Expanded Polystyrene (EPS) Roofing

Expanded Polystyrene (EPS) Roofing Solutions

For more than 35 years, expanded polystyrene (EPS) roof insulation has been an exceptional building solution for a new or remodeling construction project. EPS is a closed cell, lightweight foam plastic insulation that is compatible with all commercial roofing systems. EPS insulation can be used in built up roofing, modified bitumen systems and single-ply membrane systems that are ballasted, mechanically fastened or fully adhered. As with any product, the successful use of EPS insulation depends upon correct installation in accordance with good building practices.

Testing Codes & Standards

EPS insulation is recognized by all major code approval agencies and testing organizations in North America.

EPS Insulation Properties

EPS insulation meets the requirements of ASTM C578, Specifications for Rigid, Cellular Polystyrene Thermal Insulation, Standard for Thermal Insulation, Polystyrene Boards and Pipe, the material standards that cover the types, physical properties and dimensions of cellular polystyrene intended for use as thermal insulation in the United States and Canada.

ASTM provides properties for seven EPS “types” and CAN|ULC-701 provides properties for three EPS “types.” This allows EPS insulation manufacturers the capability to provide a range of product types offering compressive resistance to meet the specification of virtually any roofing project. Compressive stress/strain characteristics of EPS insulation are determined using ASTM D1621, Standard Test Method for Compressive Properties of Rigid Cellular Plastics, or ASTM C165, Standard Test Method for Measuring Compressive Properties of Thermal Insulations. The most important mechanical property of EPS insulation and building products is its resistance to compressive stresses, which increase as the density becomes higher. EPS has a compressive resistance between 10 - 60 psi for most construction applications. Within that range EPS can be produced to meet specific strength requirements.

International Building Code

EPS insulation meets the requirements of the International Building Code (IBC). According to IBC Section 2603 Foam Plastic Insulation, for roofing applications foam plastic insulation must be separated from the interior of the building by a thermal barrier consisting of 0.5” (12.7 mm) gypsum board or wood structural panel sheathing not less than 0.47” (11/9 mm) thick.

Fire Resistance

Fire-resistance classifications A, B and C relate to exterior fire exposure and are intended to represent different levels of fire resistance performance. They are defined by ASTM E108 and CAN/ULC S107 as follows:

•I Class A roof coverings are not readily flammable, are effective against severe fire exposures, and do not carry or communicate (i.e., spread) fire.
•I Class B roof coverings are not readily flammable, are effective against moderate fire

exposures, and do not readily carry or communicate fire.
•l Class C roof coverings are not readily flammable, are effective against light fire exposures, and do not readily carry or communicate fire.

Factory Mutual

Factory Mutual testing protocol, FM 4450, Approval Standard for Class 1 Insulated Steel Deck Roofs, assesses the flame spread of an interior fire on the underside of the roof deck assembly. Recognized by U.S. and Canadian code organizations, FM 4450 covers fire, wind uplift, live load resistances, corrosion of metal parts and fatigue of plastic parts. The standard applies to the assembling and performance of all components of an insulated steel deck roof. Assemblies that pass FM 4450 are given a FM Class 1 rating. Those that don't are rated Class 2. It is important to make a distinction between what FM defines as an "acceptance" and an "approval". An "acceptance" refers to installation in a specific project and means the product must be evaluated on a case by case basis while an "approval" of a product applies to multiple products.

Tapered Roofing

EPS insulation is a versatile, cost effective choice in low-slope or tapered roofing systems where proper drainage is the key to maximum performance and longevity. EPS provides the required positive slope while retaining the structural and economic advantages of a flat roof deck.

EPS can be customized and cut to obtain the desired pitch, from 1/8 inch per foot up. Installers can cut the EPS insulation on site which gives a precise fit and allows application in a single layer creating a continual form. This design versatility translates into considerable savings in labor and framing costs. Usually the ridges and valleys necessary to provide correct drainage are supplied at 45 degree increments to the horizontal, but custom angles can be easily accommodated.

EPS manufacturers are available to provide complete specification and design assistance. Field assistance
becomes even more valuable when unanticipated modifications become necessary. Delays are avoided with EPS since the material can be cut to specification on site, achieving a precise fit and decreased labor costs.

Built Up Roofing

EPS insulation has been successfully used in built up roofing (BUR) applications for more than 35 years. BUR systems constructed with a concrete roof deck allow roof insulation to be applied directly to the deck since there is no thermal barrier requirement with the noncombustible concrete deck. The EPS foam may be affixed to the concrete deck with asphalt using a technique described as "mop and flop" by the roofing industry. Hot asphalt is applied to the concrete deck and allowed to cool slightly before the foam is permanently dropped into place. A coverboard is then "mopped and flopped" onto the EPS with the joints overlapping and taped. The BUR is then applied on top of the coverboard which provides a uniform and consistent base for the weatherproofing system.

The thermoplastic properties of EPS insulation make it necessary to place a coverboard above the foam in BUR systems. This provides protection from hot asphalt used to adhere and build up the waterproof protective roof covering materials. In a typical BUR system there will be three or four alternating layers of materials which will include bitumen, either asphalt or coal tar, and roofing felts which can be surfaced with some type of exposed aggregate embedded in hot asphalt or a smooth coating or cap sheet.

EPS foam used in BUR systems can be installed as described above or may be delivered to the job site as a complete composite panel that includes the insulating foam, coverboard and, when necessary, a thermal barrier. This composite panel is mechanically fastened to the concrete or steel deck. The use of prefabricated composite panels for BUR roofing applications is growing steadily because of labor savings during installation.

Single-ply Roofing

EPS is ideal for single-ply membrane systems. Available in a variety of joint details, such as tongue and groove and shiplap edge, EPS provides maximum dimensional stability and high thermal efficiency and can be specified to meet numerous design conditions. While the typical thicknesses for roof applications are up to 12 inches, EPS can be tapered to 1/8 inch per foot to provide adequate drainage on structurally flat roof decks.

Single-ply membrane systems account for over 40% of all new low-slope construction and about 32% of re- roofing. Unlike BUR membrane systems that are constructed on the roof, single-ply membranes are factory manufactured from bitumen and reinforcing fabric materials. They are generally categorized as either thermo-plastic or thermo-set and are often identified by their chemical acronyms, i.e. ethylene propylene diene monomer (EPDM) or polyvinyl chloride (PVC). The membranes may contain reinforcement layers of polyester fabrics, glass fiber or felt. The finished membrane thickness is referred to as mil thickness where 1 mil equals 0.001 inch. Typical membrane thickness range from 30 to 60 mils; however, greater thickness can be produced depending upon the manufacturer and product type.

Single-ply thermo-plastic membranes will soften when heated and harden when cooled while thermo-set membranes are irreversibly set and will not soften when heated. Because of these fundamental differences single-ply membranes may be installed in the following ways: ballasted, mechanically attached or fully adhered.

The top surface of the EPS insulation must be protected from melting in built up roofing applications, in torch on membrane applications and in single ply membrane applications when solvent and adhesive attack are possible. In these cases, a protection board of fibre board or particleboard is generally used.

Direct-to-Deck

The application of polystyrene foam roofing insulation applied directly to steel roof decks without a thermal barrier in single-ply membrane roofing systems is also possible. EPS insulation can be applied directly over steel roof decks as a component of a Class A, B or C roof covering without the use of a code specified thermal barrier. Direct-to-Deck EPS insulation is a cost-effective, durable and energy efficient solution for roof insulation. It is compatible with all major roofing materials and assemblies and available in flat, tapered and compound tapered panels in densities ranging from 1.0 to 2.0 pcf.

Summary

EPS insulation offers many benefits in a wide variety of roof insulation applications. EPS manufacturers are often local, close to building sites, reducing shipping costs. They can design roof layouts to reduce installation labor time and costs. Also, the manufacturers maintain test and code approvals necessary to protect the consumer.

The insulating value of EPS remains constant after manufacture and does not decrease over time, providing the same protection over the life of the roof.

Since EPS insulation is available in a range of compressive properties and thicknesses, the builder can select the most economical product to meet design requirements.

In addition, the energy-saving properties and the ability to incorporate recycled material into EPS insulation make it a natural choice for “green building” applications.

Tapered Roofing Systems

Poor drainage on commercial roofs can result in damage far more destructive than either wind or other natural elements. Building owners often under estimate the advantages of tapered roofing when evaluating the life expectancy of a roof.

Positive drainage is necessary to insure a safe, long lasting roof. Ponded water and freeze-thaw cycles can result in costly repairs and even pre-mature roof failure, which is rarely covered under warranty or by insurance. Positive sloped roof systems result in reduced maintenance and less stress to the building structure.

According to the Uniform Building Code, roof systems must be sloped a minimum of ¼ inch in 12 inches for drainage. All three major code bodies accept this standard. However, some local codes accept retrofit roofs with a slope of only 1/8 of an inch per foot.

