ABSTRACT

A roofing system includes a first membrane, second membrane and an adhesive layer with no VOC content. A portion of the second membrane overlaps a portion of the first membrane. The adhesive layer directly adheres the overlapping portions of the first membrane and the second membrane together.
ROOFING SEAM WITH REACTIVE ADHESIVE

RELATED APPLICATION


FIELD

[0002] The present invention relates to one-part and two-part adhesives with low volatile organic content for use roofing seams.

BACKGROUND

[0003] In many roofing applications, for example in large, flat commercial roof decks, the roofing substrate is a concrete, light weight concrete, wood, gypsum, wood fiber or steel roof deck. The roofing membrane is used to seal and protect the roof deck from environmental weather conditions and is placed over insulation boards, which provide insulative qualities. The insulation boards are typically secured to the roofing substrate or roof deck via an adhesive composition or fasteners. The roofing membrane may be made of various materials, such as polymeric materials including EPDM (ethylene propylene diene M-rubber), Mod Bit (Modified Bitumen), TPO (thermoplastic polyolefin), or polyvinyl chloride (PVC). The roofing membrane may also be a composite material that includes EPDM or TPO. The roofing membrane is adhered overtop insulation boards or panels using an adhesive composition such as mopping asphalt (typically Type III or Type IV) or other conventional adhesive compositions. Conventional adhesives normally are required to be applied to both the roofing membrane and the substrate.

[0004] When the membrane sheets are applied to the substrate the edges of adjacent membrane sheets are typically spliced together with a seam tape. Prior to the application of the tape, a primer is applied to the membrane sheets. Conventional primers contain high levels of volatile organic compounds (VOC), and low VOC primers are expensive.

[0005] Accordingly, there is a need in the art for splicing adjacent membrane sheets together with adhesive compositions that exhibit favorable properties, such as, for example, sufficient adhesive strength, low to no VOC content, and are easily applied.

SUMMARY

[0006] A roofing system includes a first membrane, a second membrane and an adhesive layer with no VOC content. A portion of the second membrane overlaps a portion of the first membrane. The adhesive layer directly adheres the overlapping portions of the first membrane and the second membrane together.

[0007] Further features, advantages, and areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWING

[0008] The drawing described herein is for illustration purposes only and are not intended to limit the scope of the present disclosure in any way. The components in the figure are not necessarily to scale, emphasis instead being placed upon illustrating the principles of the invention. In the drawing:

[0009] FIG. 1 shows a cross-sectional side view of overlapping membranes adhered to a substrate with an adhesive composition in accordance with the principles of the present invention.

DETAILED DESCRIPTION

[0010] The following description is merely exemplary in nature and is not intended to limit the present disclosure, application, or use.

[0011] Referring now to FIG. 1, there is shown a roofing seam implementing of adhesive compositions described below. The adhesive composition can be a one-part adhesive or the first and second components of the adhesive composition are prepared and packaged separately, and then combined in the proper ratio for application at a job site. As shown in FIG. 1, in accordance with the principles of the present invention, the adhesive composition 22 is applied between the polymeric roofing material 20, such as, for example, EPDM, and a roof-deck substrate 18. The adhesive composition can be allowed to cure for a desired period of time at a desired temperature to obtain optimum bond strength. The overlapping sheets or membranes 20 may then be joined with a splice adhesive 11 at the time the roofing material 20 is applied to the substrate 18 or after the adhesive composition 22 is cured to form a continuous membrane. The splice adhesive 11 can be made of the same composition as the adhesive composition 22. The implementation shown in FIG. 1 does not require the overlapping sheets to be primed prior to the application of the splice adhesive 11. Further the implementation does not require the use of a seam tape as commonly employed to form a seal between the overlapping sheets 20, since the strength of the seal between the overlapping sheets 20 is as strong as the bond between the sheets 20 and the substrate 18 with the use of the adhesive composition 22. Note again that the formation of the seam formed with the sheets 20 is primerless so that the sheets do not need to be primed before joining the sheets together to form the seam. Also, an additional tape layer is not required to join the sheets together. Further note that the implementation is not limited to the use of the adhesives described below. For example, the primerless seam can be formed with other technologies, such as, but not limited to, to a polyurea or epoxide type composition, or any other suitable adhesive composition.

