**:

N-1-1-TS	NN-1-1-TS	I-1-1-TS	NN-O-4-C
N-1-1-TG	NN-1-1-TG	I-1-1-TG	NN-B-4-C
N-1-1-HG	NN-1-1-MG	I-1-1-HG	I-O-4-C
N-1-1-MG	NN-1-2-20/30	I-1-1-MG	I-B-4-C
N-1-2-20/30	NN-0-2-25/HG	I-2-1-TGP	N-B-4-C
N-1-2-TG		I-2-1-HGP	N-B-5-C
		I-3-1-TGP	
		I-2-1-MGP	
		I-3-1-MGP	
		I-3-1-HGP	
		I-1-2-20/MG	
		I-1-2-25/HG	
		I-1-2-TG	

Protected Membrane Roof Assemblies (PMRA) (continued)

- Only extruded polystyrene insulation (XPS) with a minimum compressive strength of 40 psi (276 kPa) is acceptable. The insulation can be installed only after the surface of the membrane has cooled to the point where sticking of the XPS board does not occur. The insulation boards must be a minimum of 2" (5.1cm) thick and must have channels on the bottom to provide for the flow of water beneath the panels toward drainage.

- The XPS boards can be plain or come with a factory applied cementitious top layer. This cementitious top layer must be weather resistant and soundly bonded to the XPS.

- The installation of the XPS boards should strictly follow the recommendations of the insulation manufacturer. In general, the boards should be snugly butted, tongue and grooves engaged where they exist.

- When no factory applied ballast exists on the XPS boards, provisions must be made for ballasting the insulation.

- Where pavers are to be used, they must be a minimum of 2 feet by 2 feet (61cm X 61cm). For a 4-foot (1.22m)perimeter of the roof, pavers must weight a minimum of 20 lbs. per square foot and as determined by the building owner or its consultant.

- Pavers must be weather resistant with a minimum compressive strength of 3,000 psi (20,700 kPa).

- Pavers must not rest directly on the XPS. A 1" (25mm) space should exist between the paver and the top of the XPS board.

- For gravel ballasted systems, a fabric such as Confil 689 H[1] (3 ounces per yard) black polyester from International Paper Co. or Rufon®[2] P 38 (3 ounces per yard) black polypropylene from Phillips Fiber Corp. must be installed over the XPS boards with side laps of 1 foot (30.5 cm) and end laps of 2 feet (61.0 cm). The ballast must be clean and dry, free of excess fines. The gravel ballast must meet ASTM D-448-80 graduation #57.

- The ballast loading must be calculated for each PMRA installation based upon each job's specific circumstances. However, in no case should the ballast be applied below a minimum rate of 10 pounds per square foot (48.8 kg/m^2) in the field of the roof and 20 pounds per square foot (97.6 kg/m^2) at the perimeter of the roof for a minimum distance of 4 feet (1.22m) from the roof edge.

- Insulation, fabric, and ballasts should be installed as the GAFMC roofing systems and flashing is completed, but in no case should the membrane be left uncovered for more than 30 days.

- For PMRA's, all parapet and rooftop penetrations must be designed to provide for flashing a minimum of 8 inches above the top of the ballast.

- GAFMC roofing system guarantees are available for PMRA assemblies. GAFMC guarantees cover the roofing membrane but do not include the insulation and/or overburden.

[1] Made by the International Paper Company.
[2] Rufon is the registered trademark of Phillips Fibers Corporation.

Asphalt

GAFMC systems require the use of ASTM D312, Type III or Type IV asphalt for the application of roof insulation, roof tape, base, ply, cap membranes, and surfaced aggregate for slopes as referenced below.

Specification and use of low softening point bitumen increases the opportunity for bitumen drippage and membrane slippage. The designer and roofing contractor must take any necessary precautions to prevent damage to the structure or interior due to bitumen drippage.

Recommendations for Asphalt Types

Asphalt Type	Softening Point	Maximum Slope
ASTM D312, Type III	185-205	up to 1/2" per foot (4.2 cm/m)
ASTM D312, Type IV	210-225	up to 3" per foot (25 cm/m)

Equiviscous Temperature (EVT) Range. The temperature at which an asphalt achieves its optimum viscosity for application of a built-up roof is the equiviscous temperature. Asphalt at the point of application should be at the EVT +/- 25°F (13.9°C). The EVT for each asphalt shipment should be requested from the asphalt manufacturer.

For SBS modified bitumen membranes, the asphalt temperature at the point of application should be at its EVT or 425°F (218.3°C), whichever is greater.

