Self-Adhering TPO Single-Ply Membranes —

PHYSICAL CHARACTERISTICS, INSTALLATION CONSIDERATIONS, AND FLASHING DETAILS

By Helene Hardy Pierce
Edward Nebesnak
William Woodring
David Scott

ABSTRACT

Self-adhering roof 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, as well as 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 at more than 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 as the performance of these products has been proven. Single-ply roofing systems are best delineated by type of membrane and 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 type of installation has its own advantages and disadvantages, and designers and building owners typically choose the membrane and installation method that best fit the needs of the building. *Table 1* lists several advantages and disadvantages of each installation method.

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

TABLE 1

	SYSTEM TYPE		
	MECHANICALLY ATTACHED	**FULLY ADHERED**	**BALLASTED**
ADVANTAGES	• Lightweight • Easily maintained • Moderate cost	• Lightweight • 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

branes are adhered using 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 when 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.

Advantages of self-adhering membranes include:

- Environmentally friendly installation
  - — There is no adhesive to apply, no open "dry" time, and 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 of adhesive.
  - — Installation of these membranes utilizes many of the same basic techniques understood and mastered by roofing contractors and their crews.
  - — Self-adhering membrane details are either the same or very similar to details used on conventional roofing systems.
  - — Clean, worker-friendly environment reduces installation errors caused by over- or under-application of membrane adhesive.
- Cost effectiveness
  - — 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;

Figure 1

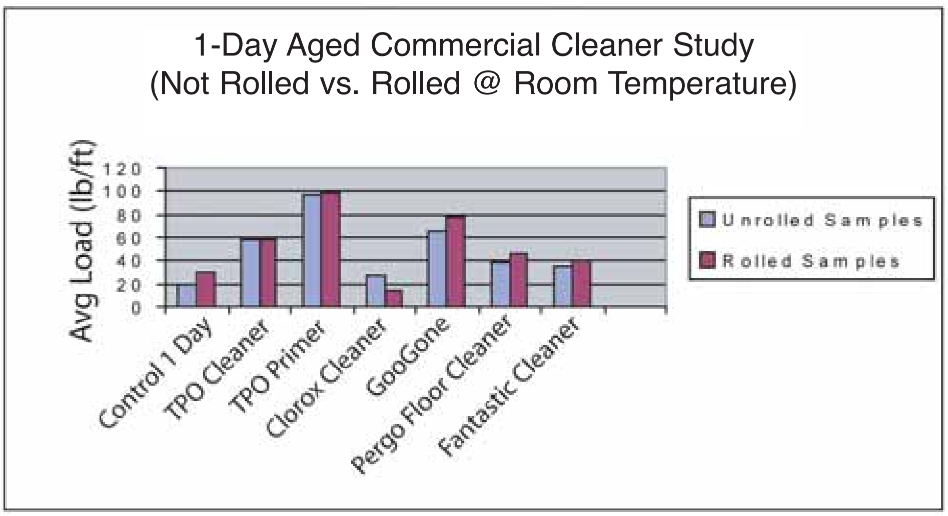
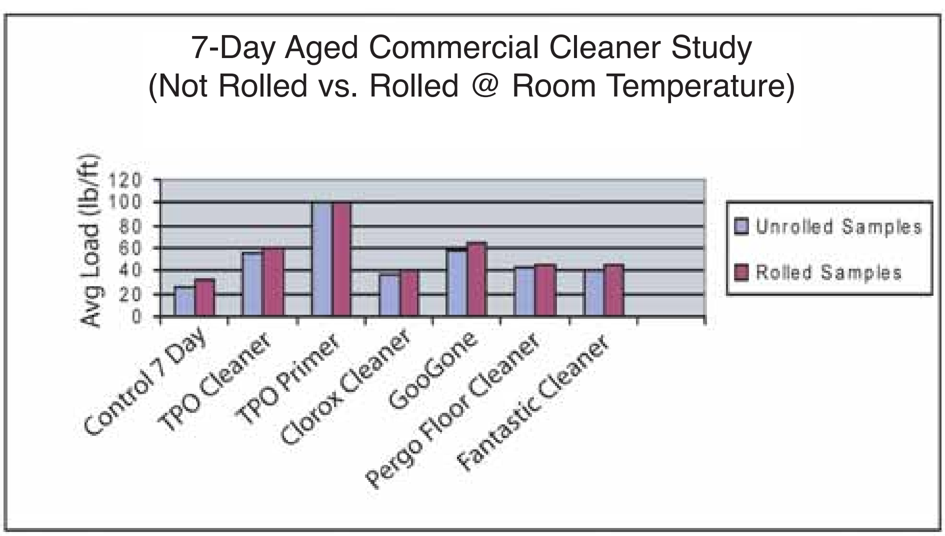