[0012] In some implementations, the adhesive composition is either a one-part or a two-part reactive adhesive composition. The adhesive composition generally includes a polyol, a pre-polymer, a catalyst, and may or may not contain an adhesion promoter.

[0013] The polyol may be any compound conventionally used in the production of polyurethanes having at least one isocyanate-reactive functionality. These polyols include glycols, diols, mono alcohols or multi-functional alcohols. One exemplary polyol suitable with the composition of the present invention includes an ortho phthalate-dihyethylene glycol based aromatic polyester polyol commercially available from Stepan under the designation STEAPANPOL PS-2352.
Another exemplary polyol suitable with the composition of the present invention includes a di-functional polyether diol commercially available from Huntsman under the designations JEFFROL PPG-1000 and JEFFROL PPG-2000. Another exemplary polyol suitable with the present invention includes a multi-functional polyester polyol commercially available from BASF under the designation PLURACOL SG360. Chemical derivatives and combinations of polyols may also be employed in the composition without departing from the scope of the present invention. The polyol comprises from about 30% to about 50% by weight of the composition.

The prepolymer or polymer precursor may be any polyurethane prepolymer formed by combining an excess of diisocyanate with a polyol to yield a diisocyanate prepolymer. The prepolymer reacts like a diisocyanate but with several important differences. When compared with the original diisocyanate, the prepolymer has a greater molecular weight, a higher viscosity, a lower isocyanate content by weight (% NCO), and a lower vapor pressure. One exemplary prepolymer suitable with the composition of the present invention includes a moisture cure prepolymer commercially available from Huntsman under the designation RUBINATE 9272. Another exemplary prepolymer suitable with the composition of the present invention includes a 4,4' -MDI prepolymer commercially available from Huntsman under the designation RUBINATE 1209. Combinations of prepolymer and commercially available polyurethanes or modified prepolymer may also be employed in the composition without departing from the scope of the present invention. In one embodiment, the prepolymer comprises from about 30% to about 70% by weight of the composition.

The catalyst may be a metal or an amine based urethane catalyst. It is preferably amine based, more preferably a diazo, and even more preferably an imidazoide. One exemplary catalyst suitable with the composition of the present invention includes 1-methylimidazole, commercially available from Air Products and Chemicals, Inc. under the designation IMICURE AMI-1. A secondary catalyst can also be used. An example includes a quaternary ammonium salt, Dabco TMR-3, commercially available from Air Products and Chemicals. Combinations of catalysts may also be employed in the composition without departing from the scope of the present invention. The catalyst comprises from about 0.5% to about 5% by weight of the composition.

The blowing agent may be reactive or non-reactive. Non-reactive blowing agents include hydrocarbons and hydrofluorocarbons. Reactive blowing agents react with the isocyanate group which produces carbon dioxide. The carbon dioxide generation produces cellular structure within the adhesive. The application of the membrane will crush the adhesive thereby releasing the generated carbon dioxide. Water is a commonly used reactive blowing agent in two-part polyurethanes. When water is included in the B side of a two-part polyurethane, the water reacts with the A side components upon mixing of the A and B sides. Additionally, water is not considered a VOC or solvent.

The adhesive composition may include adhesion promoters such as chlorinated waxes, chlorinated paraffins or chlorinated polyolefins. An example is Paroil 6011, commercially available from Dover Chemicals.

The adhesive composition may further include other additives, such as, for example, tackifiers, fillers, plasticizers, surfactants, rheology modifiers, viscosity modifiers, and thixotropic agents. Fillers, plasticizers, rheology modifiers, surfactants, and thixotropic agents may be used to alter the liquid viscosity to either or both of parts A and B, optimize mixing properties during dispensing, enhance air entrainment, improve wet out, and improve flow properties of the adhesive during application. Examples of fillers include silica particles and talc. Examples of plasticizers include process oils and phthalates. Examples of rheology modifiers include organoclays, natural clays, and fumed silica. An exemplary organoclay is CLAYTONE APA available from Southern Clay Products. The surfactants may include silicone based or non-silicone based compounds. Tackifiers may be added to improve initial green strength and may be selected, for example, from a group including polyterpenes, resin esters, phenolic resins, hydrocarbon resins, and hydrogenated resins.

