HISTORY AND DEVELOPMENT OF MODIFIED BITUMEN

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The development of modified bitumen (MB) roofing began in Europe. Its use has spread throughout the world; MB roofing is the fastest growing type of roofing on the market today. Because of the various types of modifiers, reinforcing, and surface treatments used, the performance characteristics of the MB products available are almost unlimited. When one combines these products with the diverse methods of installation (heat-welding, hot asphalt, and cold adhesive), and the ways of attachment or nonattachment to the roofing base, it becomes apparent that the selection of an MB may be difficult. Not all MB roofing is equal, and the product selected must be carefully matched to the requirements of the building being roofed and to the environment in which the MB roof will be expected to perform.

HISTORY OF BITUMEN

Bitumen has been used for centuries[1] in a variety of ways that include the preservation of mummies by the Egyptians and the waterproofing of baths by the Babylonians. Bitumen was used in its natural state until the early 1900s when the distillation of crude oil began. The use of asphalt in built-up roofing was normally restricted to use on steep-slope roofs (1 inch to 3 inches per foot) prior to the late 1940s and early 1950s when, by modification during the manufacturing process, a product was developed that was suitable for use on low-slope roofs (1/4 inch per foot or greater). Development of the asphaltic bitumens for low-slope roofs was spurred by the problems arising with workers who were required to apply the coal-tar pitch roofs that had been used on low-slope roofs before that time, i.e., premium pay, complaints involving burning of eyes and skin, and alleged lung damage from breathing fumes.

The use of BUR

Built-up roofing (BUR), so called because the roof is manufactured on the jobsite from alternating layers of reinforcement and bitumen, was used with few problems until the end of World War II. The building boom that followed saw many changes that affected the performance and life of a BUR. Some of the more common items cited are:

- Architectural design changes that resulted in the use of more low-sloped roofs (many "dead level") that ponded water.
- The practice of installing the mechanical equipment on the roof surface. Much of the mechanical equipment used is not watertight in itself and the required maintenance results in excessive traffic on the roof and the possibility of roof damage by workers performing the maintenance (dropped tools, etc.).
- The use of lightweight, flexible metal decks.
- The increased use of roof insulation under the BUR creating stresses in the membrane. Some types of insulation may create other problems when used under BUR. (i.e., blistering over some foam-type insulations).
- The quality of the roofing materials that were available. "Rag" felts did not contain rag as they had in the past, and problems with roofing bitumens seemed to increase, i.e., slippage, interior drippage, etc.
- The development and sale of coated roofing felts resulted in failures that gave the entire roofing industry a "black eye."

The result was a roof that could no longer be expected to last "20 years." Early failures based on poor workmanship and faulty materials increased, and the search began to find a replacement or substitute for BUR as well as ways to improve BUR. The problems with BUR and the search for new methods and products was not limited to the United States, but was common throughout Europe as well.

Other events only increased the need to find new, improved roofing products. They include, among other things:

- The oil embargo of 1973.
- Safety and health requirements stipulated by OSHA and other regulating authorities.
- The increasing shortage of qualified workers for installation of BUR. Workers became more and more difficult to find, to train, and to keep.
- The constant call for unrealistic, unobtainable tolerances for the installation of BUR.

A HISTORY OF THE DEVELOPMENT OF MODIFIED BITUMEN ROOFING

The search for information on the dates, places, and people involved in the development of modified bitumens results in answers as diverse as the products themselves. Just as no two MB products are identical, no two answers are identical.

Definition

Perhaps it is appropriate to define MB roofing as used for this paper. A Modified Bitumen is a factory prefabricated, reinforced sheet, composed basically of bitumen, reinforcing sheet and various bitumen modifiers.[2] A modified bitumen roofing membrane is not usually a true "single-ply" roofing membrane, but is usually used in conjunction with a base ply of similar or different roofing material. Under strictly controlled circumstances, it may be used as a pure single-ply roofing membrane.

Development in Europe

Europe took the early lead in developing MB roofing and, as might be expected, European efforts took as many avenues of development as there are nations. Each area of Europe has unique work skills, climates, attitudes, and equipment previously used to install BUR. The people of each area attempted to develop prod-

ucts easily adaptable to their requirements and resources.

