

PVC MEMBRANES:

Traditional Formula

OR

New Innovation?

BY JOHN C. GREKO

Since their entrance into the commercial roofing market in the 1960s, polyvinyl chloride (PVC) membranes have experienced tremendous growth and acceptance, along with many beneficial changes, both in formulation and in manufacturing processes. Are these changes positive? Which type of PVC is better to use: one that is comprised of traditional formulations and manufacturing methods, or one that has been produced with an improved formulation on innovative manufacturing lines?

Many are fixated only on the formulation, but the process of manufacture can have a negative or positive impact on the long-term performance of PVC. As with baking, the recipe for PVC has instructions for the ingredients, as well as for the type, quantity, and order of mixing. The recipe also includes instructions on equipment, length of time, and temperature. Formulation by itself does not guarantee a performing product; the manufacturing process also affects the long-term performance of the end product.

There are differing opinions on these issues, and data presented from both sides. This article will discuss the advancements in PVC formulation and manufacturing technology.

There are currently three primary methods used for manufacturing PVC membranes; they are, in order from newest to oldest: extrusion, calendering, and spread-coating. Let's first review the differences in these processes.

Spread-coating, the original manufac-

turing process used for PVC, starts with a carrier sheet (internal reinforcement) that is transported through a production line where viscous liquid PVC is spread onto the carrier to create a thin coating of PVC. The carrier, now spread-coated with PVC, travels through extremely hot, long ovens where the PVC is cured. To coat the underside, the material is flipped and the process is started over (*Figure 1*).

Many manufacturers of PVC eventually moved from spread-coating to a newer process called calendering. The calendering process is initiated with the compound (formulation) in solid form of powder or pellets, which are mixed, forced through an extruder, and then immediately squeezed between heated calender rollers, which press the compound into the desired thickness. The PVC is then allowed to cool and is rolled up for packaging. This calendering process exposes the formulation to long periods of heat exposure, as does the spread-coating process. Changing from the spread-coating operation, which uses the viscous liquid formulation, to the calendering or extrusion process, which utilizes the solid compound, requires a formulation change.

The newest and most innovative

process for manufacturing PVC is the extrusion process, in which the PVC formulation is heated to an appropriate softening point and forced through an extruder and out a flat die. Fabric is introduced at this point and processed through a roll stack, where the fabric is encapsulated between the top and bottom extruded plies under pressure. In contrast to the calendering process, the thickness of the membrane is determined by the extruder die, not by roller compression as in the calendering process. The rollers in the extrusion process simply press the material together and cool the membrane. (See *Figure 2*.)

While the extrusion process has been around for decades, it has made the greatest technological advancements (when compared to other manufacturing processes) over time. Extrusion is the manufacturing process that most innovative manufacturers use, and the one we believe has been proven



Figure 1 – Knife-over roll coating line.

to produce higher-performing material due to decreased manufacturing stress on the material. In fact, newer extruders are much more efficient and effective than the extruder equipment of just ten years ago. There are many reasons why we believe using the most up-to-date extrusion process is the ideal option for manufacturing PVC.

“With today’s technological advances and the ability to precisely monitor and control temperatures, pressures, and thicknesses, the process of manufacturing PVC roofing materials has significantly improved,” said Bill Knuf, Carlisle Construction Materials’ Greenville, IL, plant manager. “These changes have made a PVC sheet that looks better, performs better, and should provide building owners with many years of great service.”

One of the key features of the newer extrusion process is the integrated control package it utilizes. This computer software fully ties all of the pieces of the manufacturing operation together, including fabric unwinding, extrusion, web forming, web handling, and material wind-up (*Figure 3*). This is important because in order for the manufacturing process to run smoothly and accurately, all



Figure 2 – Typical extrusion line.

of these steps have to take place at just the right time; and in order for that to happen, every operational process must be precisely controlled from start to finish. This is one of the main advantages of using a newer extru-

sion system, as many older extrusion systems do not have fully integrated software and can experience breakdowns in the manufacturing operation and potential inconsistencies in product quality.



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Figure 3 – Computer-integrated controls for process control.



Figure 4 – High-speed blender and cooler.

The two greatest advantages provided by integrated process control software are repeatability of performance and traceability of past product. The idea of repeatability of performance takes into account the fact that your PVC membrane performance consists of both a formula and a manufacturing process. The formulation and the manufacturing process are equally important for the production of a high-quality membrane. You need to know the variables in both the formulation and the process in order to create a consistent product. Manufacturers' newer computer-integrated extrusion processes provide just that; they monitor both the formulation and the manufacturing process to ensure that the end result is a consistently produced and performing PVC membrane.

The second advantage of integrated process control software is traceability of past product. At any point in time, computer-integrated systems are monitoring over 10,000 data points that are collected from the entire production line. This provides manufacturers with the ability to define specific performance criteria for the PVC membrane and consistently match those criteria through each roll of membrane produced. It also means the ability to easily identify and correct production errors as they occur in

the manufacturing process, ensuring that defective product does not reach the end of the production line—let alone the customer—while also facilitating future improvements in product and longer-term performance.



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Another aspect of the extrusion process is that it takes into account the nature of PVC material, minimizing the heat and tension to which the membrane is exposed during the manufacturing process. Both excessive temperatures and long exposures to heat (which can create free radicals and start the breakdown process) and tension are detrimental to long-term performance. Newer extrusion processes are unique because every roller in the entire production line features load cells that measure and equalize the tension that is placed on the material across its entire width throughout the process. Many of the older lines do not have this extensive measurement of tension.