The Finished Blowing Temperature (FBT) is the minimum temperature at which the blowing of the asphalt has been completed during its manufacture. Heating the asphalt for an extended period of time above this temperature can result in lowering the softening point of the asphalt as well as changing other characteristics of the asphalt.

Surfacing

- Can improve reflectivity, weather resistance, fire resistance, and impact resistance and may provide an aesthetic value.
- There are four types of surfacing used with modified bitumen and BUR membranes:
    - Factory applied mineral granules
    - Flood coat and aggregate: use aggregate meeting ASTM D1863. The pour coat of asphalt should meet ASTM D312, Type III or IV. Aggregate that does not meet ASTM D1863 must be approved by GAFMC.
    - Aluminum coatings should meet ASTM D2824, Type III.
    - Emulsion coatings should meet ASTM D1227, Type II or III.

Note: For smooth surfaced GAFGLAS® BUR (North and South Zones only), a glaze coat of ASTM D-312, Type I asphalt may be used on slopes up to 1/2" per foot (4.2 cm/m) applied at the rate of 20 lbs./sq. (1kg/m^2)

Walkways

- Walkways for normal rooftop traffic can be constructed from two plies of mop or torch grade modified bituminous membranes.

- Construct walkways prior to the application of field surfacing by solidly adhering a first ply of smooth surfaced membrane to the field of the roof and then adhering a top ply of granule surfaced membrane to the surface of the first ply. Walkway sections should be no longer than 10' (3.05m), with a 6" (15.2 cm) minimum gap between each section to allow for drainage.

- Surface the roof around and between the pads if additional surfacing is applied to the GAFMC membrane.

Flashing

Flashing is used to waterproof the field of the roof anywhere it is interrupted, e.g., at walls, curbs, edges, penetrations, drains, etc. and the juncture of the field of the roof and vertical surfaces. Flashing are the most vulnerable moisture infiltration points on any roof.

- Wall flashing can be divided into two categories, non-wall supported roof deck and wall supported roof deck. Non-wall supported roof deck design provides for differential movement between the wall and roof deck. The wall supported roof deck design is structurally constructed without the anticipation of differential movement. GAFMC provides details for both situations.

- Isolate the structural deck, roofing system and base flashing from vertical walls, projections, etc. This is best accomplished by the use of horizontal and vertical wood nailers installed at perimeters, projections, etc. and through the use of metal counterflashing to divert water over the base flashing.

- Insure that water drains immediately away from all flashing.

- Minimum height of base flashing should be 8" (20.3 cm) above the roof surface level and the maximum height should be 24" (61.0 cm) above the roof level. Wall coverings above the base flashing are not a part of the roofing system and are not included in GAFMC roofing system guarantees.

- Wood nailers should be installed at open perimeter edges and secured to the roof deck.

- Use only polyester reinforced modified bituminous membranes for base and wall flashings.

- When metal cap or counterflashing cannot be installed on the same day as the membrane base flashing, the top edge of all base flashings must be stripped-in using flashing cement and glass fiber reinforcement. All stripped-in material must be removed prior to torch welding of any membrane.

- "Through-wall" flashing should be used on all masonry walls. If "through-wall" flashing is not possible, masonry walls must be designed to prevent moisture infiltration.

- All base flashings must be mechanically fastened at the top edge of the flashing with 1" (25mm) round or square metal cap nails or appropriate fastener on a maximum of 8" centers for flashings up to 12" (30.5 cm) in height and on 4" (10.2cm) centers for flashings up to 24" (610 mm) in height. Termination bars may only be used in conjunction with proper counterflashing and the fastener spacing shall not exceed the spacing of cap nails.

Flashing (continued)

- Apply flashing details after the installation of the roofing membrane, but before the application of any surfacing materials.
- The use of pitch pans is not recommended. Pitch pans are maintenance items that can easily become sources of leaks if not maintained or improperly used or installed.
- Due to the differential expansion between metal and asphalt, large metal flanges are undesirable surfaces to flash; such units should be mounted on canted wood curbs at least 8" (20.3 cm) above the level of the roof surface.
- Metal gravel stop flanges must be primed, properly nailed to a wood nailer, and installed between a stripping ply of modified bitumen membrane and the field of the roof. Where metal gravel stop flanges are flashed to the roof membrane, leaks caused by metal movement are not covered by GAFMC guarantees, and are the responsibility of the building owner.
- Piping and conduit should not run across the roof; where no alternative exists, the piping/conduit should be elevated at least 8" above the surface of the roof on properly flashed supports that are secured to the structural roof members. Lightweight piping/conduit, less than 2" (5.1 cm) in diameter may be set on wood blocks with pads over the finished membrane.

