ISSUES TO CONSIDER REGARDING

Self-Adhering TPO Single-Ply Membranes

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ABSTRACT

Self-adhering roofing systems in the single-ply industry are growing in use, providing the benefits of fully-adhered membranes without the need for field-applied adhesives. Their use presents installation considerations that the roofing professional should include when designing and installing these systems. Data will be presented on the physical characteristics of the membranes themselves and how these characteristics can affect the waterproofing quality of the installed system. Following this discussion of physical performance characteristics, a review of installation considerations, flashing details and how they can be designed and installed, and issues specific to this type of roofing system and its installation will be presented. While much of the data and discussion relate to self-adhering TPO membranes, the general concepts and considerations are applicable to all self-adhering, single-ply membranes.

INTRODUCTION

Growth in the single-ply industry during the past two decades has been significant, with current estimates placing single-ply membranes as representing over 1.7 billion square feet (17 million squares) per year. Advancements in the materials and systems have continued on pace as the market has matured and the performance of these products has been proven. Single-ply roofing systems are best delineated by type of membrane and by installation method. Thermoset membranes (EPDM) and thermoplastic membranes (most commonly TPO and PVC) represent the membrane types, while installation methods are typically separated into mechanically-attached, fully-adhered, and ballasted.

Each of these assemblies has its own advantages and disadvantages, and designers and building owners typically choose the membrane and installation method that best fits the needs of the building. *Table 1* lists several of the advantages and disadvantages of each type of installation method.

As the industry has matured, several innovations in the application of these systems have been developed. Examples include paver systems for ballasted roofing, the use of taped seams for thermoset membranes, and the use of fleece-backed membranes to act as a separator layer or to pro-

TABLE 1

	SYSTEM TYPE		
	MECHANICALLY ATTACHED	FULLY ADHERED	BALLASTED
ADVANTAGES	• Light weight • Easily maintained • Moderate cost	• Light weight • Easily maintained • Wind performance	• Low cost • Fast installation time
DISADVANTAGES	• Frequency of fastening for wind uplift resistance • Penetration into structural deck	• Fumes/odors of adhesives • Higher installed cost/more labor intensive	• Leak detection • Cost of overburden removal for repairs • High installed weight

TABLE 2						
PRODUCT	THICKNESS OF TPO MATERIAL OVER SCRIM		WEATHERING (CAP) LAYER THICKNESS		TOTAL THICKNESS	
	Avg. mils	Std. dev.	Avg. mils	Std. dev.	Avg. mils	Std. dev.
A	12.4	0.8	15.6	1.3	42.6	1.4
B	15.9	0.3	22.0	0.4	45.5	0.4
C	16.0	1.1	22.0	1.8	45.4	1.3
D	11.6	0.4	20.3	0.7	42.5	0.5

vide for the installation of fully-adhered membranes in hot asphalt.

A more recent innovation in the single-ply roofing industry is the use of a factory-applied adhesive on the back or underside of the membrane to provide a fully-adhered system without the use of additional adhesives. Traditionally, fully-adhered membranes are adhered using either a solvent-based adhesive, a water-based adhesive, or hot asphalt. The introduction of "self-adhering" membranes ("self" implying that additional adhesives are not required) provides another alternative to the roofing professional looking for the performance characteristics of a fully-adhered membrane.

SELF-ADHERING MEMBRANES – THE DATA

Consideration of the disadvantages of traditional fully-adhered systems led manufacturers to consider the application of butyl technology to develop fully-adhered membranes that have a factory-applied adhesive layer. Butyl technology has a proven performance record, and combined with thermoplastic polyolefin (TPO) membranes, building owners and roofing professionals are provided the benefits of a fully-adhered membrane that has none of the fume/odor issues that can accompany installations utilizing either adhesives or asphalt. These membranes are available with a heat-welded seam if so desired, or with adhesive in the full seam area.