New extrusion processes also reduce the amount and length of heat to which the PVC is exposed. Unlike older extrusion technologies and spread-coat methods, new extrusion processes extrude material at its exact thickness, which means that the rollers on the manufacturing line are not heated (which causes longer exposure to excess heat), but rather cooled. This not only reduces the heat exposure to the PVC, but also provides significant energy savings, making new extrusion line technology more energy-efficient. Older PVC extrusion lines do not have the ability to extrude to exact thicknesses, so they extrude a bank of material into a heated calender roll stack, which is a form of modified calender operation.

One of the most important factors in producing consistent, high-quality roofing membranes is the ability to monitor the thickness of the product, both in real time and over historical production periods. Newer PVC extrusion lines feature a measuring device that monitors the material thickness across the membrane's entire width, automatically adjusting the die when necessary to ensure consistent quality and thickness. Because these data are stored, the integrated process control package can monitor the consistency of material thickness over time, not just for one roll or one batch of product.

The blending process is another vital element of PVC production. New, state-of-the-art compounding and blending towers (*Figure 4*) utilize a complete component delivery system, which requires no manual weighing or adding of materials, eliminating the potential for human error. Many calender operations have hand-weighed and packaged ingredients, which are hand-fed into mixers or Banburys. The formula's materials are stored in a blend tower (*Figure 5*) that moves



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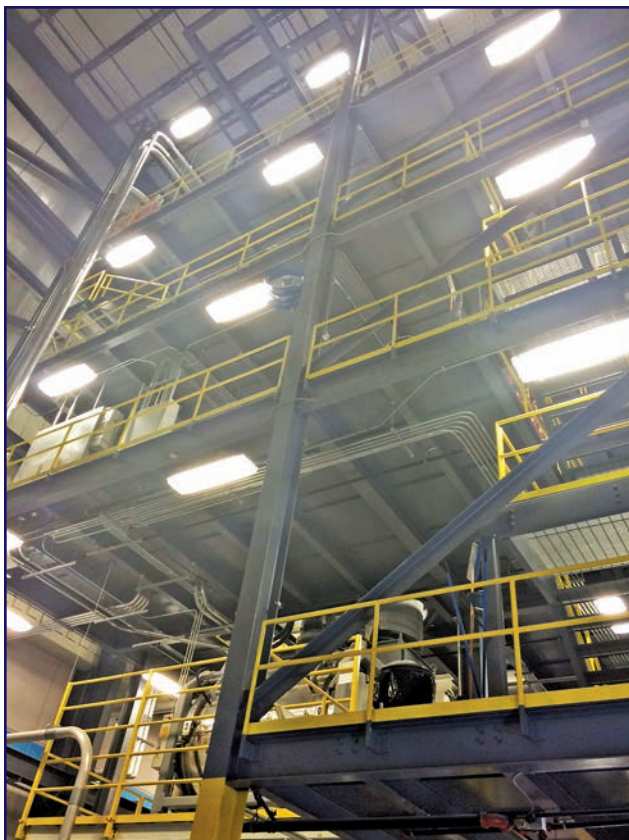


Figure 5 – Ten-story blending and compounding tower structure.

and measures solids and liquids into weigh scales in the correct formula proportions. The materials are then blended, with speeds and temperatures increasing throughout the blending process to trigger the addition of different materials at different times for optimal blending. The entire process is monitored and registered by the software system, which means that if any material does not make it into the blender, the computer will notice and make sure that the missing material is added before production continues. This ensures that batches of product do not proceed down the entire production line before an incorrect formulation is caught.

This blending process also monitors the material inventory levels, signaling when inventory is diminishing and more materials are needed, thus increasing efficiencies in inventory control and reducing backorders.

As can be seen, the extrusion process is complex and intricate, yet also refined and efficient—one of the best commercial roofing technologies available today. While there are many ways to manufacture PVC, we believe data demonstrate that extrusion is the most efficient and accurate method for producing a high-quality, consistent, and durable rooftop.

One of the important aspects of PVC production is that formulas have changed over time, due to government regulations or chemical manufacturers being sold or going out of business

entirely. Manufacturing processes have improved with new equipment and greatly enhanced controls. I was told recently by a supplier of extrusion equipment, “Ten years ago, 75% of our engineers were mechanical; today, 75% of our engineers are electrical,” emphasizing the development of improved process control and automation.

Advancements in integrated process controls help to ensure consistency in manufacturing. As the industry has moved from spread-coating to calendering, and more recently to extrusion, formulas have necessarily changed to optimize membrane production for each of these methods. All

formulas for PVC membrane manufacturing include common ingredients, such as PVC polymer, plasticizers, stabilizers, process aids, flame retardants, biocides, heat stabilizers, and pigments. However, while there are common ingredients across the board, it is essential that some of these ingredients change according to the manufacturing process being used. For instance, it is not possible to extrude a PVC membrane with the same formula used in the spread-coating process. When processes are changed, formulations must change in order to produce a consistent, top-notch product. The global environment is also harsher than it was 20 years ago, demanding increased performance.

While there are varied methods for manufacturing PVC roofing membranes, new technology and the most up-to-date formulations and manufacturing processes available should produce a consistent, high-quality, and longer-lasting PVC rooftop covering. 



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John C. Greko is currently PVC Product Manager for Carlisle Construction Materials and first started in the PVC roofing business in 1982. He previously was VP of engineering and QA for a roofing manufacturer, was a faculty member of RIEI, a Certified Roofing Instructor for BOCA, a member of ASTM, director for SPRI, and a consulting editor for Architecture magazine. Greko holds four patents for products and/or processes used in single-ply roofing.



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