Figure 2



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 go to the traditional, smooth-backed TPO membrane they are built upon. The standard 45-, 60-, or even 80-mil membrane installed every day in mechanically attached, fully adhered, or ballast-applied 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 materials themselves? 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 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 contaminated or exposed for a period of time. 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-in seam tape where the membrane does not have an adhesive to form a seam; e.g., with a heat-weldable-grade membrane, a 3-in 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 this 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 this data, to ensure a watertight lap during actual jobsite conditions, it is recommended that 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 the primer are xylene-based, and the GooGone (a commercial hand cleaner) contains petroleum distillates. All of the other cleaners consist mostly of surfactants in a water base, and none contains any organic solvents to aid in adhesion. Additionally,

Table 3				
Sample Description	**Product**	**Avg. 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.)

Table 4		
Self-adhering asphaltic product	**ASTM D903 as modified by D1970**	**Adhesion to plywood @75F, lbf/ft. width**
A	12 lbf/ft. width	30.9
B		21.0
C		40.7

care should be taken with cleaners containing a surfactant, because a residue film left on the membrane may interfere with adhesion.

Another area that needs to be understood is the adhesion characteristic of the membrane. *Table 3* summarizes the results 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. 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 performance of the substrate; e.g., the mode of failure is failure 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 exceptio: 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.

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; 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 nonadhering membrane over the self-adhering 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.

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, the roofing professional should pay attention to testing data and system approvals of the manufacturer.

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, preformed 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 preparing the seam correctly prior to its fabrication.

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 than 45˚F and rising, 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.

Substrate preparation is the same; the substrate must be suitable, sound, smooth, dry, clean, and free of debris, sharp projections, etc., to ensure good adhesion. As noted in the uplift-resistance discussion, care must be taken to ensure that the substrate is suitable.

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 lacks adhesive along the length of the roll. This can result in more waste on the project, because any cutouts or interruptions in the membrane will increase the amount of flashing strip-ins, and any cutout 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 percent, 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 inches or by forming a lap with the self-adhering membrane and heat welding a flashing strip over the end lap.

Installing these membranes requires attention to placement of the sheet and care in its handling. Once installed, repositioning is not advised because such attempt can cause damage to the underlying substrate (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 as they 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-backed membranes 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 by understanding 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 should follow the installation recommendations and requirements of the manufacturer of the specific product being put in use.

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REFERENCES

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.

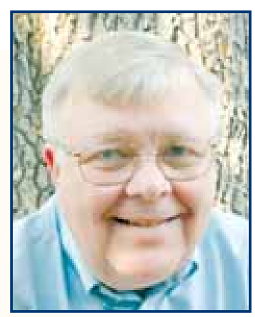
Helene Hardy Pierce

Helene Hardy Pierce is vice president of technical services, codes, and industry relations for GAF Materials Corporation in Wayne, NJ. She is a fellow of ASTM and of RCI and received the prestigious James Q. McCawley award from MRCA in 1999. Helene was graduated from the University of Missouri-Rolla with a BS degree in 1983, is a member of the university's Women in Science and Engineering Hall of Fame, and received an honorary professional degree from its School of Engineering in 2007. Helene has been active in the roofing industry for over 25 years.

Edward Nebesnak

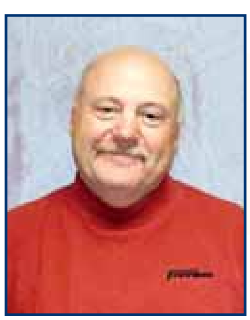
Edward Nebesnak, director of marketing, thermoplastics, for GAF Materials Corporation and former manager of research and development, has over 25 years of experience in research and development of construction products that include roofing, fireproofing, thermal, and acoustical products. He has been granted nine patents and has 12 published applications pending.

William J. Woodring



William J. Woodring has been with GAF Materials Corporation for 38 years, holding various positions in research and development, marketing, and field technical support in connection with built-up, modified-bitumen, and single-ply roofing, as well as shingles. He is currently director of technical services and is responsible for providing technical information, training, and assistance to contractors in resolving installation issues.

Dave Scott



Dave Scott is the EverGuard specialist for GAF Materials Corp., located in Wayne, NJ. In the past 21 years, Dave has held many field technical positions and was responsible for the initial installation testing on the first peel-and-stick thermoplastic membrane offered to the roofing industry.