The amount of the components included in the composition is selected to balance tack, cure speed, and adhesion strength of the adhesive. For example, the embodiments presented exhibit adhesive tack when cured and the foam adhesive is substantially soft with a low modulus. The low modulus allows for diffusion of the adhesion promoter to the substrate surface and improves heat aged adhesive strength.

The “A” side and “B” side are mixed so that the ratio of the reactive components, i.e., ratio of “A” side isocyanate groups to “B” side hydroxyl groups, is greater than 1.5:1. This ratio is also known as the isocyanate index and stoichiometrically one isocyanate group reacts with one hydroxyl group. In several of the examples presented below, this isocyanate index and prepolymer incorporated combine to produce a soft, non-rigid adhesive.

The adhesive composition is prepared by mixing the components prior to application on a substrate. In a one-part adhesive configuration, the components are mixed prior to packaging into a single container. The adhesive is then dispensed or otherwise applied to the roofing substrate or the roofing membrane and is cured in-situ via moisture cure. Due to the reactive nature of the adhesive composition, the adhesive composition may be applied in ribbon or bead method and may be applied to only one side of the membrane or roofing membrane. Additionally, the adhesive compositions provided herein are sprayable. In some of the adhesive composition examples described below the sprayability of the adhesive composition is facilitated using equipment that is capable of modifying the viscosity of the adhesive through the application of heat or like methods.

In a two-part adhesive configuration, the adhesive is formed by combining two separate compositions or blends just prior to application on the roofing substrate. The two parts include a “B” side or resin side and an “A” side or prepolymer side. Each of the sides is packaged separately and is mixed by an applicator prior to applying on the roofing substrate. The A and B side components may be packaged in several ways. For example, each may be stored in a collapsible bag disposed within a box such as Cubitainer® by Hedwin or Chester® by CDF, stored in rigid containers such as drums or barrels, paired in cylinders, or in flexible, fully compressible structures such as collapsible tubes that dispense the materials. In the example provided, the B side includes the polyol and the catalyst and the A side includes the prepolymer. The adhesive, once mixed, is dispersed or otherwise applied to the roofing substrate or the roofing membrane to splice adjacent membranes together. During mixing, and after mixing, the components react to form a polyurethane adhesive having suitable physical properties. Due to the reactive nature of the adhesive
composition, the adhesive composition may be applied in ribbon or bead method and may be applied to only one side of the substrate or roofing membrane. As noted above, the A Side and B Side components are preferably mixed by an applicator just prior to being dispensed or otherwise applied to the roofing substrate. Forms of application include using a cartridge, using low pressure pumping of the two components and mixing them with a static mixer, or using high pressure tanks that are brought to about 500-1500 psi with an inert dry gas, such as Nitrogen. In the latter form of application, the A and B side materials are metered as two individual components and brought together and mixed by high pressure impingement or by a static mixer and then applied in a bead or ribbon form.

[0023] The “A” and “B” side components are generally mixed in a ratio of 1:1 by volume, however the ratio may range from about 10:1 to about 1:10. During mixing, and after mixing, the A Side components and B Side components react to form a polyurethane adhesive having suitable physical properties. Preferably, the adhesive composition is applied in discrete beads or ribbons overtop the roofing substrate, such as the insulation boards or roof deck or roofing membrane. Next, the roofing membrane is rolled or otherwise positioned overtop of the adhesive composition and the roofing substrate. Overlapping sheets as shown in FIG. 1 are then joined together with the splice adhesive 11, which is typically the same adhesive composition. The adhesive composition then cures and secures the roofing membrane to the roofing substrate, as well as securing adjacent roofing membranes together. Due to the formulation of the adhesive composition of the present invention, the roofing substrate and the roofing membrane may be unmated, i.e., no primer or membrane fleece back is required to achieve the desired adhesive strength. Therefore, no fleece backing or primer needs to be applied during membrane production in the factory or during membrane installation at the job site. As discussed earlier, the overlapping membranes also do not need to be treated with a primer before applying the splice adhesive. Also, as mentioned earlier the adhesive composition can be a one-part configuration.

