Originally introduced in Europe in the early 1960s, polyvinyl chloride (PVC) roofing systems were among the first single-ply commercial roofing materials. Today, reinforced PVC roofs – also called vinyl roofs – account for 65 percent of the European commercial roofing single-ply market, and North American growth has outpaced the commercial roofing industry as a whole for more than 10 years. In 1985, PVC roofing systems were the first single-ply roofing products to obtain a standard designation from the American Society for Testing and Materials (now ASTM International): ASTM D4434 – Standard Specification for Polyvinyl chloride (PVC) Sheet Roofing – which is regularly updated. Today, PVC is an increasingly popular thermoplastic roofing membrane worldwide. PVC roofing systems have witnessed tremendous growth in recent years due to a variety of standout characteristics, notably: longevity; durability in harsh weather and temperature extremes; low life-cycle costs; energy efficiency; heat and solar reflectance; flame resistance; chemical and grease resistance; ease of maintenance; ease and flexibility of installation; and inherent recyclability/re-use, among many other benefits. Often referred to as the first “cool roofing” system, PVC is energy-efficient, environmentally sustainable, long-lasting and cost effective.

These materials have proved suitable for use on any substrates, especially those with marked structural movements, i.e. metal parts or prefabricated concrete slab. This roof membrane brings particular unique features to owners of flat roofs -- significant energy savings from reflective membranes, solid performance in ponded conditions, inherent flame resistance, integral seam fusion, and ease of inspection, leak detection, and repair. However, in the mid-1980s, a rash of catastrophic membrane shattering to aged, non-reinforced, monomeric-plasticized PVC roofs occurred in a number of developed countries hitting the reputation of PVC roof systems. In
response, non-reinforced roof system manufacturers discontinued these specifications and products in favor of today’s standard, thicker, fabric-reinforced PVC roof systems.

Six distinct categories of membrane systems dominate the current low slope roofing market in world: (i) built-up asphalt; (ii) built-up coal-tar pitch; (iii) thermoset rubber (EPDM); (iv) SBS-modified bitumen; (v) APP-modified bitumen; and (vi) thermoplastics (PVC, PVC alloys, and TPO). Selection of the optimum roofing solution for a given project is dependent upon a number of building owner’s criteria (Table 1). Although some owners focus on only a few criteria, others may have multiple reasons for selecting a particular membrane system. All of these categories of roof systems demonstrate benefits to owners. No single classification of roof system satisfies all criteria because each brings distinct features to a vast spectrum of owner and building needs.

Know How of PVC Roofing Membranes

Features

PVC (polyvinyl chloride) is a ubiquitous polymer. The annual demand for PVC resin is 14 billion pounds (three billion kilograms). A large percentage of this polymer is used in the construction industry as rigid piping, cable sheathing, cabinetry, wall covering, flooring and to a small extent, flat roofing. Building owners and specifiers of exposed PVC roof systems often focus on the following distinct benefits of PVC roof installations:

- competitive installation cost
- verification of details and workmanship ease
- installation may occur during very cold and/or damp conditions that would impair or prevent installations of other roof systems
- provision of inherent flame-resistant chemistry of the base polymer to the roof of commercial buildings
- across the entire roof, if properly installed is a consistent, predictable fusion of membrane panels into a single, flexible waterproofing skin
- ease of leak detection, ease of repair and long-term integrity of “the patch”

Characteristics:

- Flexibility in low temperatures
- Insensitivity to hot-cold cycles
- High mechanical resistance.
- Resistance to static and dynamic puncturing
- Vapour permeability
- Adaptability to structural movements
- Resistance to root growth and micro-organisms
- Do not rot
- Resistance to weathering and ultraviolet rays
- The surface colours may be chosen from the RAL range

Mode of PVC Membrane Failure

PVC membranes provide important benefits to owners and specifiers. However, the characteristic aging of PVC membrane is noteworthy. The collective observations of the authors collaborate that long-term failure modes with conventional PVC roof membranes are largely about gradual membrane embrittlement due to exposure to the elements - heat and ultraviolet light. Although crystallization of the base resin contributes to embrittlement, it has always been observed and measured that when a conventional PVC membrane feels brittle, the plasticizer is departing from the membrane.

PVC roof membranes are comprised of fabric reinforcement and film blends both above and beneath the reinforcement. The film blends are formulations of following three main groupings:

(a) PVC resin - 50 to 60% of the formula (by weight)
(b) Plasticizers - 25 to 35%
(c) “All other components” - generally 10 to 15% of the formula

The category “all other components” covers an array of ingredients added to formulations imparting specific properties to the membrane skin - UV resistance, coloration, heat and compound stabilizers, process enhancers, antifungal agents, and fillers. Fillers defined here are low-cost solids that increase the mass of a product without compromising its performance. Each manufacturer has proprietary formulations for its PVC roof membranes. These formulations reflect a delicate balance between the limitations of process equipment, marketing and profit goals, and design objectives of products. PVC formulations are sophisticated chemistry with many choices among the three principle groupings - resin, plasticizer, and “other” ingredients. Change one component and there is an impact on the production process, membrane cost and roof performance. Plasticizing agents are key features of PVC membrane. They impart flexibility to a solid PVC resin. They provide the ability to fuse seams and cold temperature performance. Plasticizers are also at the heart of a PVC membrane failure. Jim Koontz notes the relationship between loss of plasticizer and the resulting changes in physical

Figure 1: A Typical Flow Diagram of the manufacturing process
properties, increase in durometer hardness, increase in specific gravity, loss of elongation and increase in tensile strength.

