Important Future Aspects of Polymer Modified Bituminous Membranes

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Key Words: Polymer modified bituminous membranes, appearance, biological growth, installation, hot-gas welding, fire resistance.

Abstract

This paper gives an overview and some specific examples of the features and product properties that are important to polymer modified bituminous roofing membranes for them to maintain and extend their competitive advantages as seen from a European perspective. The paper discusses the following topics: Appearance and how it is affected by a roofing membrane’s upper protective layer and biological growth on the finished roof surface; installation properties of the membrane and how they may help a roofing contractor provide an efficient and safe installation of the roof; fire-safety aspects and alternatives to traditional open-flame burners; and finally, the fire resistance of bituminous roofing membranes and how it is of considerable importance to manufacturers of polymer modified bituminous membranes in the future.

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Introduction

Since roof membranes built up from coal tar were first introduced in the 19th century, bituminous membranes have, as most other industrial products, gone through major changes and improvements in terms of raw materials, production technology, appearance and the methods of installion. Some of these developments are illustrated in figure 1.

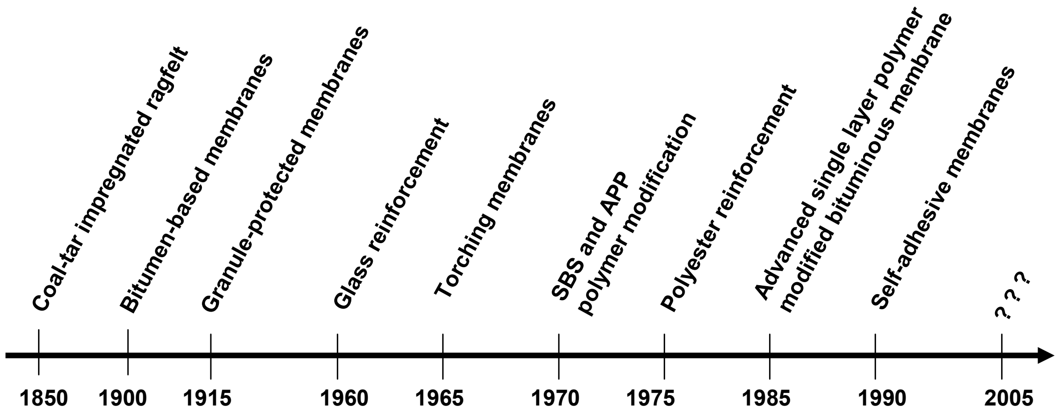


Figure 1. Highlights of the development of bituminous membranes

Obviously, the most important requirement for bituminous membranes is to provide a building with roofsystem, that prevent penetration of water and other materials to the inside of the building. Today, of course, this is not the only matter to consider when installing a new roofsystem or refurbishing an old one. Manufacturers of polymer modified bituminous membranes face a broad range of issues when considering or doing business with the different parties involved in the roofing process. Figure 2 illustrates the many parties and issues involved.