Tapered roofing is equally suited for new and replacement construction. In new construction, this can be achieved by designing a slope into the structure of the building. In this case, the roofing support columns are varied in height so the final roof deck has high and low points from which to place the roof drains. The easiest way to improve the slope of an existing roofing system is with the addition of insulation underneath the membrane. The thickness of the insulation is varied to create the necessary slope.

A Proven Track Record

Expanded polystyrene is a logical, cost effective choice in low-slope roofing systems. Tapered EPS insulation provides the required positive slope to drain while retaining the structural and economic advantages of a flat roof deck. It maintains long-term thermal performance, dimensional stability and consistent moisture-resistance. EPS effectively controls the transfer of heat within all roofing systems.

Moisture is extremely detrimental to any roofing system. The purpose of the membrane is to keep the water out. However, in the event of water penetration, EPS has been shown to effectively resist moisture and retain its mechanical properties. In a study conducted by Structural Research Incorporated, Madison, Wisconsin, in 1984, it was demonstrated that no wet insulation was found in the EPS or wood fiberboard overlayment. The moisture content of EPS insulation samples ranging in age from 6 to 15 years was found to be very low, i.e., a maximum of 0.04% by volume. Likewise, results for R-value performance indicated no deterioration in R-value over time, meaning EPS thermal resistance values may be used without adjustments for aging.

Expanded polystyrene can be molded into thicknesses up to 50 inches and then cut to obtain the desired pitch, ranging from 1/8" per foot or greater. EPS can be applied in a single layer creating a continual form. This design versatility translates into considerable savings in labor and framing costs. Usually the ridges and valleys necessary to provide correct drainage are supplied at 45° increments to the horizontal, but custom angles can be easily furnished.

Design Considerations

A designer must take into consideration the details of the roofing area as well as budgetary concerns. A roof might include skylights, internal and external drain locations, expansion joints and height limitations of parapet and other adjacent walls as well as house HVAC units. The layout of the insulation must work around these components and within a specified budget.

Solutions are found by utilizing various layout options to move unwanted water off the roof.

Shed Roof Design - This is the most basic layout design. The roof slopes from a high point to low point causing the water to travel to the edge of the building or into a gutter.

Two-Way Slope - The roof is split into two parts with a slope on each part. It can either slope inward toward the center of the building or to the outside. The two-way slope is more cost effective than the one-way slope because the total thickness of the insulation is less at the high point since it is split into two.

Three-Way Slope - This layout is used on roofs of smaller building attached to larger structures because it slopes to a point that lies on a side of the drained area. Instead of forming a valley as seen in the two-way slope, the water is forced to a small area, usually a roof drain.

Four-Way Slope -It is considered the most effective layout to insure proper drainage. The insulation is sloped to a single point located inside the area being drained. Or, the slopes are inverted to create a high roof center where the water is brought down to edges of the building. In some designs, the center of the slopes can create ponding. To eliminate this chance, a special set of tapered products, crickets and saddles, should be installed.

Once the layout is determined, the thickness and slope of the insulation must be calculated. The designer must take into account the cost of the insulation as well as the required R-value when deciding on the needed thickness to achieve an adequate slope. Steep slopes may do a great job in eliminating ponding but the problems could outweigh the benefits. Cost can be escalated and the roof drains may be overloaded. Extra long fasteners will also increase the cost of the tapered roof.

The Perfect Choice

Depending on the type of roofing system chosen, EPS insulation is available in both faced and unfaced rigid foam. It may be laminated at the point of manufacture or on the jobsite and helps to provide added strength and durability. To protect from roof traffic, hot asphalt, single ply adhesives and modified bitumen applications, the lamination is adhered to the top of the insulation. It is laminated on the bottom when a thermal barrier is required.

EPS manufacturers are available to provide complete specification and design assistance. Field assistance becomes even more valuable when unanticipated modifications become necessary. When problems occur on the jobsite and the slope of the insulation needs to be adjusted, contractors typically experience delays while requisitioning a reconfigured piece. Delays are avoided with EPS since the material can be cut to specification on site, achieving a precise fit and decreased labor costs.

Other considerations include interior and exterior temperature variations. When interior relative humidity is 80% or less at 70°F, with cold exterior conditions, no moisture build-up will occur in EPS insulation. However, the use of a vapor retarder is recommended with extreme indoor humidity (above 80% relative humidity at 70°F) and cold exterior conditions (average winter temperatures less than 40°F). A vapor retarder is recommended with high interior humidity (above 40% relative humidity at 70°F) and cold exterior conditions (average winter temperature less than 40°F) when a wood fiberboard overlayment for EPS is installed. Based on NRCA/MRCA sponsored studies, vapor retarder placement for EPS insulated roof systems is less critical than for other types of roof insulations.

Code Compliance

EPS roof insulations are compatible with most commercial roofing systems, including, but not limited to built up roofing and modified bitumen systems and single-ply membrane systems that are either ballasted, mechanically fastened or fully adhered. Expanded polystyrene insulation meets the requirements of ASTM C 578 Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation. When specifying EPS insulation using ASTM C 578, the best possible product selection is ensured.

Roof assemblies are tested based on the type of fire exposure. The different roof construction assemblies are listed in the materials and equipment approval manuals published by each of the testing facilities.

For product information, installation guidelines and specific code approval information, contact your local EPS manufacturer.

Design Issues:

1) Allow time for "Design Assistance" by taper manufacturers
2) Determine minimum acceptable slope
3) Determine if layout is suitable for 4-way or 2-way design.
4) When designing crickets and saddles, insist on a minimum valley slope of 1/8" where

possible
5) Projects that taper and flat insulation areas should be noted on plans with hatching and clear notes.

Built-Up Membrane Systems

The National Roofing Contractors Association (NRCA) reports that built-up roofing (BUR) systems have been in use for more than 100 years and account for roughly 20 percent of all new low-slope roofing construction applications and 21 percent of re-roofing. EPS has been used in this roofing application for more than 30 years. Performance properties for EPS thermal insulation can be found in ASTM C578, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation. This standard covers the types, physical properties and dimensions of commercially available EPS insulation products.

BUR systems constructed with a concrete roof deck allows the roof insulation to be applied directly to the deck since there is no requirement for a thermal barrier due to the noncombustible concrete deck. The EPS foam may be adhered to the concrete with asphalt using a technique described as "mop and flop" by the roofing industry. Hot asphalt is applied to the concrete deck and allowed to cool slightly before the foam is permanently dropped into place. In this BUR system a coverboard is then "mopped and flopped" onto the EPS with the joints overlapping and taped. The BUR is then applied on top of the coverboard, which provides a uniform and consistent base for the weatherproofing system.

When using a steel deck the building code requires a thermal barrier with an index of 15, such as 1/2 inch gypsum board. The required barrier protects the foam from ignition as well as limiting the potential contribution to under-deck flame spread during a fire by the roofing system components. In BUR systems because of the thermoplastic properties of EPS it is necessary to place a coverboard above the foam to protect it from hot asphalt used to adhere and build up the waterproof protective roof covering materials. In a typical BUR system there will be three or four alternating layers of materials which will include bitumen, either asphalt or coal tar, and roofing felts, which can be surfaced with some type of exposed aggregate embedded in hot asphalt or a smooth coating or cap sheet.

EPS foam used in BUR systems can be installed as described above or may by delivered to the job site as a complete composite panel that would include the thermal barrier when necessary, the insulating foam and the coverboard. This composite panel can then be easily adhered or mechanically fastened to the concrete or steel deck saving on-site labor. The use of prefabricated composite panels for BUR roofing applications has been steadily growing because of the labor savings involved in installation.

Modified Bitumen Membranes

The NRCA reports that polymer-modified bitumen membrane systems have been used in the United States since the mid 1970's and account for approximately 18 percent of all new low-slope construction and 23 percent of re-roofing applications. These membranes are available in either asphalt or coal tar based systems that have been modified with a polymer and reinforced with a variety of materials including glass fiber, polyester or polyethylene. They can be installed with torches, in hot asphalt, cold adhesives and/or self-adhered and sometimes in combination with hot-air welders. Performance properties of the membrane are dependent upon the modifying polymer and the reinforcing material. EPS insulation used in modified bitumen roofing systems should be handled and installed similarly to BUR systems and will require thermal barriers and coverboards.

EPS should not be used in new construction applications when coal tar adhesives are present. In re-roofing applications where EPS is applied over an existing BUR that contains coal tar adhesives special precautions must be taken to protect the foam during extremely high temperature conditions. It is possible that vapor emissions from the coal tar used to seal or join the edges of the original roof membrane system will deteriorate the polystyrene foam. The use of a coverboard with tightly sealed taped joints is recommended.

Single-Ply Membrane Systems

Single-ply membrane roofing systems account for just over 40% of all new low-slope construction and about 32% of re-roofing. Single-ply membranes are factory-manufactured roof coverings compared to BUR membrane systems that are constructed on the roof from bitumen and reinforcing fabric materials. Single-ply membranes are generally categorized as either thermo-plastic or thermo-set, and are usually identified by their chemical acronyms, such as ethylene propylene diene monomer (EPDM) or polyvinyl chloride (PVC). The membranes may contain reinforcement layers of polyester fabrics, glass fiber or felt. The finished membrane thickness is referred to as mil thickness where 1 mil equals 0.001 inch. Typical membrane thickness range from 30 to 60 mils; however, greater thickness can be produced depending upon manufacturer and product type.

Single-ply thermo-plastic membranes will soften when heated and harden when cooled while thermo-set membranes are irreversibly set and will not soften when heated. Because of these fundamental differences single-ply membranes may be installed in the following ways:

EPS roofing insulation can be installed as a component in almost all single-ply roof membrane systems. Polystyrene foam is subject to deterioration when subjected to petroleum-based solvents. Several single-ply membrane systems contain solvents that will attack EPS. Consult the membrane supplier to determine the compatibility of the membrane and installation adhesives with EPS foam.

EPS insulation can be mechanically fastened or fully adhered directly to a concrete roof deck with no thermal barrier and depending upon the membrane, the installation system may or may not require a coverboard. Ballasted systems may not need a coverboard, where as mechanically attached or fully adhered membrane systems typically will require a coverboard to provide additional strength for attachment fasteners or a barrier to petroleum vapors released from membrane sealing adhesives.

EPS insulation is available in thickness up to 40 inches, typically with square edges. Tongue and groove and shiplap edge details are also available. It can be tapered to 1/8 inch per foot to allow for adequate drainage on structurally flat roof decks. Typical thicknesses for roof applications are up to 12 inches. EPS insulation is available with a variety of compressive and flexural strength properties. Consult the current edition of ASTM C578 for the physical properties of specific EPS products types.

Benefits of EPS Roofing

CONSISTENT R-VALUE
•Consistent over life of roof
•Measurable energy savings
•Lower cost per R-value than many other insulation products

DESIGN ATTRIBUTES
•Design flexibility and versatility in meeting projectspecific applications
•Compatible with fully adhered, ballasted or mechanically fastened systems
•Compatible with common roof assembly components

SUPERIOR PERFORMANCE
•Dimensional stability
•Moisture resistance
•Compressive strength

ENVIRONMENTAL BENEFITS
•Recycled EPS incorporated in many insulation products
•Never manufactured with ozone-depleting gases, such as CFCs or HCFCs
•Lightweight, less material required to meet R-value standards.

More About Expanded Polystyrene Insulation

At the core of every ESP product is a state of-the-art expanded polystyrene, foamed-plastic insulation core. Its unique closed-cell structure provides remarkable physical and thermal properties. While lightweight and resilient, it is also capable of supporting virtually any of the loads typically encountered on a roof. This material has long-term, non-degenerative thermal properties (R-Value), excellent moisture resistance and dimensional stability. It is compatible with virtually every commercial, low-slope roofing system offered, with only a few exceptions. Styrene is the primary ingredient used in the production of ESP insulations. Styrene (styrene monomer) is a derivative of both crude oil and natural gas processes. The styrene is polymerized to form polystyrene. Expandable polystyrene resin is processed in a molten state into which a pentane blowing agent is introduced and formed into tiny spheres, similar in size to beach sand. With steam, these miniature beads expand up to 40 times their original resin size. The expanded beads are stabilized in curing bins, fused into billets or blocks in a block mold, and cut into roof insulation and sheathing boards of various thicknesses, sizes and tapers. Typical roof insulations are manufactured to a nominal density of 1.25 pounds per cubic foot; however, products may be ordered in nominal densities ranging from 1 to 3 pounds per cubic foot.

Energy Efficiency

The escalating price of petroleum and natural gas continues to make energy consumption and conservation a critical issue for building owners and designers. Typically, the initial or design R-Value of an insulation product is the primary factor in determining which product to use. Some insulations exhibit a phenomenon known as thermal drift. This is a result of diffusion or dilution of the blowing agent (a gas that has high resistance to heat flow) in the insulation's cells. Some insulations will lose up to 30% of their initial insulation capability over the design life. ESP products do not use these blowing agents for insulating purposes, and therefore do not exhibit this degradation. The products provide the same consistent and reliable thermal performance after 60 days, one year or twenty years, as they did on the day they were purchased. Designers should request the specific thermal design value from the manufacturer and not rely on general, typical or average R-Value tables found in most manufacturers' literature. Additional factors to be considered in a design are roof components that can cause thermal shorts or bridging, air infiltration, as well as unique construction details and quality of workmanship. Each of these factors can have a significant impact on the thermal performance of the roof assembly.

Environmental Issues

Another issue facing the building design and construction industry is the impact a product will have on the environment. While many products are marketed as green or environmentally friendly, it is difficult for the owner and designer to determine the real impact of a given product. The designer should consider the long-term characteristics of the insulation, its thermal resistance, initial recycled material content, recyclability after the system's life-cycle, and the re-usability in the next roof system. Some insulations contain ozone-depleting gases, CFCs (chlorofluorocarbons) or HCFCs (hydro- hlorofluorocarbons). ESP does not contain these chemicals. Manufacturers of products that contained these gases were forced to re-formulate their products several times in the past decade, and as a result, the thermal and physical product properties have changed dramatically. Today, of these products employ the same family of blowing agents that have been used in ESP since their origin. However, while the chemistry used to make these ESP products is tried and true, the alternative insulations have limited track records.

Standard EPS Insulation:

I, II, VIII and IX

EPS standard roof insulation product offering consists of I, II, VIII and IX. These products are high-performance insulations consisting of a superior closed-cell, lightweight and resilient expanded polystyrene meeting or exceeding the requirements of ASTM C578, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation. These products have excellent dimensional stability, compressive strength and water resistant properties.

Tapered EPS

Tapered ESP is cut from the same quality stock as our flat ESP products. Available in thicknesses up to 40", Tapered ESP is significantly more cost-effective than the competing tapered systems requiring fill pieces. Tapered ESP can also be supplied as custom-cut crickets and saddles. ESP employs well-trained taper design specialists throughout the country.

EPS Holey Boards

EPS Holey Boards are manufactured for use in lightweight insulating concrete systems consisting of cellular concrete, vermiculite or perlite. EPS Holey Boards can be provided in a range of sizes, thicknesses and profiles to meet job-specific needs. EPS Holey Boards is often installed in a stair-step fashion to create a tapered or sloped roof substrate.

Physical Properties

EPS mechanical properties depend on two primary factors: the density of the material and the fusion, or integral bonding, of the expanded polystyrene beads. Although density plays a key roll in defining the mechanical properties, density alone does not adequately define the important characteristics and should not be the sole criteria used to specify the product. The degree of fusion achieved in the forming process is a critical factor. EPS's ongoing investment in state-of the- art manufacturing equipment and controls results in the highest quality material available. Not all expanded polystyrene products are created equally. Care should be taken to make certain the manufacturer is able and willing to certify the mechanical properties of their product will meet those prescribed for the project. For roofing systems, the most critical mechanical properties to consider are compressive strength, flexural strength, dimensional stability, water and moisture absorption and thermal value.

ASTM C578, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation is the generally accepted document used to define the physical properties of expanded polystyrene used in the United States. Note that the values in this specification are the minimum properties recommended for each material type. These properties are determined using ASTM C203, Test Method for Breaking Load and Flexural Properties of Block-Type Thermal Insulation, ASTM C165, Test Method for Measuring Compressive Properties of Thermal Insulations and ASTM D1621, Test Method for Compressive Properties of Rigid Cellular

Plastics.

Compressive Strength is required to support or resist dynamic loads (e.g. foot and construction traffic) as well as static loads (e.g. mechanical fasteners) to which typical roof systems will be exposed during the construction process and while in service. EPS VIII, II and IX will best meet or exceed the desired compressive resistance for mechanically attached systems. Compressive strength increases as density increases, and depending on the product, ranges between 10 and 60 psi. A cover board, EPS I may exhibit creep when under load for extended periods of time. Compressive Strength must be considered during the design and selection process.

Flexural Strength is required to ensure the product can be handled without being damaged, can span irregularities and roof deck flutes, and can resist bending forces from wind loads on the roof system. The flexural strength of the EPS product increases with improved fusion and increased density.

Dimensional Stability is imperative to the long-term performance of a roof system. Inadequate dimensional stability can result in the exposure of roof membranes to stresses that can lead to splits, punctures, wrinkles and membrane delamination. EPS products are among the most dimensionally stable insulations available in the roofing industry. This dimensional stability remains even at thicknesses of 3" and above. EPS products may exhibit some dimensional changes when under load or when exposed to extreme temperatures above 180 °F. The use of cover boards, light covered membranes or reflective coatings can protect the product from these exposure conditions.

Absorption indicates a product’s susceptibility to take on moisture. EPS products do not readily absorb moisture from the environment. All foam-plastic insulations absorb some moisture over time. However, in the long-term, EPS will better retain its mechanical properties and outperform most alternative insulation materials. EPS products are successfully used in Geofoam, marine and below-grade applications, as well as roofing applications.

The mechanical properties of the insulation are very important in adhered assemblies. The performance of the roof assembly depends greatly on the integrity and characteristics of the insulation. Typically, adhered single ply and built-up roofing systems will require a cover board. EPS I may be used when a cover board is part of the system.

Finally, an additional factor to consider is the overall resiliency of EPS products. The products not only have the ability to resist loads, but can also recover their original thickness once the load has been removed. This characteristic enables the EPS products to deflect or elongate when exposed to forces such as roof-top traffic and deck or building movement from thermal expansion and contraction, and then return to their original configuration. Because EPS easily accommodates irregularities in decks, substrates and existing roof systems, it provides a uniform and even base for
new roofs.

Physical Properties of EPS

Testing results were obtained under controlled laboratory conditions and do not represent minimum standards. EPS is not obligated to manufacture its products per a designer's specifications or physical standards unless agreed to in advance by EPS. It is the purchaser's obligation to ensure any purchased EPS materials meet a specification's physical properties.

Property	**Type I**	**Type VIII**	**Type II**	**Type IX**	**Test Method**
Nominal Density	1.0	1.25	1.5	2.0	ASTM C303
C-Value (Conductance) BTU/(hr•ft2•°F) @ 25° F (per inch) @ 40° F @ 75° F	.23 .24 .26	.22 .235 .255	.21 .22 .24	.20 .21 .23	ASTM C518 or ASTM C177
R-Value (Thermal Resistance) (hr•ft2•°F)/BTU @ 25° F (per inch) @ 40° F @ 75° F	4.35 4.17 3.85	4.54 4.25 3.92	4.76 4.55 4.17	5.00 4.76 4.35	ASTM C518 or ASTM C177
Compressive Strength (psi, 10% deformation)	10 - 14	13 - 18	15 - 21	25 - 33	ASTM D1621
Flexural Strength (psi)	25 - 30	32 - 38	40 - 50	55 - 75	ASTM C203
Dimensional Stability (maximum %)	< 2%	< 2%	< 2%	< 2%	ASTM D2126
Water Vapor Transmission (perms)	2.0 - 5.0	1.5 - 3.5	1.0 - 3.5	0.6 - 2.0	ASTM E96
Absorption (% vol.)	< 4.0	< 3.0	< 3.0	< 2.0	ASTM C272
Capillarity	none	none	none	none	–
Flame Spread	< 20	< 20	< 20	< 20	UL 723
Smoke Developed	150 - 300	150 - 300	150 - 300	150 - 300	UL 723

Insulations

Product Information

An effective roof insulation reduces overall energy consumption, brings about improved comfort for the building's occupants and provides an excellent substrate for a new roof system. The EPS product line can satisfy these needs for virtually every type of roof system. The preceding section reviews the complete EPS product line. To ensure correct selection of any roof insulation or membrane, it is recommended that a product's performance be considered.

Thermal Values of EPS Products The following chart provides the EPS thicknesses needed to obtain the corresponding R- value. Over the last century, the average temperature within the contiguous United States as reported by the National Oceanic and Atmospheric Administration (NOAA) was 52.8 °F. EPS generally quotes the R-Values of its products at 40 °F, which is one of the testing temperatures provided within ASTM C518. This temperature most closely reflects the average overall temperature throughout the U.S. The R-Values were determined per ASTM C518, Standard Test Method for Steady- tate Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

Warranties The owner of a low-slope roof may wish to receive a material and labor warranty that covers both the EPS insulation and the membrane. EPS insulations are eligible for inclusion in many membrane manufacturers' total system warranties. Contact your local EPS representative for a list of membrane manufacturers with which EPS is a partner. Product Considerations Roof insulation should perform two basic functions; it is a thermal barrier for the building's roof and a substrate for the roof system. In order to perform these functions, it should have the following basic characteristics:

Stable thermal resistance (R-Value) to meet the longterm needs of the designer and building owner Resistance to damage during typical construction traffic during the installation of the roof or roof-top units (antennae, HVAC, etc.)

Rigidity to span rib openings in metal decks and minor deck irregularities, and to support the roofing membrane

Material Storage and Handling

General Storage Recommendations

Roofing materials can be damaged by exposure to the elements and may be susceptible to moisture retention; all material should be protected from the weather and stored in a dry location.

Insulation that is stored outside should be covered by canvas tarpaulins that can breathe. Tarpaulins or other covers should be properly secured. Loose insulation material should be weighted down to prevent wind blow-off or damage.

General Handling and Installation Recommendations

Materials that are stored outside should be placed on pallets or raised platforms to keep them off the ground or roof deck. Use caution when handling any roofing insulation to avoid breaking, crushing or cracking the board or its edges. Load or stage insulation in a manner that will minimize repetitive movement of the material. Install only as much insulation as can be covered by a roof system and/or made watertight by the end of each day. Any temporary water cut-offs or roof tie-ins should be completely removed before additional insulation is installed.

EPS insulations should be protected from solvent based or petroleum-based adhesives and from direct contact with coal-tar products. EPS insulations should not come in contact with asphalt at temperatures above 250 °F. EPS insulation should not be exposed to open flames or other ignition sources. Any decks or substrates that require a primer should be primed at least 24 hours before the installation of EPS insulations. Allow approximately 1/4" between EPS products and any vertical surfaces or roof projections. Do not force or jam product into place.

In cut-up areas and for complex tapered layouts, material should be laid out unattached to allow for trimming and fitting. The use of a chalk line is recommended to start the installation of any Tapered EPS system. Whenever practical, Tapered EPS systems should be installed starting from the thickest point and working towards the thinnest point. This will allow any trimming or cutting to be done at the drain points. This will not be feasible for factory-fabricated valley or ridge systems. When starting first and second rows of taper, start one of the rows with a half-length board so that joints are staggered between rows. Repeat throughout the tapered system.

Do not dispose of any end cuts until the installation is complete. These pieces may have been figured in and required elsewhere in the system. End cuts should be marked with a permanent marker with the same letter or number as the piece from which they were cut.

General Tapered Insulation Recommendations

Asphalt Recommendations

Asphalt-applied roofing membranes are not to be installed directly to EPS insulations. Always mop an area 6"- 8" larger than the insulation piece being installed.

The asphalt mop should not come in contact with any previously installed insulation pieces. Only solid mopping of EPS insulation is recommended. Spot or strip mopping is not recommended. Do not overload the mop, as asphalt will cool more slowly than normal if excessive quantities are applied. EPS should not come in contact with asphalt at temperatures above 250 °F. A common rule-of-thumb for appropriate asphalt temperature is the lack of visible fuming of the installed asphalt.

All insulation boards must be walked-in immediately after being placed in the mopping asphalt. If the board is slightly cupped, apply the cupped face downward.

Asphalt is not recommended for EPS-to-EPS attachment. For these applications, contact your EPS representative for recommendations on approved adhesives.

When EPS is used in a hot-asphalt system (BUR or modified bitumen), a suitable cover board is required. The membrane manufacturer should be contacted for recommendations on approved cover boards. The joints between the cover board and the joints of the initial layer of

EPS should be staggered a minimum of 6".

Cover boards to be mopped to EPS should have the asphalt applied to their bottom sides only. Asphalt should not be applied directly to the EPS insulation. To minimize asphalt migration between insulation joints, EPS recommends the use of 6" strips of an ASTM D2178 Type VI ply felt over the joints and the application of asphalt over the strips using a small mop. Asphalt should be hot enough at the point of application to bleed through the ply felt so that it will attach to the insulation. Mechanized equipment may also be available for strip application.

An alternate means of addressing asphalt migration through insulation joints would be to apply a protection sheet (e.g. red rosin, Kraft paper) between the cover board joints and the EPS insulation.

Tapered Roof Insulation

The performance risks associated with a roof that does not have positive drainage have been known in the roofing industry for many years and are covered further in the Roof Decks Section of this manual. Tapered EPS offers the designer an easy and economical means of adding positive slope to virtually any building. With a trained tapered design staff at every location, EPS can efficiently assist roofing professionals with recommendations on designing, ordering and installing Tapered EPS insulation systems. To facilitate the installation process, EPS provides detailed shop drawings for every Tapered EPS project.

Tapered EPS systems can be used for new, re-roof and re-cover projects. Assemblies can include complete and integral systems that incorporate sloped panels for the field of the roof as well as crickets and saddles to further assist in directing water to drainage outlets.

There are several basic elements that should be considered for every project: minimum slope required, locations of drains (internal and external), mechanical equipment, curbs, expansion and control joints, allowable overall insulation thickness (imposed by parapets or equipment curbs), and alternative system layouts. Alternative tapered layouts and additional roof drains should be considered when existing project conditions limit the performance of a system.

Tapered EPS is available in six standard slopes: “A” panels have a slope of 1/8" per foot, “B” panels have a slope of 3/16" per foot, “C” panels have a slope of 1/4" per foot, “D” panels have a slope of 3/8" per foot, “E” panels have a slope of 1/2" per foot and “F” panels have a slope of 3/4" per foot. Custom slopes are available upon request. To facilitate installations, each panel is hand-labeled at the EPS plant.

Tapered EPS panels can be provided in thicknesses up to 40" from most EPS manufacturing locations. The ability to produce specific panels (up to 40" thick) for each course of insulation eliminates many of the complexities associated with those tapered insulation systems in which individual panel thickness is limited to approximately 3". With fewer pieces to handle, Tapered EPS systems are significantly less labor-intensive to install. In addition, pre-cut ridge and valley panels are available. These panels are typically cut to 45° angles, though other angles can be provided upon request. Tapered EPS panels can also be easily fabricated on site by the roofing mechanic.

Crickets and Saddles

Directing water to or from specific areas of the roof can be achieved quite easily with Tapered EPS cricket and saddle systems. These materials can be used with numerous other insulation systems or integrated into a total Tapered EPS package.

In the roofing industry, the terms cricket and saddle are often used interchangeably. For this manual, the term saddle is defined as a relatively small, elevated area of a roof that is constructed to divert water around a chimney, curb or other projection.

Equipment Curb

Drainage

A cricket is defined as a small structure that directs surface water to drains, frequently located in a valley, and often constructed like a small hip-roof or a pyramid with a diamond shape base. Several examples are given below.

Tapered Insulation System Options

Continuous Perimeter Drainage A simple tapered insulation solution for moving water from the field of the roof to the gutter edge is a full or partial hip-style tapered insulation design. A hip-style layout is well suited for buildings that can drain water freely around the entire perimeter. In the following example, the arrows indicate the direction in which the water will drain. Interior Drains and Parapet Walls A common tapered insulation solution for buildings with parapet walls and interior drains consists of compound mitered panels with overlay crickets. In the field of the roof, the tapered system will divert the water away from the parapets, while the crickets (dashed line) and mitered panels will direct water into the valleys and towards the drains (shown as dark circles).

Note: Even if not required by local building codes, consideration should be given to have backup or overflow drains at each drain location. Set slightly higher, the backup drain will provide a safety outlet in the event the primary (lower) drain becomes obstructed or clogged.

External Drains and Parapet Walls If the building has parapet walls around its perimeter and exterior drains (scuppers, shown as trapezoids), a combination of sloped field-panels can be used to form a ridge in the center of the roof, and be overlaid with factory-fabricated crickets (dashed lines) to direct the water away from the parapets and towards the valleys and scuppers.

Buildings with multiple sections often employ combinations of all the systems previously shown. EPS can provide assistance in determining which alternatives best suit your needs.
Basic Heat Flow Fundamentals

Heat is the energy associated with the random motion of molecules, atoms or smaller structural units of matter. Heat always flows from higher to lower temperatures. All materials and matter, including air, contain heat down to a temperature of absolute zero (approx. 460 °F). There is no such thing as cold! Cold is the absence of heat. When we feel cold it is not cold penetrating our clothes or structures, but rather the rapid loss of heat from our bodies.

The flow of heat cannot be stopped but only slowed by the use of insulation, trapped air or heat-reflective surfaces.

Heat flows by means of conduction, convection or radiation or a combination of any or all of these.

Conduction – The transfer of heat in a material due to the molecule-to-molecule transfer of kinetic energy. An example is when the handle on a skillet gets hot when the bottom of the pan is heated on the stove. With most materials, the denser the material, the higher the rate of heat flow due to conduction.

Convection – The transfer of heat by physically moving the molecules from one place to another through fluid flow either in air or liquid. An example would be a forcedair heating system in a building or the heat rising from a steam or hot-water-heated pipe.

Radiation – The transfer of heat through space from a very hot object through electromagnetic energy. An example would be when you feel the heat from a fireplace while standing many feet away. Another example is the heating from the sun during the day. Radiant heat is not affected by air. In a roofing system, radiation is seldom a cause of concern in heat lost.

Radiation from the sun during the day impacts the roof-top surface of a dark-colored roof membrane. In these situations, insulation is typically used to block the heat flow into the building. Another method to minimize heat flow from radiation on a roof surface is to use a reflective roof membrane or a “cool roof”. Contact the membrane manufacturer for additional “cool roof” information.

Heat Flow Terminology

Heat is measured in terms of BTUs, or British Thermal Units. A BTU is the amount of heat required to change the temperature of one pound of water by one degree Fahrenheit at sea level. An example of 1 BTU would be the energy released by a typical wood match that is allowed to burn end to end. Thermal Conductivity, k-Value (BTU•inch/hr•ft •°F) Thermal conductivity, or k-Value, is the measure of the amount of heat that will be transmitted through a 1" piece of a homogenous material, per hour, per square foot, per degree Fahrenheit temperature difference. The smaller the k-Value, the better the insulator. This is the basic physical property of a material measured in the laboratory.

Thermal Resistance, R-Value

Thermal resistance, or R-Value, is a material’s resistance to heat flow. The higher the R-Value, the higher the insulating value of the insulation. All materials that have the same R-Value, regardless of thickness, weight or appearance, are equal in insulating value.

Fastener Load Study

EPS insulations have been used in single ply, mechanically attached systems since their inception. Questions have been raised regarding EPS’s ability to resist membrane fastener loads. To address these questions, EPS embarked on a study of fasteners typically used for membrane attachment and their effect on various insulation systems. Samples of the insulation systems were placed in a Dillon Compression Test Apparatus and covered with a single ply membrane. The membrane was attached to the insulation to duplicate a typical field application. Once the membrane and insulation systems were in place, a 2" membrane fastener plate was placed through the membrane. The force of the test apparatus was channeled through a 2" column onto the plate. A load was applied to the plate at a rate of 0.2 inches per minute until 120 pounds was reached. The load was recorded for a period of 72 hours.

A review of the final data showed that there was not a significant difference for the insulation systems tested. The following chart gives the insulation system tested and the average load retained for each system after the monitoring period.

Roof Decks

The roof deck is the structural foundation for the roofing system. It must be designed to provide sufficient support for all dead and live loads to which it will be exposed and must provide enough resistance to racking, flexural and torsional loads to prevent any deformation that might cause a roof failure. It must be rigid, eliminate excessive positive or negative deflection under load, and have a smooth surface with no large cracks or gaps. It must also be even and securely anchored to the building structure. Positive attachment of the roof assembly to the deck is critical. The decking material must readily accommodate the roof system's attachment method. An inspection of the deck's condition prior to beginning roof construction should be a key part of the installation process. Everyone involved in the design and construction of the roof should participate; the owner's representative, the designer, the roof consultant, the roofing contractor and the decking contractor. Any surface irregularities, blemishes, voids, unacceptable elevation changes, etc. in the deck must be addressed prior to the roof installation. Expansion joints should be provided in all roof decks to accommodate movement that will result from expansion and contraction of the deck or structure. These elements should allow for both vertical and horizontal movement. The entire roof assembly (membrane, flashing systems and insulation) should be terminated at all expansion joints.

Wood Nailers

Most roof membranes and deck materials require the use of wood nailers or curbs at roof penetrations, openings and building perimeters. Nailers provide both protection for the edges of insulation and a substrate for terminating roof membranes, base flashings and metals (gravel stops and edging). Nailers must be securely fastened to the roof deck or building structure. An uplift resistance of 200 lbs per lineal foot is typically recommended for nailers. Designers should provide details and specifications addressing the nailer type, grade, attachment methods and fastener schedule. Tapered edge-strips are often used to divert water away from roof edges. Nailers should be equal in thickness to both the total thickness of the tapered edge-strip and insulation, and be wide enough to accommodate fastening of metal edges or gutters.

Roof Drainage

One of the most critical features of any roof system is its ability to drain properly. A roof membranes performance can be impacted if it is exposed to prolonged periods of standing water or ponding. Some decks are designed and installed with little or no slope. Tapered EPS is one of the most effective ways to provide drainage for a roof assembly. Drainage should move all water to the drains, scuppers and gutters. The outlets should be set below the plane of the roof membrane surface at the lowest points of the roof. Many manufacturers' warranties limit the amount of time water is allowed to pond on their membranes, as there are numerous detrimental conditions that can result from ponding water:

Freezing and Thawing

This repetitive action can scour protective surfacings (granules or coatings) off the membrane, exposing the system to the harmful ultraviolet light or physically damaging the membrane itself.

Excessive Amounts of Water

This can increase deck deformation, or deflection, causing the roof to retain substantial quantities of water that might exceed design expectations and possibly compromise the deck's structural integrity and/ or expose the roof membrane to severe stress. *The Accumulation of Algae and Vegetation* Ponding water can promote organic growth. Some materials are susceptible to attack by algae and other organisms. Over time vegetation root growth can penetrate even the thickest membrane. *Basins or Bird Baths* These areas are a point of collection for dust, debris and chemicals from various sources. Prolonged accumulation of these mixtures result in thick layers of sludge. It can contain a number of agents, many of which can harm the membrane. If a sufficient quantity accumulates, deep cracks or fissures will form and can exert stresses on the membrane, which results in leakage or premature aging of the material.