[0024] The adhesive compositions can have a low modulus of elasticity. For example, the adhesive can have a modulus of about 121.5 psi. Similarly, the adhesive can also have soft and flexible characteristics that promote mobility of the chlorinated paraffins within the adhesive.

[0025] The method of adhering a “neat” EPDM roofing membrane to a roof member as well as forming a seam between adjacent membranes provides several advantages over existing methods. The present method provides a VOC free application using curable chemistry between two water-impermeable membranes. Furthermore, the present method does not require a fleece backing or priming to adhere the EPDM roofing membrane to the roof member.

[0026] In various arrangements the two-part adhesive exhibits a slow reaction initiation time to allow greater wet out of the substrates for improved adhesion. Some imidazole structures (permethylated nitrogen) act as latent catalysts and are more effective after heat aging of the polymer. Other imidazole structures (active hydrogen) produce blocked isocyanates that become un-blocked with heat. Various two-part adhesives exhibit an acceptable cure time of the adhesive which allows for enough green strength to resist wind up-lift forces on a roof. (This improvement is from polymer viscosity build and tensile strength increase.) The two-part adhesive can exhibit an acceptable cure time of the adhesive to lock down the membranes to allow normal activities on a roof. (This improvement is from polymer viscosity build and tensile strength increase.) The two-part adhesive in some implementations has an NCO to OH ratio resulting in a soft polymer with a modulus of less than 500 psi and is tacky with a T-peel breakaway strength of greater than 0.5 pli.

[0027] The two-part adhesive can contain an MDI isocyanate pre-polymer having a high 2-4' content which exhibits a slow reaction initiation time to allow greater wet out of the substrates for improved adhesion. (This is due to a balance of 4-4' MDI with 2-4' MDI allowing for fast polymer formation from 4-4' and slower reaction and good wet-out due to steric hindrance of the 2-4'.) Certain two-part adhesives contain Di-ethanol amine or other additives which disrupt the hard/soft segment blocks of the polyurethane adhesive resulting in a soft polymer with good peel strength. The two-part adhesives can contain a hard composition that can alter the surface tension or chemistry of the adhesive or membrane allowing for better wet out or creation of reactive sites and improved adhesion.

[0028] In various arrangements, the adhesive compositions described above may or may not include paraffins or other adhesion promoters. Any of the compositions may include chain extenders such as, for example, glycerin, diethylene glycol, etc. for back end cure speed improvements. The addition of glycerin or similar chemistries provide a formulation that performs as a roofing adhesive over a wide application temperature range. This allows sufficient we-out time during the initiation of the reaction time to allow for adhesive to the roofing substrate. Further, the formulation with glycerin or similar chemicals exhibits acceptable completion of reaction to make the membrane resistant to wind up-lift forces in a timely manner. In certain compositions with glycerin or similar chemistries, the application temperature range for these compositions have a range from about 0° F. to about 190° F.

[0029] The adhesive compositions may be pressure sensitive adhesives (PSA). Such adhesives can be readily dispensed as a liquid that cures to its final form within a desired period of time with final physical properties (i.e. pressure sensitive adhesive) that allow it to adhere to, for example, a polymeric sheet with adequate bond strength to resist application stresses.

[0030] The compositions can include high molecular weight polymer additions such as tackifiers and rheology modifiers. The reduction or elimination of entrapped air can be obtained through polymer cure speed, polymer rheology or the method of applying the adhesive. For example, employing faster polymer viscosity increase or use of the spreader to trap less air between membranes.

[0031] Further details of suitable adhesive compositions as well as the application of such compositions are described in U.S. patent application Ser. No. 14/069,653, filed on Nov. 1, 2013, the entire contents of which are incorporated herein by reference.

