How Thermoplastic membranes changed the low-slope roofing market

by **Mike Ennis, RRC**

Without question, thermoplastic roofing membranes have been the fastest growing form of low-slope roofing products for more than a decade. Thermoplastic roofing membranes come in different technologies, inclusive of TPO, PVC and PVC alloy. Long before TPO was introduced into North America, PVC membranes capitalized on several events during the 1970s to solidify its position. First, the oil embargo of 1973 inflated the price and restricted the availability of quality roofing asphalt. At the same time, high-energy costs increased demand for higher roof system insulation R-values. This began to make single-ply membranes more attractive. This attractiveness included their direct compatibility with polyisocyanurate insulation, also a growing product at the time.

In 1984, Ducker Research Inc. (now Ducker Worldwide) predicted single plies (including PVC and PVC alloys, EPDM, Hypalon® [CSPE] and CPE), would capture 25 percent of the low-slope market. By the middle of that year, single plies share reached 35 percent of the roofs installed and Ducker Research soon revised its year-end forecast.

TPO membranes were also introduced and by 2006, the thermoplastic market share had grown astonishingly. PVC and TPO together represented about 30% of the commercial roofing market, according to Ducker Research (now Ducker Worldwide)[3].

Five years ago, SPRI also reported that the great majority of the billions of square feet of single-ply membrane cumulatively sold in North America (including TPO and PVC) performed without issue.[4]

Attributes of TPO/PVC membranes

Some attributes shared by TPO and PVC membranes include long-term weathering resistance, cold temperature flexibility, tear resistance, resistance to puncture, chemical resistance and heat-seaming capability.

These membranes can be manufactured in a wide range of colors, do not cure after exposure to the elements and they remain capable of hot-air welding throughout their service lives.

Each TPO and PVC membrane has a unique formulation. Probably the most visible differing physical property attribute among these thermoplastic sheets is their relative stiffness. Some thermoplastic membranes feel relatively soft and flexible while others feel more rigid, noting this has no relation to cold temperature flexibility. The stiffness characteristics affect only the membrane installation process. Generally, roofing contractors claim stiffer sheets aid in the seam welding process but can be difficult to work with in flashing applications where more flexibility is desired. Typically, however, all thermoplastic membranes exhibit the essential physical property characteristics mentioned above.

Thermoplastic membranes also are highly resistant to a variety of chemicals and both TPO and PVC materials are formulated to be fire-resistant. When designed as part of an appropriate roof assembly, both TPO and PVC roofing systems can achieve Underwriters Laboratories (UL) Class A fire-resistance listings. Beyond fire testing, thermoplastic membranes have been approved by Factory Mutual wind-uplift resistance classifications exceeding 500 lbf.

TPO and PVC membranes have a reinforcement layer made of either polyester or fiberglass, incorporated at the factory using a variety of techniques. Regardless of manufacturing line configuration, the compounded material is heated to a high temperature to allow the forming process to occur.

What makes them popular?

One factor driving the growth of TPO and PVC membranes is the "green" building movement. Global warming has become a focus point for many property owners, specifiers and government agencies. Electrical blackouts caused by the increased use of air-conditioning have energy providers looking for ways to reduce peak electrical demand while designers attempt to limit a building's carbon footprint. Highly reflective roof membranes can help alleviate the heat load placed on a building by reflecting sunlight and maintaining a lower surface temperature than darker colored roof surfaces.

In the early 2000s, Chicago mandated cool roofs, and several other municipalities also got on board. In 2005, California adopted building energy efficiency standards that required "cool" reflective roofs on low-slope, nonresidential roofs as part of the already existing Title 24 requirements.

Additionally, the U.S. Green Building Council created its LEED® certification program for buildings that are designed, constructed and operated with sustainability in mind. The program assigns points for certain types of designs and provides a construction "point" for roofs that have high reflectivity, such as PVC and TPO membranes.

Another reason for the increasing popularity of TPO and PVC roofs is the induction welding attachment of these membranes to buildings. Induction welding is the use of an electromechanical field to heat a pre-attached bonding plate located under the thermoplastic membrane to weld to the TPO or PVC membrane. This is considered a "nonpenetrating" attachment method.

From an economic and labor standpoint, on large building roofing contractors often like to use the widest TPO/PVC sheet possible when installing mechanically attached systems. This reduces the labor required to install the roof.

However, to meet certain wind-uplift requirements, the spacing of the fasteners may not allow a contractor to use the widest sheets available or may require fasteners be spaced closely together in the lap. A narrower width sheet can help distribute the uplift forces over more structural members, allowing it to withstand greater uplift pressures and using more fasteners in the lap area reduces the load each fastener is subjected to in a wind event.