In any event, ponding water will pose a greater threat to having the roof leak.

The National Roofing Contractors Association and the Midwest Roofing Contractors Association recommend that roofing systems be designed to provide drainage throughout their service life.

EPS recommends that the following guidelines be followed when designing a roof:

1. Provide adequate outlets (drains, scuppers and gutters) to completely drain all standing water from the roof surface.
2. Locate outlets at the lowest points of the roof.
3. Divert water with crickets and saddles around any building element that will impede the flow of water to outlets.
4. Provide for raised edge-metal by employing tapered edge-strip at building edges.
5. When draining to the interior of the roof area, provide sumps at all drains to ensure complete removal of standing water.

All EPS locations manufacture tapered roofing systems. EPS will provide shop drawings for the contractor to assist with proper installation of the Tapered EPS system. These systems can provide a solution for both new construction and re-roofing applications in which standing water might be expected. Contact your local EPS representative for assistance with your next roof drainage problem. Also, refer to the tapered insulation information in the Roof Insulations section of the EPS Roofing Manual.

Steel Decks

The most common decking material used for low slope roofing systems is currently cold-formed steel decking. These decks are made in several styles and gauges, and galvanized (G-60 or G-90) or painted finishes. When properly designed and installed, they provide a stable and economical substrate for virtually every type of commercial roofing system. Most membrane manufacturers require that steel decks are primed and have a minimum 22-gauge thickness. Some applications require the use of galvanized steel. Steel decks are secured to the building’s structural members by welding or mechanically fastening. Fastening of the side laps is often required as well; this prevents differential movement between deck panels that are exposed to roof-top traffic. If side laps re not fastened, excessive movement could damage the roofing system. The finished deck installation should result in a surface that can receive a sheathing material or insulation. These membrane substrates should be of a thickness that spans the deck flutes and provides support for any anticipated construction traffic, and in-service live and dead loads. Steel decks are typically categorized as: 1. Narrow Rib - with a flute opening of 1" or less 2. Intermediate Rib - with a flute opening of 1" to 1 ¾" 3. Wide Rib - with a flute opening of 1 3/4" to 2 ½" 4. Deep Rib - with a minimum flute depth of 3" and a maximum flute opening of 2 3/4"

It is recommended that roof insulation be secured to the steel deck with mechanical fasteners or adhesive systems. Some membrane manufacturers do not accept adhesive applications of insulation to steel decks. Refer to the membrane manufacturer’s requirements. EPS roof insulation is used in numerous Direct-to- Deck™ applications. In these assemblies the insulation is placed directly over the steel deck. To ensure that EPS performs during both the construction process and throughout the service life of the roof assembly, it is imperative that the appropriate minimum thickness be used.

Concrete Decks – Poured In Place

Poured- or cast-in-place concrete decks also provide a suitable substrate for most roof assemblies. These decks can accommodate a number of attachment methods when installed and prepared properly. Concrete decks must be adequately cured to support roof construction traffic. Consult the designer for recommendations. The deck must be dry and have a reasonably smooth surface. Adhesive attachment of insulations may require the use of a primer to ensure an adequate bond. Consult the adhesive manufacturer’s recommendations. Hot-asphalt attachment typically requires the application of a solvent-based primer prior to the application of the asphalt. In either case, if a solvent-based primer is used, make certain it is completely dry and that all of the solvent has evaporated before applying the adhesive/asphalt and any EPS insulation. The roughness of the deck will impact the quantity of adhesive or asphalt required to adequately bond the insulation. Prior to installation of the insulation, the roofing contractor should check the dryness of the deck. If any moisture is present, the application should be delayed until the deck is dry. When hot asphalt is being used as the adhesive, the dryness of the deck can be checked by applying hot asphalt at its EVT (Equiviscous Temperature), which is printed on the package. If frothing or foaming occurs, the deck is not sufficiently dry. There are numerous fasteners available that will permit mechanical attachment of EPS insulations directly to a poured concrete deck. For an example of a concrete deck fastener and typical fastener patterns, refer to the charts at the end of this section.

Poured Gypsum Decks

Today, poured gypsum decks are not usually used for new construction. However, they can be encountered in re-roofs of existing buildings. It was not uncommon for poured gypsum decks to experience cracking over structural support members during curing. Once completely cured, they are relatively stable. Most roof membrane systems have performed well over poured gypsum decks when designed and installed correctly and allowed to completely cure (dry). There are specially designed insulation fasteners available for use with these decks. Contact a specialty fastener supplier to determine astener frequency, patterns and acceptable deck conditions. Prior to installing any insulation over these systems, the roof designer and contractor should make certain the deck is capable of supporting and receiving the new roof assembly and related construction loads. In order to accommodate mechanical fasteners, a minimum gypsum deck thickness of 2" is typically recommended. Pull tests are recommended to determine the holding capability of the fastener. This data is used to determine the fastener frequency needed for the designed wind conditions. For an example of a gypsum deck fastener and typical fastener patterns, refer to the charts at the end of this section.

In all applications in which a cover board, Oriented Strand Board (OSB) or a gypsum-based product, is used in conjunction with EPS, the minimum thickness is 1.00 inch for all densities and deck types. It is very important that the insulation be securely attached to the roof deck. Uneven or loose insulation can impact the performance of the roof membrane, and can exacerbate roof damage resulting from wind loads. When mechanical fasteners are used to attach the insulation or sheathing material, they must have a length that will permit the fastener to penetrate the steel deck by a minimum of 3/4". For multiple-layer systems, the first layer of insulation may be secured with the mechanical fasteners or a suitable adhesive and the second layer may be attached with an approved adhesive. It is also acceptable to mechanically fasten through multiple layers of insulation (EPS and/or cover boards).

The required number of roof fasteners is dependant on the area of the roof being covered and the membrane being installed over the insulation.

Additional fasteners are usually required at building corners and perimeters. For more detailed design information on wind uplift resistance, refer to the Wind Loads section of ASCE/ SEI Standard No. 7-05, Minimum Design Loads for Buildings and Other Structures provided by the American Society of Civil Engineers. For an example of a steel deck fastener and typical fastener patterns, refer to the charts at the end of this section.

Today, the use of asphalt to attach insulations directly to steel decks is rarely acceptable. This is due to historically poor wind resistance that resulted from inadequate bonding to the steel. There were numerous reasons that led to these conditions. Two commonly cited conditions were that process oils on the steel often prevented adequate adhesion, and rapid cooling of the asphalt did not allow sufficient time for the installer to place the insulation.

These decks were considered by many membrane manufacturers to be nailable only – meaning they were suitable to receive a nailed asphalt-coated fiber glass base sheet. These base sheets are frequently referred to as G2 base sheets, referring to their Underwriters Laboratories, Inc classification. The decks are not considered suitable for direct adhesive or hot-asphalt attachment due to their surface condition and residual moisture. Therefore, roof assemblies including insulation frequently require it to be hot-mopped or adhered to a fiber glass base sheet.

Pre-Cast Concrete Decks

Many of the recommendations for cast-in-place concrete decks also apply to pre-cast concrete decks. However, one common condition encountered with pre-cast decks is the difference in height between adjacent panels, which results from placement or variation in curvature. Any height difference must be addressed by grouting the lower panel to provide a transition capable of accommodating the roof insulation. It is strongly recommended that fill boards be used to provide an even substrate for the roof membrane in areas of differential panel height. If not addressed properly water can accumulate in low and uneven areas. Mechanical attachment to thesedecks is not recommended.

Pre-Cast Gypsum

Again, these types of decks are not typically used in new construction today, but can be encountered on re- oofing projects. It is very important that the original deck manufacturer's roof installation procedures and recommendations be followed closely. These decks can accommodate nailed base sheets and mechanical insulation fasteners; however, they must be of a design approved by the deck manufacturer. Tongue and Grooved (T&G)

Wood Decks

For many years, these were the decks of choice, particularly in the western part of the country. Proper design and installation, as with any decking material, is critical to the performance of the deck and subsequently the attached roof assembly. Wood is hydroscopic – it tends to absorb moisture from its environment. As wood's moisture content changes, it will expand or contract, causing movement of the deck. It is desirable to separate any deck movement from the roof membrane. Mechanically fastened insulations can provide adequate separation from these changes.

Wood decks should not be warped, cupped or have an excessive number of knots or cracks. Cover small cracks and knots with a layer of 20-gauge sheet metal or an adequate thickness of insulation. Many built-up and modified bitumen roofing membrane manufacturers recommend minimum board widths and thicknesses in order to prevent excessive deflection or other movement of the wood deck. If the wood deck has been treated with any oil or creosote, EPS products must not be applied without an approved separator sheet, either red-rosin paper, fiber glass base sheet or SecurePly. This separator sheet will prevent any undesired bonding of the insulation to the wood as a result of seeping wood resins. Plywood and Oriented Strand Board (OSB)

In most cases, engineered wood products have replaced solid wood as the standard material in building construction. Plywood Decks Plywood is a panel that consists of multiple layers of rotary cut veneers, laminated together with alternating plies with their grain running perpendicularly to the adjacent ones. Panels used as roof- eck sheathing should meet the standard properties prescribed in U.S. Product Standard PS-1 81 (ANSI A199.1). Fire-treated plywood must be certified by the manufacturer for use in low-slope roof applications. Oriented

Strand Board Oriented Strand Board (OSB) is made by bonding relatively small wafers or chips of wood into panels consisting of multiple layers, laid perpendicularly to each other. These products should carry the American Plywood Associations (APA) label indicating that the product is CD, Exposure 1, Struc 1, with the minimum thickness recommended by the membrane manufacturer.