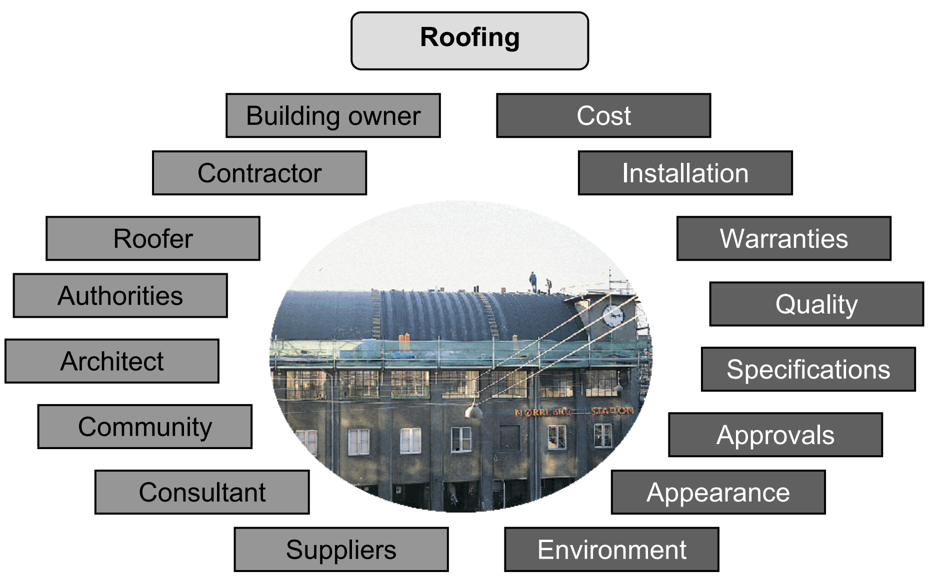


Figure 2. Parties and issues involved in the roofing business

For a manufacturer and supplier of polymer modified bituminous membranes to be successful in the future, it will require knowledge and resources to keep developing products and concepts that fit the needs and demands of all interested parties. The following describes, from a European perspective, some of the features and issues that may be considered important to maintain and extend the competitive advantages of polymer modified bituminous membranes as a roofing material for the future.

It must be noted that Europe, despite the European Union and progress of harmonized trade conditions and technical standards, still is made up of distinct roofing markets where tradition and formal requirements for construction, roofing technology and workmanship vary from country to country. This paper does not necessarily reflect the situation on all European markets but will merely deal with general trends.

Important aspects and requirements

Naturally, it is not easy to outline with precision the most important future requirements for polymer modified bituminous membranes. Moreover, they depend very much on your perspective. From a manufacturer's point of view, of course, it is crucial to maintain a competitive advantage over other roofing materials and roofing technologies. To this end, a wide range of product properties, the majority of which are already important today, have to be prioritized by a manufacturer of polymer modified bituminous roof membranes in future research and development work (see figure 3).

How can one improve and develop a product like bituminous membranes? The bituminous membranes of today are complex products that mix large numbers of different components and are assembled into laminated composites. This means that there are several parameters (figure 4) in which to play in the typical SBS-modified bituminous roof membrane. Not all aspects of development will be discussed in detail. The following will focus on the appearance of the membranes, their installation properties, installation methods and fire-resistant properties.

Figure 3. **Matters of importance to polymer modfied bituminous membranes**

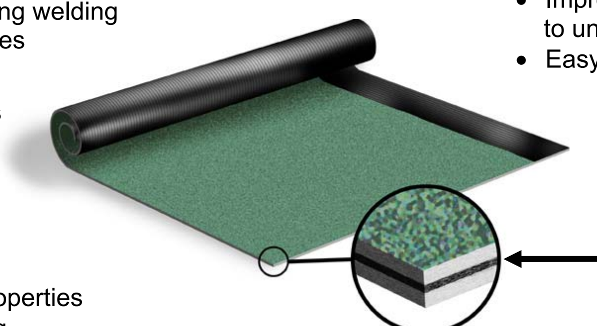


Figure 4. **Developing polymer modified bituminous roofing membranes**

Appearance

For many low-sloped industrial buildings, the aesthetic appearance of the finished roof is not of primary concern to the owner of the building. The important thing is that the installer has done a good job at a reasonable price, meaning that the roof is watertight and stays watertight under the physical and chemical influences such as wind force, building movements, roof traffic, ultraviolet radiation rain, hail, snow and airborne particulates.

In Europe, however, an increasing trend toward the appearance of the finished roof is noticeable. The trend is, of course, more pronounced for pitched roofs and visible low-slope roofs on private homes, high profile buildings and office buildings. But to some extent, appearance has also become an issue for traditional flat-roofed industrial buildings.

Focusing on appearance necessitates further development of the polymer modified bituminous membrane in different directions. One alternative for sloped roofs is to create more sophisticated designs on the roof surface, for example by incorporating wooden lists into the design vertically or horizontally as illustrated in fugure 5.

Figure 5. Examples of roof designs improving the aesthetic appearance

Another option, which is already popular and is expected to gain widespread use in Europe over the course of the next few years, is green roofs. A green roof system comprises a root resistant waterproofing membrane, a drainage layer, sedum and soil to allow plants, grass, etc., to grow. Examples of green roofs can be found in figure 6.

Figure 6. Examples of green roofs

As far as the membrane itself is concerned, future development work might include alternative protective layers on the upper surface and trying to limit biological growth on the roof.