Manufacturing Process of PVC Membrane Waterproofing

The PVC roofing membrane is made by a process of heat welding seam technology, which not only allows for one single piece of PVC roofing to cover an entire roof’s surface and eliminate seams and joints, but also provides excellent flexibility. This makes PVC roofing applicable to practically any shaped surface, and makes the installation process quick and simple. The material itself is extremely durable, and has a high resistance to punctures and impact, as well as fire propagation and flame exposure resistance. PVC roofing also has good tolerance for thermal movement because of its flexibility, and is exceptionally tough against contamination and rooftop soiling. Additionally, PVC roofing is virtually maintenance free, as it is both waterproof and dirt resistant. Usually woven with fabrics such as glass fibre and polyester, the PVC roofing membrane can provide up to 80% solar reflectivity, thereby reducing heat island effects and cooling costs. And to top it all off, PVC roofing is aesthetically appealing, and suitable to both old and new structures. Discussed below is the manufacturing process of PVC membrane called caste spreading.

Caste Spreading - This is a manufacturing process that creates waterproof membranes in which the reinforcement becomes an integral part of the liner. At room temperature, a spreading head lays a substrate of a mixture of liquid viscous state products called “plastisol”. This contains resins, plasticizers, stabilizers, pigments, etc. and determines the final characteristics of the waterproof liner. After gelation (a melting process), achieved by raising the temperature inside the ovens, the plastisol solidifies. The spreading and gelation process is repeated on line four times in a row. Thus, membranes manufactured by the spreading method are composed of four differently formulated layers. An internal reinforcement, either polyester or glass mesh, is inserted between the second and third layers. This manufacturing system establishes a molecular bond between the four layers creating a homogenous and flexible single-layer liner that can be combined with a thermally treated geotextile layer that improves its gripping characteristics or allows it to be laid on materials that are not chemically compatible with PVC-P. The spreading process can also produce two-color, single-layer membranes with a signal layer. Refer Figure 1 for the flow diagram of a typical manufacturing process.

Installation of PVC Membrane Waterproofing

Prior to installing any membrane system it is essential that the substrate to which it is being applied is appropriately prepared (Figure 4). Concrete must be appropriately cured for the type of membrane being applied and any debris, curing compound, oil, grease, dust and loose material should be removed. Waterproof membranes rely on a complete system to ensure that the waterproofing of the roof or podium slab is not compromised. It is essential that the manufacturer’s instructions are meticulously followed and that:

- Any depressions, joints or cracks are filled and sealed as required
- Any required reinforcing tape or bond breaker is applied to joints and cracks
- Any necessary suitable primer is applied (Figure 2)
- Specified coverage thickness is maintained for liquid applied membrane
- Re-coating times are adhered as per specification
- For preformed membrane, rolled out and align the membrane over the primed surface (Figure 3)
- Torch on the membrane under side with acetylene gas to softening point (Figure 4) and press hard on to the surface
- Keep overlap for minimum 100 mm (Figure 5)
- Finishing the joints with slight torching (Figure 6)
- Finishing up to parapet and seal the edges with polysulphied sealant (Figure 7)
- The application of screeds or other finishes is not undertaken until the membrane has sufficiently cured
- Membranes are appropriately protected from damage until floor finishes are installed (Figure 8)

Energy-efficient white roofing

Energy issues are growing in importance in the selection of all building materials, and roofing is no exception. Factoring in overall energy performance as part of system’s life-cycle cost, many customers and contractors are insisting on “white” as the color of choice in roofing.

The exceptional light and heat reflective properties of a white membrane can reduce a building’s internal cooling costs dramatically. In urban areas, white roofing can also help mitigate the “heat island” effect, helping reduce outdoor ambient temperatures. Urban heat islands are often 6 to 8 degrees hotter than nearby rural areas due to the concentration of black rooftops, paved surfaces and dark masonry surfaces.

Conclusion

PVC roofing membranes available in today’s market bring together attributes desired by quality-oriented contractors and building owners: toughness and flexibility in a thin profile; easy installation and repair; reduced smoke hazard; long-lasting resistance to pollutants, aging and brittleness; and the potential energy-savings of cool white roofing. Recent evidence has shown that some properly compounded PVC membranes are lasting well over 20 years. They are still weldable (repairable) after all that time and may be suitable for recycling at the end of their life. However while application the most important thing to be kept in mind is compatibility between the PVC compounds and substrates.

Reference

- Rebuild, Quarterly News Letter, ADVANCES IN WATERPROOFING MATERIALS & TECHNOLOGY, Dr. Fixit Institute of structural protection and rehabilitation, Vol. 5 No. 1 (Jan-Mar 2011)
- http://www.elvaloy.dupont.com/
- http://www.rci-online.org/