It is recommended that these panels NOT be abutted directly against each other. A gap, typically 1/8", is left to accommodate any movement resulting from moisture gain. If installed too tightly the roof deck can buckle at the panel joints. For this reason, the deck material should be kept dry, requiring that exposed decking be roofed as quickly as possible. In order to prevent condensation on the interior surface of the deck adequate EPS insulation should be installed. Lightweight Insulating Concrete

Lightweight insulating concrete (lightweight concrete) is a poured-in-place slurry composed of Portland cement, water, sand and aggregate or a foaming agent (cellular). These decks, when designed and installed correctly, provide a suitable foundation for most roof assemblies. In addition, they provide excellent wind and fire resistance.

One of the key features of these decks is their ability to buildin slope for the roof with multiple layers of EPS. The EPS in these applications is often referred to generically as holey board because of the integral voids formed into the panels. During application, the slurry migrates through these large perforations and bonds to underlying layers, forming a composite matrix of EPS and lightweight concrete. Most membranes systems can be mechanically attached to these decks.

The aggregate-based lightweight concrete contains either vermiculite or perlite fillers that are employed to keep the density low and provide some insulation value. Minimum thicknesses recommended depend on numerous factors, including the membrane to be installed, the type of fasteners and the desired thermal performance. Vented decks accommodate evaporation of excess moisture from the slurry. The manufacturers of these materials permit placement over vented, or slotted, galvanized steel decking, pre-cast or poured-in-place concrete, or existing roofing systems. The cellular lightweight concrete systems employ a foaming agent that creates small uniform bubbles in the cement mixture. These systems typically consume all free water during

the curing process, making them ideal for most roof assemblies. The manufacturer’s mixing and installation procedures must be followed precisely to ensure that the system does not dry too quickly and cause severe surface cracking, or contain an amount of moisture that could impact the performance of the roof membrane.

These systems have been approved for use by Factory Mutual, and the FM Approval Guide should be consulted for approved types and fastening rates.

The use of EPS HB (Holey Board) roof insulation in these systems can provide desired thermal values as an integral part of the deck assembly.

These can be highly competitive alternatives for both new construction and re-roof applications. In addition, re- oof applications over these decks can be performed without disturbing the deck material and EPS insulation, eliminating expensive insulation replacement costs. Cementitious Wood Fiber Panels

Cementitious wood fiber deck panels, are made from long strands of wood (historically aspen), coated with a portland cement binder. These panels exhibit excellent acoustical properties and provide an attractive surface for the interior of the building.

Products used in roof deck applications may be made with a moisture-resistant cement binder, and have a sufficient density to support the desired live and dead loads to which the roof will be exposed. The designer should consult the deck manufacturer or the Structural Cement Fiber Products Association for design assistance.

As with any building material, there are limitations that should be considered with these decks. In the past these materials were used extensively over indoor pools and gymnasiums. This often resulted in the accumulation of moisture in the deck, which adversely affected the performance of the roof membrane. Other issues can be encountered as a result of the gaps between the panels, differential heights of adjacent panels (which must be leveled) and excessive deformation over time.

Differential heights can easily be addressed with a leveling layer of EPS insulation, which may be mechanically fastened to the deck using specialty fasteners shown at the end of this section of the manual.

The deck manufacturer's installation recommendations must be followed closely. All leveling, mechanical attachment and protection procedures must be followed. For an example of a cementitious wood fiber deck fastener and typical fastener patterns, refer to the charts at the end of this section.

What is a Vapor Retarder?

A vapor retarder is defined as a material or membrane that has a permeance (perm) rating of 0.5 or less when tested in accordance with the American Society for Testing and Materials (ASTM) standard E96, Standard Test Methods for Water Vapor Transmission of Materials. Permeance is a measure of how quickly water diffuses through a material. Materials with a perm rating of 0.0 allow virtually no moisture diffusion. Vapor retarders are used as part of a roof assembly to prevent moisture migration and condensation within that assembly. Moisture migration or condensation can be a concern within an occupied building and also during building construction. In all cases, the vapor retarders should be installed on the warm side of the insulation.

Types of Vapor Retarders

Vapor retarders can be classified as either bituminous or non-bituminous in make-up. Bituminous vapor retarders are typically 2 plies of a glass fiber roofing felt manufactured in accordance with ASTM D2178 Type IV. The roofing felts are applied to an approved substrate in either hot asphalt or a compatible adhesive.

Non-bituminous vapor retarders can consist of plastic sheets or films, kraft paper, kraft laminates and aluminum foil combinations. Follow the installation instructions of the vapor retarder supplier when using these products. Unless no other alternative exists, a vapor retarder should not be installed directly to a metal deck. As vapor retarders are vulnerable to punctures or other damage from construction traffic when installed directly to a metal deck, this type of installation is usually ineffective.

Roof systems to include a vapor retarder and to be installed over a metal deck typically require a layer of low- hermal substrate prior to the application of the vapor retarder. Contact the manufacturer to ensure the material can span the deck rib openings and to obtain general installation recommendations. Also refer to the Insulation Specifications section of the EPS Roofing Manual for additional general installation considerations.

Wood, lightweight insulating concrete and gypsum decks should not have bituminous vapor retarders applied directly to them. A nailed, asphalt base sheet is commonly applied prior to the application of the vapor barrier. Bituminous vapor retarders can be applied directly to a primed structural concrete roof deck.

For projects that include vapor retarder installations, other trades should be notified that care should be exercised when working on or over a vapor retarder. Determining the need for a Vapor Retarder The need for a vapor retarder in the roofing system should be determined by a professional roof system designer. There are several guidelines and methods used to determine the need for a vapor retarder.

For wood deck applications:

Foam plastic insulation under a roof assembly or roof covering that is installed in accordance with the code and the manufacturer's instructions shall be separated from the interior of the building by wood structural panel sheathing not less than 0.47 inch (11.9 mm) in thickness bonded with exterior glue, with edges supported by blocking, tongue-and-groove joints or other approved type of edge, or an equivalent material. And for applications meeting the above criterion: A thermal barrier is not required for foam plastic insulation that is part of a Class A, B or C roof-covering assembly, provided the assembly with the foam plastic insulation satisfactorily passes FM 4450 or UL 1256. EPS has passed UL 1256 with numerous roofing membrane systems. Contact your local EPS representative for a list of partner membrane suppliers.

EXPANSION/CONTROL JOINTS

What is an Expansion Joint?
A roof expansion joint is a flexible closure used to minimize the effects of building movement or stress on a roof system. A roof designer will usually require roof expansion joints to coincide with a building's structural expansion joints or places which there could be significant movement.

What is a Control Joint?

A roof control joint's primary function is to separate roof areas or divide areas into smaller sections to facilitate maintenance or future roof replacement. Unlike an expansion joint, it is not intended to accommodate structural movement. Roof control joints are also commonly referred to as area dividers or relief joints. The following are examples of roof locations for which control joints should be considered: Roof systems located in areas that experience extendedfreeze-thaw cycles and do not have expansion joints Roof systems that will be re-roofed or replaced in phases Roof areas that have different roof systems in place A common rule of thumb was to install a control joint at 150- to 200-foot intervals to break up large roof expanses. This practice was more critical with low-tensile organic and asbestos built-up roofing felts and may not be required with today's membrane systems. Consult with the membrane manufacturer for recommendations.

Roof Membranes

EPS's insulation and sheathing products can be used as an integral component in virtually any traditional roof membrane system. Customary application techniques and methods are used in order to accommodate the various characteristics and requirements of each.

Polymer-Based Single Ply Systems

Single ply roofing membranes are one of the most popular systems due to their flexibility, relatively easy and clean installation, lightweight and competitive price. One key feature is that they are produced in a factory to strict qualitycontrol requirements that minimize the risks that are inherent in traditional built-up roof systems. In addition, these systems can employ light-colored, reflective roof surfaces that reduce energy consumption and potentially permit the use of smaller, less expensive heating and cooling plants.

The most limiting characteristic of these systems is that they are single ply, offering no redundancy, compared to other systems. Care must be taken to avoid damaging the membrane both during installation and once in service. Single ply membranes are typically categorized as thermoset or thermoplastic materials. This classification is based on mechanical behavior with respect to the heating and cooling of the membrane, or more accurately, the polymer used to produce the membrane.