Upper surface layers on the membrane

Traditional polymer modified bituminous roof membranes are protected on the exposed surface by mineral granules like slate, stone or sand. These materials are generally very well-suited for extending the lifetime of the membrane by protecting the polymer modified bituminous layers underneath from exposure to ultraviolet radiation, and mechanical influences. Mineral granules have been used on top of polymer modified bituminous membranes for more than 100 years. This fact contributes to the mistaken opinion held by many people that a polymer modified bituminous membrane is an old-fashioned type of product that has not changed its composition or properties for many years. Mineral granules also create some technical challenges to the future development of bituminous membranes. Consider the following:

- Some of the granules fall off when the membrane is handled and installed
- Rough surfaces are more susceptible to dirt and organic growth
- Full embedding of granules in the bitumen can be difficult in end laps and flashings
- The weight is approximately 0.2 pound/square foot (1 kg/m^2), which reduces the practical length of rolls

Redesigning polymer modified bituminous membranes by replacing the granules with something modern, however, is a rather difficult task. The upper protective layer influences a broad range of crucial properties of the membrane and consequently the finished roof. Obviously, the new protective layer must not jeopardize these properties solely to offer a pleasant-looking colored coating that might fade and crack after a short period of time anyway. To summarize the challenges facing such a development, a new upper layer for polymer modified bituminous roof membranes might be characterized by:

- Smooth or slightly embossed surface
- Nonporous surface to reduce susceptibility to dirt and algae growth
- Range of colors and limited color fading
- Superior initial and long-term adhesion to bitumen
- Weldable to bitumen in side and end laps
- No discoloration because of migrating bitumen components
- No stickiness when stored in rolls
- Resistance to degradation caused by heat and UV radiation
- Mechanical strength
- Can be walked on even at raised temperatures during installation and in summer
- Reasonable price
- Resistance to fire
- Low weight to allow for longer or wider rolls and fewer seams on the roof

Figure 7 outlines four approaches that may be taken, when developing a surface covering characterized by some or all of the previously mentioned items. Some of these technologies are already being used for existing products while others still require substantial research and development efforts.

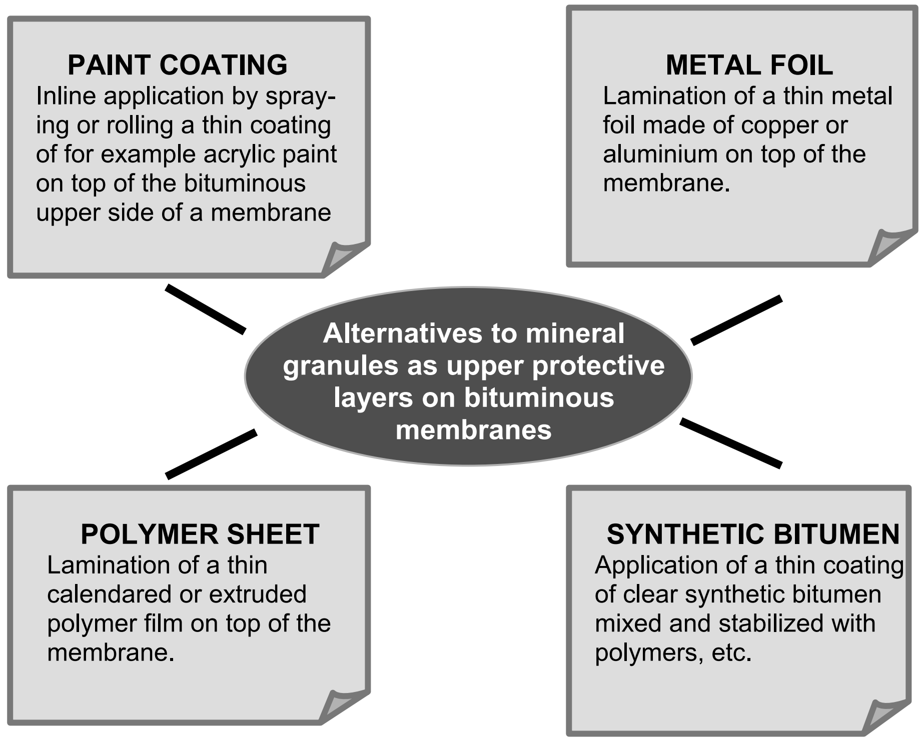


Figure 7. Upper side protective layers

Biological growth
The appearance of a roof is also influenced by biological growth. Such growth occurs on almost all surfacings of roofing materials. As shown in Figure 8, the location and extent of the growth depends on many parameters. Normally, the growth consists of algae, lichen or mosses.

Biological growth mainly causes aesthetic problems. Algae and mosses do not have roots or secrete any harmful substances, which could damage the roof. However, lichen will penetrate the roof surface in some cases.