First patent
Some evidence would indicate that a patent was first issued in 1929 for the modification of bitumens in Scandinavia. Because Scandinavians destroy most records after they are 10 years old, no information was available on this patent. At any rate, no major development seemed to occur until the Scandinavians began further development in the 1950s. Whale oil was used as the modifing agent and a very simple mixing tank as shown in Fig. 1 was used. The torch used for application resembles a soldering torch (fig. 2). The odor of the burning whale oil during application was a major problem with this product.

Development dates
Other important dates for European MB development include:

1. In the 1960s, Ruberoid obtained a British patent for MB.
2. 1965—An Italian, Romolo Gorgati, successfully combined atactic polypropylene (APP) with bitumen in a manner that avoided degradation of the APP. Mr. Gorgati constructed his first plant in the mid 1960s at Bologna, Italy and marketed the first product in 1967.
3. 1969—MB was introduced in Germany.
4. In the 1970s styrene-butadiene-styrene (SBS) was introduced in Europe.
5. 1972—MB roofing was introduced in both Holland and the United Kingdom.

The progress of MB throughout Europe has been steady since it was introduced, and its use has resulted in relatively few problems in the field.

History of modified bitumen in the United States
Because of the problems previously cited for BUR, the Midwest Roofing Contractors Association (MRCA) asked two members of MRCA, Tom Manson and Paul Morris, to go to Europe to study new roofing products that the Europeans had developed and were currently using. It was during this trip in 1970 that they were first introduced to MB roofing; however, after observing a short demonstration, they quickly agreed that MB was not a viable product for the U.S. market because of cost, methods of application and because they lacked full understanding of the material. The oil embargo of 1973 forced a re-examination of this position.

First U. S. installations
In 1972, the W. R. Grace Co. marketed an SBS modified bitumen roofing in the United States that was developed in this country. In 1975, the Koppers Co. introduced an APP modified bitumen that was developed in cooperation with Texsa, S. A., a Spanish firm. While these products were a valuable addition to the available roofing products in the United States, many roofing contractors were slow to accept a new product that required installation procedures they had not previously used.

During the 1974 Convention of the National Roofing Contractors Association (NRCA) in New Orleans, the Scandinavians were invited to present a demonstration of MB application to NRCA's Technical and Research Committee. This demonstration was well accepted and interest was expressed in finding out more about the possible use of MB in the United States. Contact was made between roofing manufacturers in the United States and modified bitumen manufacturers in Europe. The process of introducing MB into the U. S. market was started; however, the next MB roofing products were not installed in the United States until 1978, when new types of APP and SBS modified bitumens were installed. In April 1978, APP modified bitumen was installed in Valley Forge, Pa., and the next month, May 1978, SBS modified bitumen was installed in Grand Rapids, Mich. Both of these products were manufactured in Europe and shipped to the United States. Customs immediately became a problem, with customs costs often being as much or more expensive than the MB roofing itself.

U. S. manufacturing started
If MB roofing was to be a major factor in the U. S. market, the obvious solution was to establish manufacturing plants in the United States. A production facility for SBS modified bitumen roofing was opened in July 1978, at Joplin, Mo. The actual marketing of this product started in January 1979. APP modified bitumen roofing continued to be imported to the United States from Europe. However, in October 1980, one manufacturer produced the first material from a new facility located in Kansas City, Mo.

MB marketing in the United States
These two manufacturers of modified bitumen roofing (APP and SBS) also chose different methods of introducing their materials into the U. S. market. SBS modified bitumen roofing manufacturers chose an agreement for manufacturing in the United States between an established roofing manufacturer from the United States and a modified bitumen manufacturer from West Germany. APP modified bitumen roofing, on the other hand, enjoyed a composite ownership of European manufacturers, distributors, and other roofing industry persons combined with U. S. roofing contractors and others from the roofing industry. The ownership formula was carefully established so that no one group could gain control of the operation. This ownership ended with the sale of all assets to a major U. S. roofing manufacturer in 1982.

Introduction of MB into the United States was stimulated by the formation of a corporation designed to help accomplish that goal. