ROOF DESIGN

Provides a quick reference of technical requirements for EverGuard® mechanically attached roofing system design

- General
- Sustainable Design
- Building Utilization
- Tear-off or Re-cover
- Roof Decks
- Parapet Walls
- Roof Drainage
- Expansion Joints
- Area Dividers
- Equipment Mountings
- Fire Resistance
- Wind Performance
- Energy Efficiency
- Water Vapor Transfer

GENERAL

Proper roofing system design and selection requires the consideration of many factors. Although GAF's expertise is in materials manufacturing, and not in engineering, architecture, or specialized roof consulting, our company has decades of 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 EverGuard® single-ply roofing systems.

SUSTAINABLE DESIGN

ENERGY STAR® is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy. It is designed to help our nation save energy and money, and to protect the environment through energy-efficient products and practices. Energy-efficient choices can save building owners significantly on their energy bills with similar savings of greenhouse gas emissions, without sacrificing features, style, or comfort. ENERGY STAR® helps consumers, contractors, architects, and property owners make more knowledgeable, energy-efficient choices.

The LEED (Leadership in Energy and Environmental Design) Green Building Rating System is a voluntary standard for developing high-performance, energy-efficient sustainable buildings. The LEED Certification System is a program that awards building points for satisfying specified green-building criteria and requirements.

Green Globes® is a web-based program for green building guidance and certification that includes an onsite assessment by a third party and is an alternative to the LEED rating system.

GAF's EverGuard® TPO is first to certify to NSF/ANSI 347 *Sustainability Assessment for Single-Ply Roofing Membranes*. This Standard is the evaluation of the sustainability of single-ply roofing membranes. The Standard includes criteria across the product life cycle from raw material extraction through manufacturing, use, and end-of-life management.

GAF's EverGuard Extreme® TPO Roofing Membrane was engineered with energy efficiency and sustainability in mind. This high-performance, reflective roof membrane is also geared for solar roof installations. The increasing use of building integrated photovoltaics (BIPV) has highlighted the challenges faced by roofing membranes exposed to concentrated heat, sunlight, and UV. GAF scientists have created a new grade of TPO single-ply membrane that is built to handle the extreme demands that new rooftop applications can place on roofing membranes. EverGuard Extreme® TPO uses proprietary stabilizers and UV absorbers to achieve weathering performance far beyond current standards.

- EverGuard Extreme® TPO can be installed up to 10 years prior to the installation of solar overburden.
- Installation of overburden will not affect the membrane performance or warranty coverage of EverGuard Extreme® TPO.
- Please contact GAF before installing any overburden on the roof.

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 living space.

Internal Temperature/Humidity

Extremes in internal temperature/humidity are most often associated with cold storage/freezer buildings, swimming pool 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 can cause a pronounced vapor flow 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.

Relevant design considerations include:

- Incorporation of a vapor retarder at deck level to control vapor flow into and through the roof assembly;
- Attention to a vapor-tight seal between the roof and side walls/penetrations;
- Utilization of closed-cell foam insulation and stainless steel fasteners to minimize potential for condensation-related degradation of the roof system;
- Limitation of penetrations through the roof deck;
- Avoidance of roof system attachment that will puncture the vapor retarder.

Positive Internal Pressure

Positive internal pressure is most often associated with manufacturing/clean-room facilities, mechanical air-handling rooms, aircraft hangars, distribution centers with multiple overhead doors, and high-rise office/residential towers. In all these instances, positive internal pressures can adversely act on the underside of the roof system.

Conditions where the positive internal pressure is constant, as in the case of clean-room facilities and high-rise towers, may cause the roof system to billow up, i.e., form a mattress effect, and may reduce the overall uplift resistance of the roofing system.

This effect is most pronounced in mechanically attached systems and can cause attachment concerns with other types of roof system installations. Conditions where the positive internal pressure is applied suddenly, as in the case of aircraft hangars and distribution centers, may cause failure of the roofing system due to pressure impact.

Relevant design considerations include:

- Use of air-impermeable deck construction, such as poured-in-place concrete or insulating cellular concrete over a steel pan;
- Alternatively, installation of an air barrier, such as polyethylene sheeting, at deck level beneath mechanically attached insulation with attachment sufficient to balance positive pressure;
- Attention to an air-tight seal between roof and side walls/penetrations.

Rooftop Traffic/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 or multiple-ply system, e.g. GAF Triposite XL™;

– Use of a higher compressive strength insulation substrate;

– Application of a concrete paver or insulated paver overlay for extreme conditions.

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 material formulation and contaminant type.

Long-term exposure, i.e., 28-day immersion 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 of resistance to contamination in all but the most common situations.

Relevant design/maintenance considerations include:

– Isolation of contaminated roof area with expectation of more frequent roof membrane replacement;

– Periodic power washing of roofing membrane with moderate pressure;

– Limitation of rooftop spillage/exhaust of contaminating materials, i.e., grease traps.

Please refer to www.gaf.com for detailed TPO and PVC Chemical Resistance Charts.

NOTE: GAF guarantees on any GAF membrane, including TPO and PVC, do not cover damage due to chemical contamination.

TEAR-OFF OR RE-COVER

The decision to tear-off/replace or to repair/re-cover an existing roofing system before installing a new roofing system is not always clear-cut.

Although not an exhaustive list, the following additional design elements typically require consideration for any reroofing project:

– 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 concrete paver overlay or walkway pad system.

Tear-off/Replace

Factors that support the tear-off approach include:

– Two or more existing roofs (building code restriction);

– Structural weight limitation;

– More than 25% of existing roof area is wet;

– Flashing height limitations;

– Need to maximize long-term performance.

The basis for any tear-off project is to provide a sound substrate for the installation of a new roofing system and minimize potential damage from tear-off activities. *At a minimum, attention to the following considerations is recommended:*

– Thoroughly inspect decking, flashing substrates, and wood nailers before installing new materials;

– Plan a 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.

Re-cover

Factors that support the re-cover approach include:

– Need to minimize cost;

– Disposal restrictions;

– Difficult access to the roof.

The basis for any re-cover project is to eliminate defects in the existing roof assembly so that their effect on the new roofing system is minimized. *At a minimum, attention to the following considerations is recommended:*

– Raise all perimeter flashings, penetrations, and equipment to provide required flashing heights;

– Address drainage deficiencies to provide positive drainage;

– Remove and replace all wet roofing materials;

– Concentrate on thorough surface preparation.

Re-covering Over Coal Tar Pitch Roofing

Coal tar pitch has oils and vapors that can be harmful to various roofing membranes and may discolor white thermoplastic membranes. Coal tar pitch may also "cold flow" through fastener holes into the building. For these reasons, extra care must be taken when re-covering over an existing coal tar pitch roof. Typically, additional insulation and a white surface help to first separate the membrane from the existing coal tar pitch roof and reduce the temperature of the finished assembly, which minimizes the potential for cold flow.

ROOF DECKS

Most common structural roof deck types are suitable substrates for the installation of an EverGuard® roofing system. 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

– Min. 22 gauge (standard FM-approved steel decking is 22 gauge in thickness).

– 24-26 gauge decks require a GAF Field Services Manager's or Director's approval. Thinner-gauge steel decks usually require additional mechanical fasteners to achieve comparable roof attachment performance.

– 18 gauge, 20 gauge, and 22 gauge Grade E high-strength steel decks usually require fewer mechanical fasteners to achieve comparable roof attachment performance.

Structural Concrete

– Min. 2,500 psi compressive resistance (98,066 kilogram-force/ square centimeter).

– Min. 2" (51 mm) thickness (pre-cast), min. 4" (102 mm) thickness (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.

– For non-insulated decks, nailers must be flush with deck surfaces.

– When applying insulation directly to the deck in hot asphalt, prime with asphalt/concrete primer, meeting ASTM D41, at a rate of 1 gal/square (3.8 m/liter) and allow the primer to dry prior to the application of the roofing system.

Pre-cast Concrete Decks

– These 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.

– 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 $^1/_8$" (3.1 mm) per foot/mm for adhered insulated assemblies.

- If the joints cannot be grouted and finished smooth, then a leveling course of lightweight insulating concrete (minimum 2" (51 mm) thickness) 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/leave open to permit venting and drying of the roof fill from below.

Poured Structural Concrete Decks

– Must be properly cured prior to application of the roofing system; twenty-eight (28) days is normally required for proper curing. Check curing agents for compatibility with roofing materials. Prior to the installation of the roof assemblies, GAF recommends the evaluation of surface moisture and deck's dryness through the use of ASTM D4263 or a hot bitumen test.

– 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 allow 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 obstruct the venting of the concrete, are just three examples of unacceptable deck assemblies.

Wood Planking

– Min. 1" (25 mm) 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.

– Check compatibility of preservatives or fire retardants used to treat decking with roofing materials.

– Decking should be kept dry and roofed promptly after installation.

– Tape and staple fastening systems may be used on wood decks when they comply with local building codes and agencies.

Plywood/Oriented Strand Board (OSB)

– Min. 1/2" (13 mm) thickness. Standard FM-approved plywood decking is fire-rated at 3/4" (18 mm) thickness.

– Tongue & groove edges or full blocking required.

– Oriented strand board (OSB) decks shall comply with Structural 1 rating.

– Plywood sheathing shall be exterior grade, minimum 4 ply, not less than 15/32" (12 mm) thick.

– Must be installed over joists not greater than 24" (610 mm) o.c.

– Must be installed so that all four sides of each panel bear on, and are secured to, joists and cross blocking; the panels must be secured in accordance with APA–The Engineered Wood Association recommendations. "H" clips are not acceptable.

– Panels must be installed with a 1/8" to 1/4" (3.1 mm to 6.3 mm) gap between panels and must match vertically at joints to within 1/8" (3.1 mm).

– Decking should be kept dry and roofed promptly after installation.

– Tape and staple fastening systems may be used on wood decks when they comply with local building codes and agencies.

– Deck shall be attached with approved fasteners at required spacing. Consult local building codes for specific requirements.

Gypsum Concrete

– Min. 2" (51 mm) thickness.

– Steel reinforcing mesh and permanent form boards required for poured-in-place monolithic decks.

– Steel-reinforced edges required for pre-cast decking units.

– An average fastener withdrawal resistance as recommended by the fastener manufacturer must be obtained. If proper mechanical attachment cannot be achieved, contact the GAF Technical Hotline at 1-800-ROOF-411 for assistance with installation recommendations.

– If either surface-wet or frozen, a poured gypsum deck is not suitable to receive a roof.

Cementitious Wood Fiber

– Min. 2" (51 mm) thickness.

– Tongue & groove panel edges required.

– OSB or insulation composite decks for use with fully adhered systems require a GAF Field Services Manager's or Director's approval.

– Should not be installed over high humidity occupancies.

– All structural wood fiber deck panels must be anchored against uplift and lateral movement.

Insulating Concrete

– Min. 2" (51 mm) thickness.

– Cellular lightweight insulating concrete decks can be installed over non-slotted, galvanized metal decking designed for cellular lightweight insulating concrete or structural concrete.

– Aggregate lightweight insulating concrete decks must be installed over permanent venting steel forms.

– Insulating concrete installed over structural concrete or existing roof membrane substrates requires a GAF Field Services Manager's or Director's approval.

– Lightweight insulating concrete decks are required to have a minimum compressive strength of 125 psi (9 kg/cm) and a density of 22 pcf (208 grams/cubic meter). Individual deck manufacturers' standards apply when their specifications exceed these GAF minimum thicknesses, compressive strengths, 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.

– Lightweight insulating concrete should not be poured during rainy periods; deck areas that have frozen before they have cured must be removed and replaced. Check decks for moisture content and dryness if exposed to precipitation prior to installation of roof membrane.

Loadmaster Decks

– Roof deck must be installed by a Loadmaster-approved contractor according to Loadmaster specifications.

– Min. 25 gauge steel decking, 15/16" (22 mm) deep with 1/2" thick (13 mm) mineral board top panel.

– Polystyrene or polyisocyanurate insulation is optional.

– Consult a GAF Field Services Manager for reroofing and re-covering requirements.

PARAPET WALLS

Most common structural wall types are suitable substrates for the installation of EverGuard® 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 coating or plywood facing 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/EIFS

- Stucco finish and EIFS systems must be removed to the underlying substrate surface.

Plywood/Oriented Strand Board (OSB)

- Min. 1/2" (13 mm) thickness (exterior-grade).
- Tongue and groove edges or full blocking required.
- Adhesives should only be used with untreated plywood/OSB.