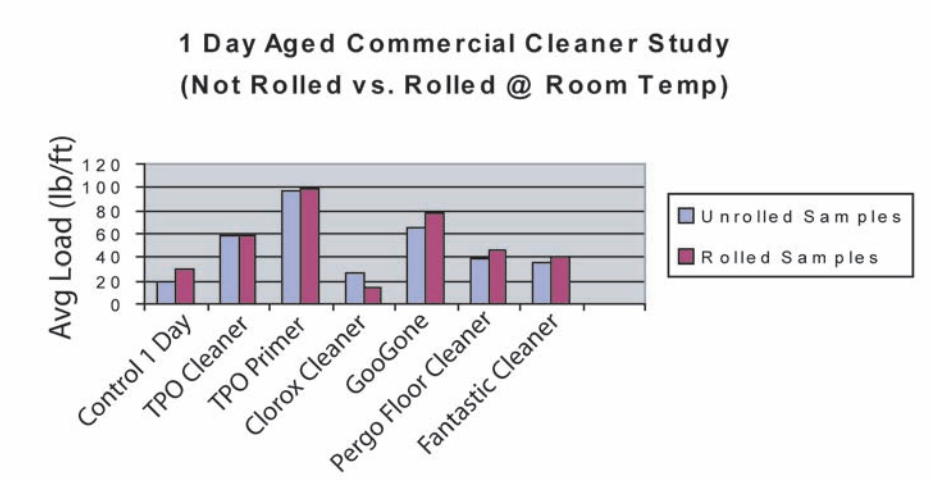

FIGURE 1

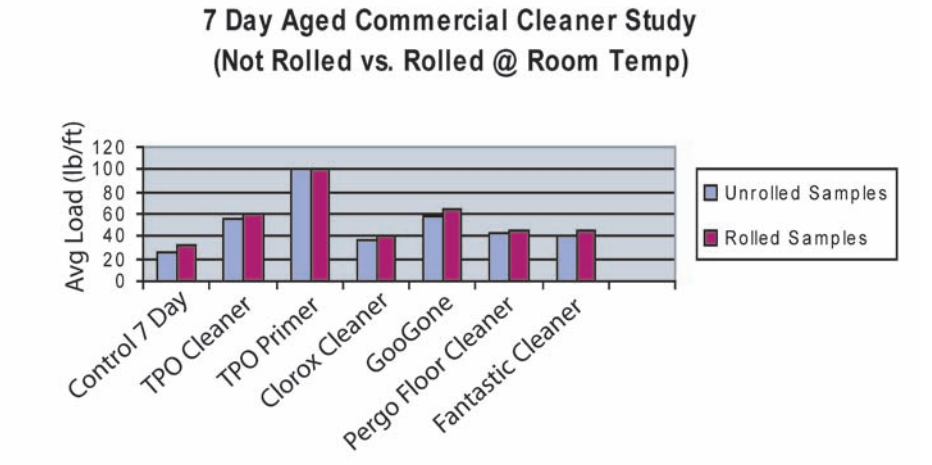

FIGURE 2

Advantages of self-adhering membranes include:

- **Environmentally friendly installation**
  - There is no adhesive to apply, no open "dry" time, and there are no adhesive solvents or fumes.
  - There are no empty bonding adhesive buckets that need to be disposed of; however, release paper does require disposal and attention on the jobsite.
  - Use of white membranes can provide an Energy Star® rated roof.
- **Improved installation quality**
  - Factory application of adhesive ensures consistent and uniform application.
  - The installation of these membranes utilizes many of the same basic techniques understood and mastered by roofing contractors and their crews.
  - Self-adhering membrane roofing system details are either the same or very similar to details used on conventional roofing systems.
  - Clean, worker-friendly environments reduce installation errors caused by over- or under-application of membrane adhesive.
- **Cost-effective**
  - The size of the crew needed for installation is reduced compared to traditional fully-adhered systems.
  - Ease of application speeds installation.