Thermosets

Thermoset polymers are composed of long-chain molecules that are linked together by small molecules with strong chemical bonds. This trait is often referred to as vulcanization or curing. The polymer network is so rigid that the molecules cannot move with respect to each other, even when heated. These types of materials do not soften or flow when heated, and the seams cannot be heat-welded in the field. They require the use of a sealing tape or adhesive to form a field-seam or lap. One of the most common polymers used in these membranes is EPDM (ethylene-propylene-diene-monomer). EPDM membranes are known for their long-term weatherability and resistance to stress (caused by the expansion and contraction typically resulting from fluctuations in temperature), ultravioletlight and ozone. The membranes are available in both unreinforced and reinforced systems, the latter of which increases tear resistance. EPDM is available in black or white, with thicknesses that range from 45 mils to 90 mils, and is offered in wide sheets that may be desirable for large projects, as fewer field seams are required.

Another thermoset material is CSPE (chlorosulfonated polyethylene) is quite different from EPDM. It is unique in that it starts out as a thermoplastic material, but over time cures into a thermoset. This membrane can be heat- elded as long as the installation takes place prior to excessive aging or curing. CSPE has been promoted for use in harsh environments.

Thermoplastics

Thermoplastic materials are made from long-chain molecules that are held together by weak chemical bonds. When heated, the molecules slide past each other, and the material softens or flows. Upon cooling, the molecules are no longer able to slide past each other, and the material hardens. Because of this property, the seams of thermoplastic single ply membranes can be heat- or solvent-welded to form field-seams. PVC (polyvinyl chloride) and TPO (thermoplastic polyolefins) are two of the most commonly used thermoplastic single ply membranes. These membranes include a reinforcing layer, usually polyester or fiber glass, which provides increased strength and dimensional stability. They are typically offered in white or light colors. PVC membranes are manufactured from a combination of PVC resin, stabilizers, pigments, fillers, plasticizers, biocides and various additives. The membranes are inherently fireresistant. Historical problems with these membranes related to the use of chemical plasticizers that ultimately evaporated (causing the membrane to become brittle and/or shrink), and have been discontinued.

TPOs are another popular thermoplastic choice. These polymers are blends or alloys of polypropylene plastic or polyprolylene and EPR (ethylene-propylene rubber) or EPDM. TPO can be installed using a number of traditional methods, the latest of which is a self-adhesive system. KEE (Ketone Ethylene Ester) membranes, in addition to having the typical properties exhibited by thermoplastic materials,are also inherently chemical-resistant. PVC, TPO and KEE remain heat-weldable throughout their service life, and simplify repairs and maintenance. Black

Membrane Applications

Due to the surface temperatures that can be reached on certain un-ballasted black membrane installations, the following chart should be followed when using EPS products with black membranes. Contact the EPS Technical Center or your local EPS representative for additional information. Single Ply System Fastening Methods Mechanically Fastened Systems in which the membrane is secured to the deck with screws, plates, bars or other anchoring devices, are referred to as mechanically fastened systems. The fastening method used will typically depend on the type of roof deck. Some applications may require the use of narrower sheets and more fasteners to reduce the likelihood of fastener pull-out.

In areas that are subject to high winds, the fastening system for attaching the membrane is critical. Due to the repetitive movement of the membrane and the resulting forces on the fastening system, the owner may be better served by selecting an alternative system type (e.g. fully adhered). EPS products are well suited for use with virtually all mechanically fastened single ply systems. These systems meet modeling building code requirements and achieve fire ratings required for most installations. Fully Adhered Fully adhered systems employ a continuous layer of adhesive that firmly bonds the membrane to a substrate (either the deck or insulation). This method requires the cohesive strength of the adhesive bond to the substrate to be capable of holding the roof in place under the design conditions. Though the roofing materials can be somewhat more expensive, the actual installed cost of these systems can be very competitive.

ROOF MEMBRANES

A recent variation on these systems includes membranes that have an integral adhesive built onto the back of the membrane – these are referred to as self-adhered or peel-andstick systems. The elimination of liquid- dhesive application can provide additional installation savings. Care must be used in selecting adhesive systems when EPS products are being used. The insulation can be damaged when exposed to petroleum- or solvent- ased adhesives or primers. When these materials are used in the system, EPS shall receive a cover board of wood fiber, oriented strand board, gypsum, Water-based and urethane adhesives have been found to work extremely well when placed directly over EPS. However, fire ratings for these systems are somewhat limited at this time. Ballasted Ballasted single ply systems typically use aggregate (round river-washed rocks), 0.75 to 1.5 inches in diameter, installed between 10 to 12 pounds per square foot. The ballast is applied directly over loosely laid membrane and insulation. While adding ballast to a loosely laid roof is most commonly associated with EPDM, other membranes can also take advantage of this fastening method. The designer must consider both the additional weight of the ballast as well as the probability of the structures exposure to high winds. In highwind areas, ballast can be lifted from the roof and cause damage to surrounding buildings or individuals. It should be noted that manufacturers of PVC membranes often do not permit the use of ballasted systems with their membranes. As an alternate to aggregate, concrete pavers, which can withstand freeze-thaw cycles, can be applied over a non-woven fleece pad to anchor the membrane. These systems are generally accepted as having the lowest installed cost per square foot, followed by mechanically fastened and fully adhered (excluding self-adhered) systems.

EPS is an ideal insulation for use in ballasted single ply membrane systems, and has been used successfully inthese applications for over twenty years. Multi-Ply Bituminous Membranes Built-Up Roofing Systems Conventional bituminous built-up roofing (BUR) membranes have been used for over 100 years and represent a notable portion of today's roofing market. The membrane, in essence, is fabricated in place, (not in a factory), and consists of layers of waterproofing bitumen alternating with plies of reinforcing felts, and finished with a protective surfacing. The primary feature of BUR is the redundancy offered by multiple plies. Molten bitumen is typically applied at elevated temperatures. These systems can be used very effectively with EPS; however, the use of cover boards and particular application techniques is required. Refer to the Insulation Specifications section for these application techniques. EPS products are not to be used with coal tar or coal-tar bitumen membranes.

ROOF MEMBRANES

The lap or bond to the roof substrate is complete once the membrane material has cooled. Cold Adhesives Virtually any of the membranes described in this section can be built or secured to the roof substrate with adhesives. Many alternatives are available, and proper selection largely depends on the roofing components employed in the system. Organic, solvent-based bonding cements have been used very effectively for many years. Although they work well with some membranes, most solvents in these adhesives can damage EPS products. When these materials are used in systems employing EPS, a cover board must be used to protect the insulation. Care must also be taken in applying the adhesive. Pouring large pools of adhesive on the cover board can penetrate the cover board and damage the insulation. A number of low-solvent, urethane and water-based adhesives are also available for use with EPS insulations. These systems may also require the use of a cover board. Membrane manufacturers typically provide their own brand or specify which adhesive materials are compatible with their membrane. Refer to membrane manufacturers' recommendations. Self-Adhered Membranes Self-adhering membranes are manufactured with an integral adhesive film on the back of the sheet that is covered with a release paper or film. They are similar in design to adhesive bandage strips. These membranes are available from single ply membrane and modified bitumen manufacturers. The sheet is installed by removing the release paper while placing the membrane over the roof insulation or substrate. Depending on the EPS product being used, a cover board may be required. EPS Roofing Manual, January 2008 31 EPS Insulation Specifications The following EPS insulation specifications are designed to allow a specifier to easily escribe a particular insulation assembly. Key Reminders The first number in these insulation specifications only indicates the number of layers of EPS insulation (1 or 2), and does not include any thermal barrier or cover board. When no thermal barrier is required, the letter N is used to indicate a direct-to-deck installation. When no second layer of EPS insulation is specified, the second set of letters are omitted. When no cover board or SecurePly is specified, the slash (/) and the two letters that follow it are omitted. rapped in the existing or new roof system.

Flat Insulation Tapered Insulation

General

This specification is intended for use over any substrate suitable to receive and support a loose laid roof insulation assembly and subsequent roof membrane. It is provided to serve as a guideline for designers and installers. Installation Considerations EPS insulations are compatible with most membrane systems; however, we recommend consultation with the membrane manufacturer for any limitations or approvals for use with their products.

Thermal Barrier Installation (If required) Some designs require the use of a thermal barrier between the insulation and occupied areas of the building. For guidance, consult local building codes, the membrane manufacturer and the Thermal Barrier information in the EPS

Roofing Manual.

Loose Laid Insulation

Install EPS insulation with continuous side joints and end joints, staggered so that they are offset by a minimum of 12" from the end joints in adjacent rows. Insulation should abut tightly against adjacent boards. Joints greater than ½" should be filled with the same insulation that is being used in the field of the roof. If insulation is being installed over a thermal barrier, an existing layer of insulation, or under a cover board, all joints must be offset a minimum of 6" between layers. When installing EPS insulations directly to a metal deck, the edges of the insulation parallel to the deck ribs must be solidly supported and centered on the ribs. Additionally, for metal deck installations, ensure that the insulation has a thickness that is adequate to span the rib openings. For acceptable inimum thicknesses of EPS installed directly over