Consequently, with induction welding, a contractor may be able to use wider sheets, fewer fasteners and less labor and still meet the design pressures required for the roof.

Easy installation

Perhaps what contributes most to the growth of TPO and PVC membranes is the variety of attachment methods ranging from

stone ballast or pavers, mechanical fasteners and plates and/or metal bars, induction welding components, and adhered with bonding adhesives. Common adhesives used as bonding agents include solvent-based, waterborne and 100 percent solids-reactive products, including two-part and moisture cured/activated adhesives.

Certain geographies of the US **limit** the maximum content of volatile organic compound (VOC) in various adhesives. As such TPO and PVC manufacturers have developed low-VOC water-based adhesives and self-adhering membranes, inclusive of self-adhering flashings and details for roof system penetrations. These products can be used anywhere there are stringent low-VOC requirements that limit or exclude the use of solvent-based adhesives **(subject to temperature and humidity limits)**.

Formulating chemists have engineered waterborne adhesives to sufficiently bond TPO and PVC membranes to various substrates such as roof insulation, wood, concrete, lightweight insulating

concrete and other surfaces. Again, these water-based adhesives are especially attractive when local air quality legislation restricts VOC content in bonding adhesives.

Prefabricated TPO and PVC accessories are available and also come with installation options. Accessories include curb wraps and split pipe seals that can save many hours of labor for a typical project.

Molded sealant pockets also are available with TPO and PVC systems to waterproof pipe clusters and other oddly shaped penetrations. Some square tubing wraps provide a split (cut) and overlap tab that allows the seals to be opened and wrapped around a square tubing penetration.

Finally, some manufacturers offer TPO and PVC cover strips constructed by a TPO or PVC membrane laminated to a fully cured synthetic rubber pressure-sensitive adhesive. This type of product is ideal for use with metal drip edges and a variety of other applications.

Product testing

TPO continues to be known as the "newest" membrane for commercial low-slope roofing, but it is far from unproven. ASTM D6878, "Standard Specification for Thermoplastic Polyolefin-Based Sheet Roofing[2]," first published in 2003, has continually **updated** TPO performance requirements. Separately, ASTM D4434, the "Standard Specification for Poly(Vinyl Chloride)Sheet Roofing" covers PVC membranes and was first published in 1985 and has seen many improvements over the past 30 years. ASTM D6754/D6754M – 15 "Standard Specification for Ketone Ethylene Ester Based Sheet Roofing" is used for PVC KEE-modified membranes manufactured using a hot melt vinyl coating technology with DuPont Elvaloy as the foundation for the vinyl compound. Updates to each of these product standards have included weathering resistance requirements which have been incorporated into their respective standards and into individual manufacturers' performance requirements.

TPO and PVC membranes are known to resist standing water. Additionally, they are not affected by freeze and thaw cycles. However, similar to other roof membranes, TPO and PVC weather from the effects of ultraviolet light and heat. For this reason, accelerated aging is conducted to expose TPO and PVC membranes to conditions often far in excess of what typically is experienced during rooftop use but in shorter (accelerated) time periods. A review of marketing claims by manufacturers suggests TPO and PVC membranes are capable of passing twice the exposure level or greater than required by their increasingly stringent ASTM standards.

Thermoplastic membranes can be challenged

While the popularity and performance characteristics of these membranes are clear, every thermoplastic membrane exhibits strengths and weaknesses. While thermoplastic membranes represent more than 50% of the low slope membrane roofing market in 2017, there are installations where their use is not recommended.

All thermoplastic membranes rely on one layer of roofing material to waterproof the building. More traditional roofing options, such as built-up roofing and modified bitumen, offer redundancy in the form of multiple layers of roof membrane protection. Some asphalt-based product specifications also offer greater puncture and chemical resistance and are more forgiving of rooftop abuse than standard thickness thermoplastic membranes.

Another installation where care should be taken is one with high heat loading combined with concentrated exposure to sunlight. Most roofing materials degrade over time when exposed to heat and UV and their long term performance depends on formulation and in situ conditions – so exposure to high temperatures and high UV, such as south and west facing walls in extremely hot climates, may warrant either a thicker membrane or a membrane formulated for such severe conditions.

Summary

There is one thing that has not changed in the low-slope roofing market over the years: the building owner usually gets the roof performance he or she pays for. Thermoplastic membranes can meet a variety of different building requirements by offering a range of options. It is also important to note that these high performance thermoplastic roofing membranes are compatible with the latest rooftop technologies, inclusive of solar arrays and vegetative roofing. Given the wide variety of installation options available, it is easy to understand why these membranes have continued to gain in use and provide long term performance for building owners.

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