These advantages and similarities are easily understood by roofing professionals; however, the cautious do well to consider what other "data" are available to show that manufacturers have indeed done their homework.

In order to understand the backbone of self-adhering membranes, one simply needs to consider the traditional, smooth-backed TPO membranes they are built upon. The standard 45-, 60- or even 80-mil membrane installed every day in mechanically-attached, fully-adhered, or ballasted systems is used as the membrane in these products. There is not a change in thickness or other physical properties of the actual membrane in exchange for the adhesive layer. Because the membrane itself is not thinner, the performance of a self-adhering membrane in terms of weathering layer, reflectivity, puncture resistance, tear resistance, etc. remains the same. *Table 2* illustrates the composition and thickness of polymer over the scrim, weathering layer, and total thickness of several commercially available 45-mil TPO membranes.

So what are the issues that should be addressed when considering self-adhering membranes? The general performance and physical attributes of the TPO material itself? How well they adhere to different surfaces? Can different cleaning methods affect the performance of an adhesive seam? Is adhesion improved by weighted rolling? Do self-adhering membranes exhibit similar performance to other fully-adhered membranes when subjected to uplift pressures? Following are the results of several different studies conducted to address these types of questions and to provide a basis for evaluating and understanding the performance of these membranes.

Many TPO membranes do not require "cleaning" of the lap prior to heat welding seams unless the membrane has been exposed for a period of time or been contaminated. Self-adhering seams may require the lap area to be primed with TPO primer to ensure a strong bond. Several commercially available cleaners were tested to evaluate the strength of the resulting lap when other cleaners were used. Additionally, the effects of rolling the lap with a hand roller or not rolling the lap after adhering the membrane to the underlying membrane were measured. *Figures 1* and *2* illustrate the results of this study.

Note: On a self-adhering lap roof system, some manufacturers will allow the use of a 3" seam tape where the membrane does not have an adhesive to form a seam, e.g., with a heat weldable grade membrane, a 3" tape may be permissible in the lap area.

All of the samples were prepared and conditioned at room temperature and tested in peel for their lap strength. Review of these data shows that statistically there is no significant difference in lap strength of samples that were either rolled or not, both after 24 hours and after seven days. Even with these data, to ensure a watertight lap during actual jobsite conditions, it is recommended the laps be rolled to provide full and consistent contact of the adhesive to the underlying membrane. From a performance standpoint, the reader should consider that greater than 25 lb./ft. of strength is desirable.

There is a clear improvement in the performance of the lap when a cleaner is used that contains solvents; both the TPO cleaner and primer are xylene-based, and the GooGone (a commercial hand cleaner) contains petroleum distillates. All of the other cleaners consist of mostly surfactants in a water base, and none contains any organic solvents to aid in adhesion. Additionally, care should be taken with cleaners containing a surfactant because a residue film can be left on the membrane that may interfere with adhesion.

Another area that needs to be understood is the adhesion characteristic of the membrane. *Table 3*, summarizes the results

TABLE 3				
SAMPLE DESCRIPTION	PRODUCT	AVERAGE LOAD LBF/FT.	STANDARD DEVIATION	FAILURE MODE
LAP, CLEANED WITH TPO CLEANER	A	47.4	4.0	Interfacial at core
	B	50.7	3.5	Interfacial at cap
MEMBRANE TO UNPRIMED PLYWOOD	A	34.2	5.10	Interfacial at plywood
	B	9.7	3.3	Interfacial at plywood
MEMBRANE TO PLYWOOD PRIMED WITH TPO PRIMER	B	43.7	7.0	Interfacial at plywood

(Note: "Core" is the underside of membrane and "Cap" is the top surface of membrane, where the "Core" has the adhesive layer.)

of measuring the adhesion of two different commercially-available, self-adhering membranes. Results are from lap-peel tests, as well as from material installed on a plywood substrate, both primed and unprimed. The results are after 30 days of conditioning at room temperature.