Figure 8. Conditions favoring biological growth on the roof

Although biological growth is considered a natural phenomenon and has limited influence on the functionality of the roof, it can cause annoyance and dissatisfaction for the owner of the building. For this reason, future improvements in the prevention or limitation of biological growth will give the manufacturer of polymer modified bituminous membranes significant competitive advantages. As Figure 8 indicates, many of the parameters influencing biological growth are not under the control of the membrane manufacturers.

The manufacturers are able to reduce the problem by incorporating algaecides into the upper surface of the product. Today, organic algaecides (mixtures of different components) and metal oxides from copper and zinc particles, are frequently used in a wide range of roofing materials. The spectrum of activity and release rate of the active compounds are very important aspects of the overall perfomance of the algaecides in terms of reducing biological growth.

Future success in this area requires that a manufacturer of polymer modified bituminous membranes invests in comprehensive research and development efforts. Understanding each type of biological growth in detail will enable the manufacturer to find a specific mix of biocides which will give the optimum effect (spectrum of activity and rate of release) on a given type of roofing material characterized by a certain surface roughness, porousity, hydrophilic, etc.

Installation features

In recent years, several new features for polymer modified bituminous membranes have been introduced to improve the installation efficiency and/or quality of the seams. Many features are developed for torched (or heat welded) membranes, because this is a popular product type and one of the most common installation methods for polymer modified bituminous membranes in Europe.

Continuing to develop and introduce new and innovative features that help the roofing contractor in the installation process will definitely be essential to the manufacturer of polymer modified bituminous membranes and a key to future success in the roofing material business.

The development of new installation features is made possible by today's advanced production technology which allows more complex products with special structures and designs for selvage, underside, endlap and others to be produced. Grooving the underside of torched bitumen, for instance, increases the installation speed, as shown in Figure 9.

A grooved profile on the underside of the torched bitumen enhances the melting of the thin polymeric separator and the bitumen.

The result is a faster installation that requires less energy.

Figure 9. Grooved underside

Another new feature is making small cutlines in the film that functions as a separator on the upper side selvage of the membrane. Cutlines facilitate the melting of the thin film, which is typically made of polyolefines or polyester. This is especially advantageous in situations where the available energy for welding is reduced, such as when welding with hot air. In these situations, special low-heat reactive bituminous blends on the underside can also speed up the installation.

Granule-free endlaps is another feature, that enhances the installation process. This feature makes the closing of endlaps more secure by helping avoid incomplete embedding of granules in the bitumen and the ensuing weak seams and potential leaks.

A feature that has gained widespread success throughout Europe for the past decade is polymer modified bituminous membranes with well-defined patterns of bitumen on the underside (see Figure 10). These patterns allow a safe and uniform partial bonding of the membrane and thereby ensure equalization of pressure, which may build up from entrapped moisture.

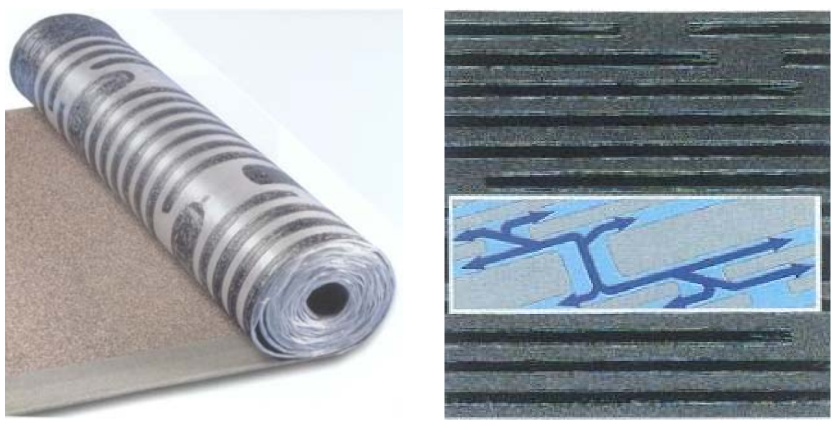


Figure 10. Bituminous underside for well-defined partial bonding

The striped underside may be used in many different applications, where pressure equalization is needed to prevent blisters of entrapped moisture from forming and thereby influencing both integrity and appearance of the roof or waterproofed area. These usages include vapor barriers, bridge-deck membranes, parking-deck membranes and roofing membranes. The technology for bitumen undersides with partial bonding (venting membrane sheets) may still be optimized further. Today, products typically use sand as separators between the bitumen areas of the underside. When the membrane is torched to the substrate, heating of the sand between the bitumen areas can not be avoided. In some cases, this causes the bitumen above the sand to penetrate the sand layer and create almost complete bonding with the substrate, which limits the pressure equalization potential. A separator that is more heat stable than sand would minimize this problem and facilitate correct installation of the membrane.

Fire-safe welding

Fire safety on a roof is a main concern in Europe today with regards to installation of polymer modified bituminous membranes. One of the most common installation methods employed today is open-flame welding using propane/butane gas burners. This is a very efficient way to melt and adhere the bitumen to the substrate or to make an overlap. When roofers pay careful attention to their work, there normally only is a small risk of starting a fire on the roof or within the roof contruction when using these burners.

However, some European countries have imposed restrictions on open-flame welding on structures such as hospitals, schools and high cost product plants. These restrictions primarily are enforced by insurance companies. In some cases, the restrictions only are enforced for work on details like upstands, penetrations and others, where the risk of igniting nonvisible materials below the upper roofing area is higher. More extensive restrictions have been imposed since January 1. in Norway where open-flame welding is no longer allowed for refurbishments of existing roofs.

Despite the relatively small number of fires caused by open-flame gas burners, it should be expected that polymer modified bituminous membranes will have increased restrictions on open flame installation in the future. Maintaining the competitiveness of polymer modified bituminous membranes will certainly require new installation techniques to match the efficiency of open-flame welding.

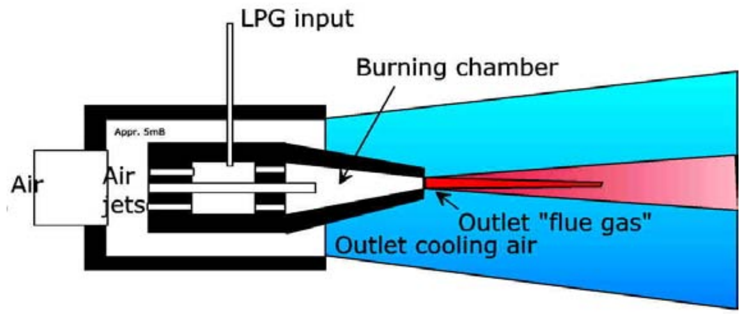
An alternative is to use electrically generated hot air to melt the bitumen. Equipment for this type of welding has been used for installing single-ply roof membranes for many years, and it is well-suited for this purpose. To a certain extent, the technique has also been used for welding polymer modified bituminous membranes. In many cases, however, the available heat from the equipment is not enough to achieve a reasonable installation efficiency when compared with open-flame welding. Especially regarding details, hot air welding becomes much more time-consuming and results in installation costs that are too high. Moreover, the equipment of today is not capable of efficiently welding the full-width underside of the polymer modified bituminous membrane and drying up the surface of the substrate.

Occasionally, patent literature discloses more sophisticated installation methods such as using electromagnetic radiation or ultrasonic energy to heat the bitumen or high-frequency currents to heat a special metal netting placed in the overlap. From a practical point of view, all these methods will need many improvements to be practical, applicable, efficient and safe.

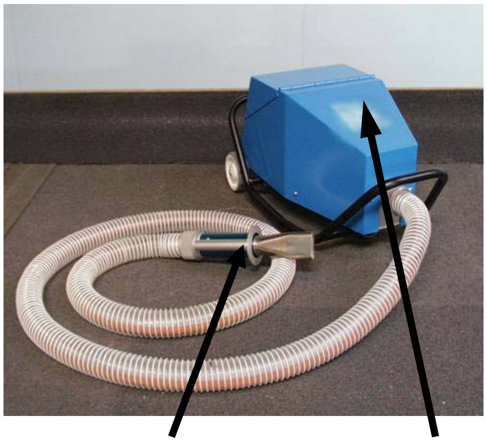
Welding with hot gas

A newly developed piece of equipment seeks to combine the best properties of open-flame welding with electrically based hot-air welding. The equipment uses gas combustion as a heat generator. It feeds a precise amount of gas and air in to a specially designed combustion chamber, that generates a short and well-defined flame. From the nozzle, that is attached to the combustion chamber, flows a hot gas with temperatures of approximately 1650ºF (900ºC) and at a speed of approximately 50 feet/second (15 m/s). The gas consists of CO_2, H_2O and excess air. In Figure 11 the principle design of the combustion unit and photographs of the complete equipment can be found.