Sheet Metal

- Min. 24 gauge steel.
- Min. .032" (8 mm) aluminum.
- Corrugated panels require overlay of 15/32" (12 mm) plywood/oriented strand board or silicone-impregnated gypsum panel.

Gypsum Panel

- Min. 1/2" (13 mm) thickness.
- Silicone-impregnated fiberglass-faced panels.
- Underlying substrate must allow securement of flashing at prescribed spacing. Mechanical attachment to gypsum panels is not acceptable.
- Use of gypsum panel decks requires GAF Field Services Area Manager's approval.

ROOF DRAINAGE

Providing positive roof drainage is important. Standing water can result in deck deflection and possible structural damage. In addition, 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 gravitate through the membrane opening. Providing structural slope in the deck assembly, installing a tapered lightweight cellular concrete overlay, installing a tapered insulation system, or adding additional drains are the most common methods of achieving positive drainage.

National building codes generally require a minimum 1/4" per 12" (6.3 mm to 305 mm) slope to drain in order to provide positive drainage and accommodate deck irregularities. Although existing buildings may or may not be required by code to achieve this degree of roof slope, providing positive slope to drain remains an important design consideration.

In situations where roof edge conditions, window/door height above the roof surface, parapet wall height, weep hole locations, rooftop equipment mountings, or other factors prevent the installation of a full slope-to-drain system, a combination of additional drain locations, tapered saddles, and crickets to direct drainage to drain points should be considered.

EXPANSION JOINTS

The function of a structural expansion joint is to minimize the effect of stresses and movements on building components and to prevent these stresses from adversely affecting the roof. The design, location, and use of building structural expansion joints must be considered at the time of original building design and are the responsibility of the architect, engineer, and building owner.

Expansion Joints:

- 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" (203 mm) above the roof surface on curbs and use either Metalastic® Flexible Expansion Joint Covers or metal caps or covers. Alternately, a low profile expansion joint can be used; see EverGuard® details for construction.
- Design drainage flow patterns so they are not blocked by any structural expansion joints.
- Where possible, position walkways on roof access points to limit roof traffic over expansion joints; provide protective coverings for expansion joints at locations of anticipated roof traffic.
- EverGuard® Pre-Fab Expansion Joint Covers are available.

AREA DIVIDERS

Area dividers are not considered structural expansion joints. They can be installed to separate different roofing systems and can be either a curb or low-profile type. Contact the GAF Technical Helpline (1-800-ROOF-411) for recommendations regarding area dividers.

EQUIPMENT MOUNTINGS

Proper mounting of equipment is an important consideration. In general, rooftop equipment should be mounted in such a way as to provide adequate flashing height for both new and anticipated re-cover roof system applications; sufficient clearance around and beneath the equipment to facilitate roof system installation; and compatibility with roofing and flashing materials so that standard flashing methods can be readily applied.

Alternately, lightweight equipment and gas/conduit lines can be installed on wood blocking or other prefabricated devices that do not penetrate the roofing system. Do NOT use this type of application for heavy equipment or gas conduit line; or where excessive movement can damage the substrate or membrane.

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. Refer to current EverGuard® listings in the appropriate UL directory to verify roof assembly requirements for specific fire ratings.

WIND PERFORMANCE

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 the appropriate FM 1-60, 1-90, or other rated system as appropriate for a specific building based upon location and exposure.

The following are common wind codes and approvals typically used in conjunction with EverGuard® roofing systems:

- **FM Global (Factory Mutual)**
  - Testing based on method described in Approval Standards 4450 and 4470.
  - Measures resistance to upward pressure applied to the roof system.
- **American Society of Civil Engineers (ASCE) document ASCE 7-10, "Minimum Design Loads for Buildings and Other Structures"**
  - 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.

Refer to Factory Mutual Loss Prevention Data Sheets 1-28 and 1-29 for specific installation guidelines.

GAF provides the following thermoplastic half sheet table to use as a guide for mechanically attached systems because wind pressures are increased in the corners of the roof, with somewhat lower 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.

Perimeter Half Sheet Table

Building Width	Building Height	Number of EverGuard® TPO 60" (1.5 m) Half Sheets	Number of EverGuard® PVC 60" (1.5 m) Half Sheets	Number of EverGuard® PVC 40.5" (1 m) Half Sheets
<200' (61 m)	0-34' (0-10 m)	1	1	2
	35-100' (10-30 m)	2	2	3
<200' (61 m)	>100' (30 m)	Install half sheet throughout the perimeter and corner region. The width of this region is defined as the least of the following two measurements: 0.1 x building width or 0.4 x building height. Note: The minimum width is 4' (1.2 m).		
	any height			

The perimeter area, as defined in the above table, may be adhered as an alternative to using half sheets. When adhering the perimeter area, the number of insulation fasteners must be increased in these areas; refer to the insulation attachment section for adhered membranes. Refer to the sheet lay-up details in the mechanically attached system section for requirements on the installation of these half sheets. Note: When designing for wind loads, ensure that the proper building classification (closed, partially closed, or open) is used if the building has large openings (i.e., docks with large loading bays, etc.). Improper classifications can result in roof attachment failure caused by designing to lower loads than actually exist for the building in question.

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 provide a moderating effect on the temperature in proximity to the building.

- **U-Value**
  - Thermal Transmittance: The number of BTUs (energy) that pass through a 1-square-foot (305 sq. m.) sample of a total material assembly in one hour with a temperature difference between the two surfaces of 1 degree F (-17°C).
  - 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 (0.1 sq m) sample of a given material thickness in one hour.
  - The R-value is the reciprocal of the C-value.

– 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.

• **Reflectance**
  – A measure of the % of solar energy that is reflected away from a surface.
  – Dark materials absorb more heat from the sun and can be up to 70°F (21°C) hotter than a reflective white surface given the same outside temperature and conditions such as wind speed, location, etc.

• **Emittance**
  – A measure of the infrared radiation emitted from a roof surface. Unlike reflectance, infrared emissivity may not be affected by dirt or discoloration of the surface of a material.

The following references provide useful information regarding energy efficiency:

• **ASHRAE Fundamentals Handbook**
  – Provides detailed design calculations and material energy transfer information utilized by mechanical engineers in the design of heating, ventilation, and air-conditioning systems.
  – Suitable for complex energy evaluation considerations such as solar heat gain, exterior shading, total building envelope, building usage, and lighting.

• **NRCA Energy Manual**
  – Provides a simplified method for determining the amount of insulation necessary to construct an energy-efficient low-slope roof system.
  – Provides a simplified method for determining the energy cost savings resulting from the installation of additional roof insulation.
  – Suitable for most roofing-related energy evaluations.

• **DOE Energy Calculator**
  – Go to www.ornl.gov/sci/roofs+walls/facts/CoolCalcEnergy.htm to find the Cool Roof Calculator.
  – This tool measures the energy savings for low-slope roofs with non-black roof surfaces.

WATER VAPOR TRANSFER

Typical single-ply roof assemblies do not include vapor retarders as a standard assembly component. For these applications, there is a natural transfer of water vapor into the roof assembly during a portion of the year, followed by a natural transfer of water vapor out of the roof assembly during the balance of the year. Under normal conditions, this type of cyclical water vapor flow does not cause a significant deterioration of the roof insulation or reduction in insulation thermal performance.

However, 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, 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 is a description 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).
  – 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.

• **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 saturated vapor (100% relative humidity) and condensation begins to form.
  – Dew Point Temperature is expressed as °F.

• **Temperature and Relative Humidity**
  – Vapor flows due to 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, and this is typically called the "warm side."
  – 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**
  - A number of basic considerations factor into the need and location of a vapor retarder. Determining the need and location of the vapor retarder is the responsibility of the design professional.
  - Vapor retarders are intended to be installed as close to the "warm side" as possible. Normally, this places the vapor retarder directly on the structural deck or directly over a minimal layer of EnergyGuard™ insulation or fire barrier.
  - A sufficient amount of EnergyGuard™ insulation must be installed over the vapor retarder to raise the location of the dew point temperature above the level of the vapor retarder.

- **Sealing At 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 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 typically require the use of a vapor retarder except when located in the most northerly 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 climactic 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 entrapped moisture within the roof system that can eventually destroy the insulation, 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. This water may move 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 is discovered and 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 vents, or via diffusion through the roof membrane itself. If this occurs, moisture can condense within the roofing system.

The following resources may provide useful information regarding vapor retarders:

- NRCA Energy Manual
- ASHRAE Fundamentals Handbook