[0032] The description of the invention is merely exemplary in nature and variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.
What is claimed is:
1. A roofing system comprising:
a first membrane:
a second membrane, a portion of the second membrane
overlapping a portion of the first membrane; and
an adhesive layer directly adhering the overlapping portions
of the first membrane and the second membrane
together, the adhesive layer having no VOC content.
2. The roofing system of claim 1 wherein the adhesive layer
is the product of mixing an A side composition and a B side
composition together.
3. The roofing system of claim 2 wherein the A side composition
includes a polyol, a catalyst and a chain extender, and
wherein the A side composition includes at least one of a
polyurethane prepolymer and a diisocyanate.
4. The roofing system of claim 3 further comprising at least
one adhesion promoter present in at least one of the A side
and the B side.
5. The roofing system of claim 4 wherein the at least one
adhesion promoter is selected from the group consisting of
chlorinated paraffins and chlorinated polyolefins.
6. The roofing system of claim 4 wherein the at least one
adhesion promoter includes at least two adhesion promoters
each selected from the group consisting of chlorinated paraffins
and chlorinated polyolefins.
7. The roofing system of claim 2 wherein a ratio of isocyanate
groups in the A side to hydroxyl groups in the B side is
greater than 1.5:1.
8. The roofing system of claim 1 wherein the adhesive layer
further includes a blowing agent.
9. The roofing system of claim 1 wherein the first
membrane and the second membrane are unprimed prior to the
application of the adhesive layer.
10. The roofing system of claim 1 wherein the first
membrane and the second membrane are sheets of EPDM.
11. The roofing system of claim 1 wherein the adhesive
layer is a one-part composition including at least one polyol, at
least one moisture cure prepolymer, and at least one catalyst.
12. A composite roof structure comprising:
a roofing substrate having a substrate surface;
a first roofing membrane having a membrane surface that
opposes the substrate surface of the roofing substrate;
a second roofing membrane having a membrane surface
that opposes the substrate surface of the roofing sub-

strate, a portion of the second roofing membrane over-
lapping a portion of the first roofing membrane and
an adhesive layer directly adhering to the substrate surface
of the roofing substrate and directly adhering to the
membrane surface of the first roofing membrane and to
the membrane surface of the second roofing membrane;
and
a splice adhesive layer directly adhering the overlapping
portions of the first roofing membrane and the second
roofing membrane together, the splice adhesive layer
having no VOC content.
13. The roofing structure of claim 12 wherein the adhesive
layer and the splice adhesive layer of made of the same
adhesive composition.
14. The roofing structure of claim 12 wherein the adhesive
layer and the splice adhesive layer are the product of mixing
an A side composition and a B side composition together.
15. The roofing structure of claim 14 wherein the B side
composition includes a polyol, a catalyst and a chain
extender, and wherein the B side composition includes at least
one of a polyurethane prepolymer and a diisocyanate.
16. The roofing structure of claim 15 further comprising at
least one adhesion promoter present in at least one of the A
side and the B side.
17. The roofing structure of claim 16 wherein the at least one
adhesion promoter is selected from the group consisting of
chlorinated paraffins and chlorinated polyolefins.
18. The roofing structure of claim 16 wherein the at least
one adhesion promoter includes at least two adhesion
promoters each selected from the group consisting of chlorinated paraffins
and chlorinated polyolefins.
19. The roofing structure of claim 14 wherein a ratio of
isocyanate groups in the A side to hydroxyl groups in the B
side is greater than 1.5:1.
20. The roofing structure of claim 12 wherein the first
roofing membrane and the second roofing membrane are
unprimed prior to the application of the splice adhesive layer.
21. The roofing structure of claim 12 wherein the first
roofing membrane and the second roofing membrane are
sheets of EPDM.
22. The roofing structure of claim 12 wherein the adhesive
layer and the splice adhesive layer are a one-part composition
including at least one polyol, at least one moisture cure pre-
polymer, and at least one catalyst.