HEAT IT UP!
New ASTM Requirements for TPO Roofing Membranes

By David French and Randy Ober

Given the recent economic conditions, it seems as though every politician has a sure-fire solution to pull the country out of any sustained or repetitive recessionary period. Suggestions about how to revitalize the flagging economy abound, from cutting corporate taxes to further stimulus packages. Any economist would certainly agree there is no one right answer – no single magic bullet to improve the economy long-term. When faced with an extreme situation such as the current economic downturn, it is a deliberate and moderate implementation of multiple plans that will often yield the best long-term results.

The evolution of any building material is not unlike the economy; extreme situations arise – situations that a building product may not have been initially designed to experience or withstand. These extreme situations do not necessarily uncover flaws of that product but rather set a new performance expectation for that product to meet. An extreme situation establishes new expectations, and a systematic improvement of multiple physical characteristics helps that building material meet those new expectations.

Manufacturers originally developed TPO formulations primarily for UV resistance, and there has been a huge improvement in this particular characteristic over the years. When TPO membranes emerged in the marketplace in the early 1990s, resistance to UV in the xenon arc weatherometer was about 5,000 kJ-m². Today, manufacturers are publishing UV resistance values of more than 25,000 kJ-m². That's a five-fold increase in the performance level in UV resistance due to huge advances in technology. In fact, the requirement for UV resistance was increased in the ASTM TPO material standard in 2006 from 5,040 kJ-m² to 10,080 kJ-m² (at this level of weathering, the TPO standard contains the most demanding requirement of any current ASTM standard for single-ply membranes).

Figures 1 and *2* show how well the surface of a TPO roofing membrane resists UV; it is barely affected, even after being exposed to more than 25,200 kJ-m² in a xenon arc weatherometer at 80°C (176°F), more than double the current ASTM requirement. These pictures were taken at 50x and 100x magnification.

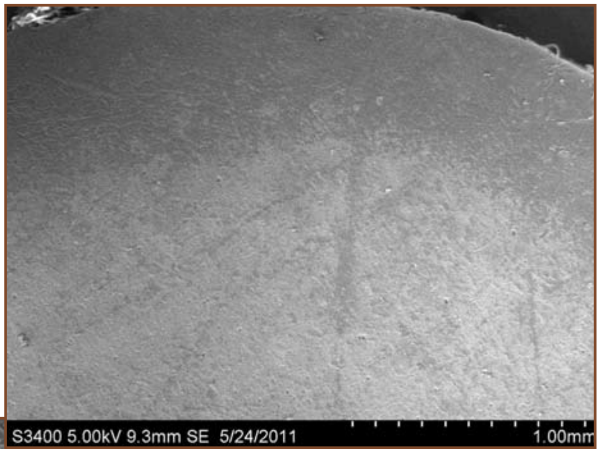

Figure 1 – 45-mil TPO at 50x magnification after 25,200 kJ-m² in a xenon arc weatherometer.

Figure 2 – 45-mil TPO at 100x magnification after 25,200 kJ-m² in a xenon arc weatherometer.

Recently, TPO roofing membranes have been subjected to increasingly demanding conditions due to changes in building design as well as implementation of new building components. Other building materials, such as vinyl siding and exterior paint, have been affected as well. See *Figure 3*.

In most instances, white TPO membrane does not reach temperatures much above ambient due to its high reflectivity.

Figure 3 – Distorted vinyl siding after exposure to adjacent highly reflective vertical surface.

However, under specific conditions in certain areas of North America, surface temperatures can far exceed what would typically be expected with a reflective white membrane. Examples of these specific conditions where TPO membrane may become excessively hot include exposure to rooftop-mounted, highly reflective ductwork or treated glass, whose surfaces can reflect the sun back onto the membrane much like a magnifying glass. Resulting temperatures can be well above what the membrane was originally formulated to resist. Roof surface temperatures in these areas can approach 300°F in the most extreme circumstances. See *Figure 4*.

Another instance that can cause TPO membranes to be subjected to extreme heat is the actual heat-welding process. During this process, a heat-welder produces hot air that is directed through a nozzle between the two pieces of membrane to be joined together. The resulting heat and pressure applied by the welder cause the two pieces of membrane to be permanently fused together (much like welding two pieces of metal together). The temperature of the hot air produced by the welder is adjustable, but for TPO welding, 1000°F is an appropriate setting (for automated heat welders). The speed of the welder is also adjustable and should be set around 12 ft. per minute. Since the duration of the heat is relatively short, the UV and heat stabilization packages contained in the TPO membrane are not affected. However, if the applicator increases the heat or slows the welder down substantial-

ly, degradation of these components can result. Visual signs of overheating are relatively obvious and include smoking membrane, discoloration of the surface, and distortion of the surface in the weld area. For this reason, a roofing applicator should ask for guidance from the TPO membrane manufacturer for proper welder settings.

In order to ensure that the TPO roofing membrane industry was producing material that could consistently withstand these high-heat conditions, ASTM International (formerly the American Society for Testing and Materials) and its membership took on the task of revising the TPO roofing membrane material standard. ASTM, the world's largest developer of standards, is an international organization that develops and publishes voluntary-consensus technical standards for a wide range of materials, products, systems, and services.

In June 2011, after almost two years in development, revisions to ASTM D6878, *Standard Specification for Thermoplastic Polyolefin-Based Sheet Roofing*, were approved. These revisions included increasing the stringency of the heat-aging requirements, as well as increasing the minimum thickness over scrim requirement for TPO single-ply roofing membranes. These increased minimum requirements are now included in the ASTM standard designated D6878-11a. Originally approved in 2003, ASTM D6878 has been thoroughly monitored and updated to meet the ever-changing environmental and regulatory conditions to which single-ply roofing is subjected.

Figure 4 – Blistered membrane caused by extreme heat generated by a highly reflective vertical surface.

This new ASTM requirement for TPO heat aging represents an 800% increase over the original standard. In order to comply with the new standard, all thicknesses of TPO membranes are now required to withstand 32 weeks at 240°F without significant changes to the membranes' physical properties. With the addition of this new requirement, the TPO membrane standard now contains the most stringent heat-aging requirement of any ASTM single-ply roofing material standard. The new requirement for heat resistance is equivalent to subjecting TPO membrane to 185°F

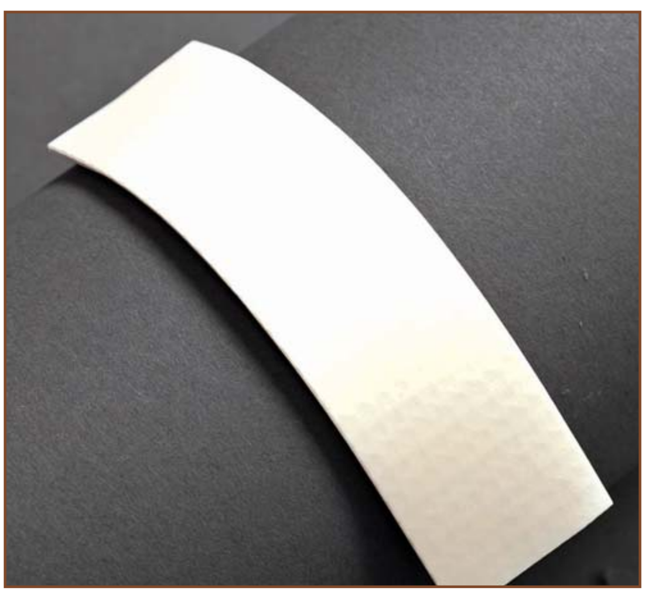

Figure 5 – Sample of TPO membrane exposed to 240°F for over 32 weeks.

temperatures for six hours a day for 20 years based on the Arrhenius equation (a formula that predicts the temperature dependence for the rate of a chemical reaction). See *Figure 5*.

In addition to the new requirement for resistance to extreme heat exposure, the new ASTM standard also increases the required minimum thickness over scrim for TPO membranes. The revised standard now requires a minimum thickness over scrim of 15 mils – a 25% increase over the previous standard of 12 mils. As expected, the thickness of the top ply directly correlates with the expected life of the membrane since an increased top ply will protect the membrane's reinforcing fabric for a longer period.

In addition to protection of the fabric, the extra mass of the top ply will resist cracking and crazing for a longer time period. This is due to a phenomenon sometimes referred to as the "reservoir effect." The additional top-ply mass contains more weathering package; and as this component is depleted by exposure to UV, any remaining weathering package migrates to the surface, providing longer-term protection. The relationship between membrane thickness and lifespan is not linear as might be expected but is actually exponential (e.g., moving from a 12-mil to 15-mil top-ply thickness will not increase membrane lifespan by 25% but by some increased percentage).

TPO manufacturers acknowledged the need for improving TPO roofing membranes, and the ASTM membership has acted accordingly by increasing performance requirements across the entire industry. TPO roofing membranes must now be substantially more resistant to heat, and they must contain a thicker top ply or additional weathering portion for the membrane to comply with the more stringent ASTM standard. Similar improvements are being considered in the vinyl siding and other building material industries. With over 10 billion sq. ft. installed nationwide, TPO has proven itself to be a durable, sustainable, and high-quality roofing material over the past 18 years. However, that is no reason not to take steps to continuously improve its ability to withstand any extreme condition to which it may be exposed.

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David French is the thermoplastics marketing manager for Carlisle Construction Materials. He has over 12 years of experience in the marketing of construction materials, six of which have been in the single-ply roofing industry. David is involved in various industry and marketing associations. For more information about Carlisle Construction Materials, please visit www.carlisle-syntec.com.

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RAVC Shepherds Roof Ventilation Code Development

The Roof Assembly Ventilation Coalition (RAVC) participated in the development of the 2012 International Residential Code (IRC), recently published by the International Code Council (ICC). The RAVC proposed language intended to add clarity to the code, provide for balanced intake and exhaust for ventilated attics, and help ensure that attic ventilators work as intended.

Section 806.2 of the 2012 IRC has been revised to include the following:

> At least 40 percent and not more than 50 percent of the required ventilating area is provided by ventilators located in the upper portion of the attic or rafter space. Upper ventilators shall be located no more than 3 feet (914 mm) below the ridge or highest point of the space, measured vertically, with the balance of the required ventilation provided by eave or cornice vents. Where the location of wall or roof framing members conflicts with the installation of upper ventilators, installation more than 3 feet (914 mm) below the ridge or highest point of the space shall be permitted.

The new revisions also include a requirement that ventilators be installed in accordance with the manufacturer's installation instructions. With increased reliance on tested components, proper installation is just as important as proper design. Attic ventilation is a proven design method that helps the roof assembly manage moisture and heat and enhances roof-covering durability.

The RAVC was formed to provide a resource to advance building design through the use of ventilated attic spaces. Headquartered in Washington, DC, the RAVC was formed in 2008 under the organization of the Asphalt Roofing Manufacturers Association. The coalition represents roof vent manufacturers, suppliers of residential roofing materials, and other interested stakeholders whose mission is to be the leading authority and technical resource on ventilated roof assembly design and performance. It aims to be the responsible advocate for proper steep-slope roof assembly ventilation.