Test Cuts

- There is no substitute for quality materials and workmanship. Should cuts for testing purposes be required, such cuts should be taken before the final surfacing is installed so that proper and adequate repairs can be accomplished.
- GAFMC will not comment on the results of any test cut that cannot be shown to be statistically representative of the roofing system.
- The party requesting the taking of test cuts from any GAFMC roof shall assume all responsibility for any detrimental effects of said test cuts.

Recover and Reroofing

Every reroofing project has its own unique design challenges that require individual assessment. GAFMC requires that a thorough investigation of the existing roof system and its support system must be made to determine the cause of roof system failure or deterioration. The determination of whether to tear-off or recover an existing roof system is the responsibility of the architect, engineer, or owner.

The decision to tear-off and replace or to prepare and then recover an existing roofing system is not always clear-cut.

When installed in strict adherence to GAFMC requirements by a GAFMC Master Roofing Contractor, Diamond Pledge or System Pledge guarantees up to 20 years are available for tear-off/replacement roofs depending on the specification selected. Ten year Diamond Pledge or System Pledge guarantees are available for recover roofs. To qualify, recover requires the use of a minimum RUBEROID® specification that incorporates a glass base sheet or for GAFGLAS® BUR a minimum 4 ply specification is required.

GAFMC will not accept responsibility for damage of its roof systems in any way caused by recovering an existing roof system.

Tear-Off/Replace

Factors that support the tear-off approach include:

- Two or more existing roofs.
- Structural weight limitations.
- Over 25% of the existing roof area is wet.
- Flashing height limitations.
- Need to maximize long-term performance.

The goal for any tear-off project is to provide a sound substrate for the installation of a new roofing system and correct existing design deficiencies. At a minimum, attention to the following considerations is recommended:

- Thoroughly inspect decking, flashing substrates, and wood nailers before installing new materials.

- Plan tear-off strategy so that roof drainage patterns are never blocked and so that construction traffic is directed away from new roof areas.

- Protect new roof areas adjacent to tear-off areas from dirt, debris and damage.

Recover

Factors that support the recover approach include:

- Need to minimize cost.
- Preserve existing thermal roof insulation.
- Disposal restriction.
- Difficult access to roof.

A recover should be considered only if the following items are addressed and preparation includes:

- Establishing the history of the old roof system and determining and correcting the cause of any premature roof failures.

- The existing roof system must be compatible with the proposed new roof assembly. Sprayed in place urethane foam roof systems are not eligible for recover. For recover installations over single ply, fluid applied, coal tar and metal roofs, contact GAFMC Contractor Services for prior approval and technical requirements.

- Determining that the deck is structurally sound to receive a new roof system.

- Taking test cuts to verify the existing roof construction and condition. Three test cuts should be made for roofs under 100 squares and one test cut per 100 squares above the minimum amount.

- All irregularities in the existing membrane and deck system can and are repaired in order to make the membrane ready to receive the new roofing system.

- Providing for proper drainage of the new roof system to eliminate ponding. Provisions must be made to insure the new roof system has proper drainage, i.e., placement of additional roof drains, use of tapered insulation, use of crickets, etc., as appropriate.

- The existing membrane surface is in basically sound condition, without excessive quantities of defects such as blisters, ridges, fishmouths, or other irregularities.

Recover (continued)

- The existing roof system components are well attached to each other and their substrate.
- Existing substrates and insulation (if applicable) are dry over the majority of the roof area. Wet or deteriorated areas of insulation and substrate must be removed and replaced with new materials.
- The existing detail conditions are readily adaptable to the increased thicknesses imposed by the recover system and comply with GAFMC specifications and requirements.
- The existing structure is capable of supporting the new loads imposed by the recover system.
- All applicable code requirements must be met for recover over an existing roofing system.
- It is highly recommended that a moisture survey be made to determine the extent of wet insulation and moisture entrapment.
- Roof systems having existing vapor retarders must be addressed with our Technical Helpline at: 1-800-766-3411.
- When Stratavent® Eliminator™ Venting Base Sheet is used as the first ply, the surface of the old smooth BUR membrane must be primed using Matrix™ 307 Asphalt/concrete Primer and allowed to dry. Install Stratavent® Eliminator™ Venting Base Sheet and the proper roof specification listed in this Manual.
- GAFMC does not recommend partial recover or reroofing of a single roof area due to the potential for defects in the portion of the roof system not replaced, to damage or negatively affect the performance of the new membrane. When required by project conditions or budget considerations, GAFMC requires full separation of the old and new roof areas by means of a full curb mounted expansion joint or area divider installed to provide a complete watertight seal or break between areas. Tie-in construction in which the old and new membranes are adhered directly to each other and stripped in are not acceptable for use in GAFMC guarantee roof systems.