The adhesion of the back of the membrane to the top surface of a membrane cleaned with TPO cleaner (lap area) is statistically similar between products after 30 days of aging at room temperature; however, the differences in the adhesion to plywood indicate that the roofing professional should be aware of all priming recommendations and requirements when using these products. To put these numbers into perspective, *Table 4* provides a comparison for reference between these products and self-adhering asphaltic underlayments.

Another performance characteristic of the membrane to consider is its wind uplift resistance performance. First, the uplift resistance of a fully-adhered assembly, whether incorporating a mechanically-attached substrate or an adhered substrate, is not affected by the thickness of the membrane, but by the adhesion of the membrane to the substrate and the performance of the substrate itself. This is different than the performance of mechanically-attached membranes that may realize improved performance with thicker membranes.

In general, the resistance to wind uplift of a fully-adhered membrane or system incorporating a mechanically-attached substrate is determined by the performance of the substrate, e.g., the mode of failure is that of the insulation or fastener, not the failure of the membrane to stay adhered. With self-adhering membranes, this generality holds true with a notable exception – if the substrate is not suitable and interferes with the adhesive characteristics of the membrane, the assembly will provide lower wind uplift performance. Likewise, failure of a self-adhering membrane assembly incorporating a fully-adhered substrate is typically found in a cohesive or adhesive failure of the substrate unless the substrate is not suitable for attachment of a self-adhering membrane.

Comparison of testing data shows good wind uplift resistance for self-adhering membranes; however, the list of suitable substrates is more specific than for traditional, fully-adhered membranes. For this reason, attention to the testing data and system approvals of the manufacturer should be given by the roofing professional.

INSTALLATION CONSIDERATIONS

The installation of self-adhering TPO membranes, utilizing either a heat-welded or self-adhering seam, is similar to the installation of traditional fully-adhered membranes. The accessories are the same for both systems, including cleaner, primer, pre-formed accessories, coated metal edges, etc. Loading of the roof and material handling by the contractor are similar; minimal weight has been added to each roll of membrane by the adhesive, although the width of self-adhering membranes is typically 5 - 6 feet. The heat welding of seams is done in the same manner as other TPO membranes and is of the same quality. Likewise, ensuring the quality of heat-welded seams is the same; by checking test welds for film-tearing bonds and by probing of finished seams for cold welds.

As indicated by the cleaner data, the true quality of a self-adhering seam is dependent upon the roofing mechanic properly preparing the seam prior to its installation.

These membranes can be installed in similar weather conditions as other installation methods used with TPO membranes; i.e., without precipitation in the immediate forecast and typically at 45°F and rising. If the temperature is colder, the self-adhering membrane installation should be delayed. Most manufacturers recommend a 40 - 45°F minimum temperature, regardless of installation type; however, mechanically-attached and ballasted systems can be installed successfully in colder weather.

The substrate preparation is the same; it must be suitable, sound, smooth, dry, clean, and free of debris, sharp projections, etc. As noted in the uplift resistance discussion, care must be taken to ensure that the substrate is suitable. Likewise, as its need to be clean, dry, and free of debris is important to ensure good adhesion.

Differences in the installation of the field of the roof are limited. The roofing contractor needs to be conscientious about the placement of membrane when using a heat-welded seam, because only one side of the membrane has no adhesive along the length of the roll. This can result in more waste on

TABLE 4		
SELF-ADHERING ASPHALTIC PRODUCT	ASTM D-903 AS MODIFIED BY D-1970	ADHESION TO PLYWOOD @75F, LBF/FT. WIDTH
A	12 lbf/ft. width	30.9
B		21.0
C		40.7