Combustion chamber



Hand-held tool for details and minor jobs



Automatic side lap welder

Figur 11. Equipment for welding with hot gas

From a fire-safety point of view, the equipment as illustrated in Figure 11 has several advantages:

- Control of the heating source is much better compared to open-flame welding
- High speed of the hot gas coming out of the nozzle makes ignition on the roof difficult
- Reduced oxygen content in the hot gas makes ignition on the roof difficult. .

Practical tests show an roof installation efficiency similar to what is achieved with conventional open-flame burners. However, the equipment is in present versions only applicable to side lap welding and detailing.

Fire resistance of bituminous membranes

Legal requirements and official standards for the fire resistance of roofing materials have existed for many years in Europe. Until now, local national approvals and test methods have been applied. The majority are system tests where the insulation and/or substrate are part of the system to be tested. Basically, the tests determine the fire propagation and fire penetration of the system. The systems must pass criteria typically stated in terms of time combined with length or area of damaged material.

Similar to most other roof membranes, polymer modified bituminous membranes require additives and/or modifications to pass the most severe European fire tests. The authorities of many European countries have increased their focus on the fire-resistance properties of building materials. This, combined with the fact that fire-resistance properties of roofing materials have become important marketing parameters on many European markets, means that manufacturers of polymer modified bituminous membranes must engage in comprehensive research and development activitities in this field to meet future legal requirements and to remain competitive with other manufacturers of polymer modified bituminous membranes, as well as manufacturers of other roofing materials.

Basic research, for instance, is required to help understand the correlation of bitumen characteristics with fire-properties in the final product. This type of knowledge is necessary to establish a proper quality control of the supplied bitumen so that variations in the bitumen quality do not influence the fire-resistance properties of the finished and already approved product. Furthermore, this type of research forms the necessary basic knowledge for the development of the optimum fire-resistance formulations and finished products.

As outlined below, several possibilities exist for improving fire-resistance properties of polymer modified bituminous roof membranes. Some are already being used today in bituminous roof membranes while others have future potential. However, research still must be done to identify the optimum formulations for fire retardant polymer modified bituminous roof membranes.

Brominated Compounds

Brominated compounds are generally very efficient as fire retardants. They reduce or extinguish the fire by scavenging and destroying free radicals formed in the fire process. A good effect can be achieved just by adding a small percentage to the bitumen. Including Antimony trioxide in small amounts will improve the effect, because it reduces the temperature at which the brominated compounds become active.

Brominated fire retardants are easy to use in the production of bituminous roof membranes, and the retardants do not significantly affect any other properties of the product. However, there is an ongoing discussion in Europe regarding the environmental impact of halogenated fire retardants (this include brominated retardants). Future legal restrictions on some of these chemicals may come into effect. Today, some of the most environmentally progressive countries and companies already try to limit or avoid the use of halogenated fire retardants.

Mineral Hydrates

Mineral hydrates release crystallized water at a certain temperature, thus producing a cooling effect and delaying the fire. Examples of mineral hydrates are aluminium trihydrates, magnesium hydroxides and colemanite. In general, they must be added in large amounts (10 percent to 30 percent in bitumen) to produce a reasonable effect. It is of course important to use mineral hydrates, which release the crystallized water at temperature lower than the actual temperatures during production and installation of the membrane.

Intumescent Compounds

Intumescent compounds function by expanding enormously at a certain temperature and thereby isolating the combustible material from the atmospheric oxygen. Examples of intumescent compounds include expandable graphite and polyphosphorous compounds. Achieving a reasonable effect requires amounts of approximately 2 percent to 5 percent in bitumen.

Conclusion

Polymer modifed ituminous roof membranes have a long and established track record as a superior type of roofing material. This paper has described some of the important areas where the product may be improved and developed to maintain and extend its performance in the future. It has to be expected, of course, that other new features and issues will arise and that the technological development will allow for even more sophisticated materials to be developed and innovative solutions to be found.

No matter what the future holds, it is evident that being a successful manufacturer of polymer modified bituminous membranes will mean constantly keeping up to date on all the new requirements brought forward by contractors, authorities, building owners and others. And it will require resources and competencies to carry out substantial basic research and practical product development to fulfil these new requirements.