Specific Deck Requirements Steel, Gypsum, Wood, Tectum

- Any gravel surfacing must be removed to provide a smooth surface.
- On smooth surfaced roofs, the old roof surface should be level and clean.
- Remove all wet or damaged roof insulation and old, wet membrane. Replace with new insulation of the same type and cover with new membrane to complete the repair.
- Old membrane must be cut on 3-foot (91.4 cm) centers to allow for the release of any trapped vapor pressure in the old roof covering.
- When additional insulation is used for recover assemblies, mechanical fasteners or a minimum of 70% asphalt attachment is required. Recover installations with asphalt applied insulation require preparation of the roof surface to remove all aggregate surfacing and provide a smooth, clean substrate. Old surface must be primed with asphalt primer prior to mopping. Recovering over existing modified bitumen smooth and granule surfaced roof systems requires the use of a mechanically attached insulation.

Specific Deck Requirements Steel, Gypsum, Wood, Tectum (continued)

- When insulation is used, it must be mechanically fastened to steel decks. On tectum and gypsum decks, after removing any gravel, new insulation can be mopped to achieve a minimum of 70% attachment. The surface of the old BUR roof surface must be primed before mopping in the insulation. Install new roof specification to insulation as outlined in this Manual.
- Topside venting is required. Use Vent Stacks installed at the rate of one per 1000 square feet (92.9 m^2) or use perimeter venting.
- All specification requirements and recommendations listed in this Manual must be followed, i.e., slope, nailing, etc.
- If the old roof is a coal tar BUR, a divorcing layer of roof insulation must be used. Proper precautions must be taken to ensure that coal tar drippage into the building does not occur. Careful preparation and cleaning of the existing roof surface is required to permit asphalt application of recover insulation. Contact GAFMC Contractor Services for additional information.

Concrete

- Any gravel surfacing must be removed to provide a smooth surface.
- On smooth surfaced including cap sheet roofs the old roof surface should be level and clean.
- When additional insulation is used for recover assemblies, mechanical fasteners or a minimum of 70% asphalt attachment is required. Recover installations with asphalt applied insulation require preparation of the roof surface to remove all aggregate surfacing and provide a smooth, clean substrate. Old surface must be primed with asphalt primer prior to mopping. Recovering over existing modified bitumen smooth and granule surfaced roof systems requires the use of a mechanically attached insulation.
- Topside venting is required. Use Vent Stacks installed at the rate of one per 1000 square feet (92.9 m^2) or use perimeter venting.
- All specification requirements and recommendations listed in this Manual must be followed, i.e., slope, nailing, etc.
- If the old roof is a coal tar BUR, a divorcing layer of roof insulation must be used. Proper precautions must be taken to ensure that coal tar drippage into the building does not occur. Careful preparation and cleaning of the existing roof surface is required top permit asphalt application of recover insulation. Contact GAFMC Contractor Services for additional information.

Lightweight Insulating Concrete

- Recovering directly over an old existing roof membrane is <u>not</u> acceptable over a lightweight insulating concrete deck.
- Old membranes and existing roof insulation, if present, must be removed. If the decking is suitable to receive a new roof system, the appropriate GAFMC specification must be followed.

Loadmaster

- The metal deck must be 25 gauge or heavier.
- The owner or its representative (not GAFMC) must establish the deck's and deck support system's ability to accept and support a recover system.
- All surface gravel must be removed to provide a smooth surface.
- Mechanically fasten insulation board.
- Install a minimum 2-ply specification with a white granule surface; a black surface is not acceptable.
- Topside venting is required. Use Vent Stacks installed at the rate of one per 1000 square feet (92.9 m^2) or use perimeter venting.

Flashing Details

- It is mandatory in a reroofing situation that all existing flashing be removed.

Note: The new membrane and any new insulation will cause changes in edge details and the height of perimeter nailers.

- All perimeter and top of curb flashings must remain open (unsealed). All curb and wall flashings left open must have a counter flashing.
- All old metal gravel stops, metal counter flashing, lead boots, and pitch pans must be removed and replaced with new metal.
- All base flashings must be removed and new base flashing installed.