TABLE 5		
DETAIL	SELF-ADHERING MEMBRANE WITH HEAT-WELDED SEAMS	SELF-ADHERING MEMBRANE WITH SELF-ADHERING SEAMS
METAL EDGES	• Coated metal – can use at the "gutter" edge, using the membrane to form a heat-welded seam; but cannot use at the rake edge without the use of a heat weldable membrane. • Standard metal – use of cover strip as in standard details is acceptable.	• Coated metal – can only use with a flashing strip of heat-weldable membrane. • Standard metal – use of cover strip as in standard details is acceptable.
TERMINATION BARS	• Acceptable as in standard details, e.g., walls.	• Acceptable as in standard details, e.g., walls.
DRAINS	• With a deep sump, install a target of non-adhering membrane over the self-adhering membrane to allow for heat welding of all four sides.	• Deep sumps are difficult to work with self-adhering membrane only – install a target of non-adhering membrane over the self-adhering membrane to allow for heat welding of all four sides.
WALLS	• Vertical surfaces should be primed with a TPO primer. • Flashing heights and top edge attachments are the same as standard details. • Typically the heat-weldable seam is placed in the field of the roof and a self-adhering lap is on the vertical surface and may have a heat-welded flashing strip installed over the vertical lap. • Securement of the field at the base of the wall should follow standard requirements.	• Vertical surfaces should be primed with a TPO primer. • Flashing heights and top edge attachments are the same as standard details. • Securement of the field at the base of the wall should follow standard requirements.
PENETRATIONS	• Coated metal, e.g., pitch pockets, can use an unreinforced flashing heat welded to the membrane, including the vertical seam. • Can use either a large, self-adhering target sheet or cover tape.	• Coated metal, e.g., pitch pockets, can use an unreinforced flashing heat welded to the membrane, including the vertical seam. • Can use either a large, self-adhering target sheet or cover tape.

the project because any cut-outs or interruptions in the membrane will increase the amount of flashing strip-ins, and any cut-out material cannot be used in flashing applications where a heat-welded seam is needed.

Membranes with a self-adhering lap typically have minimal waste in the field; however, a larger lap is required from the same sheet width. This results in the net area of coverage being reduced by approximately 5% and the use of cut-edge sealant along the finished lap edge may be recommended.

Endlaps in the field of the roof may be constructed with either a self-adhering overlap of typically 6" or by forming a lap with the self-adhering membrane and heat welding a flashing strip over the endlap.

Handling of these membranes when installing them requires attention to placement of the sheet and care in its handling. Once installed, repositioning is not advised because attempting to reposition the sheet can cause damage to the underlying substrate, such as delaminating the facer on the top insulation layer. Separately, if the adhesive on the sheet happens to stick to another portion of adhesive, it may have to be cut out and replaced. As with other paper-type debris generated by the roofing process, (e.g., wrappers), release paper/film can easily be blown about by a light breeze and care must be taken to dispose of any debris properly and quickly so it will not get under subsequent sheets that are applied.

FLASHING DETAILS

The detailing of roofing systems utilizing a self-adhering membrane can follow two routes – either staying "true" to the use of self-adhering membranes, or using standard smooth or fleece-back membrane in standard details. The decision between either of these choices depends on the roofing professional's belief in the performance of tapes or his or her comfort with heat-welded details.

Regardless of which method is used, items such as flashing heights, attachment of the membrane at penetrations and walls, attachment at perimeter edges, and the use of TPO accessories such as pre-formed corners, typically mirror standard TPO details. *Table 5* provides several specifics to consider when designing details for these types of systems.

CONCLUSIONS

Self-adhering TPO membranes have been used successfully in the roofing industry since 2002[1] and offer an alternative to other fully-adhered, single-ply membranes. While appreciating the benefits of self-adhering membranes, roofing professionals will be well served to understand the challenges and particular requirements of these systems. This understanding will help to ensure successful installations that will perform.

This paper has attempted to provide a general discussion of considerations for the use of self-adhering membranes. As with any membrane roofing system, the roofing professional is best served by following the installation recommendations and requirements of the manufacturer of the specific product to be installed.

[1]Self-adhering TPO membranes were introduced to the commercial market in 2002; note that field applications of self-adhering single-ply membranes started during the late 1990s.

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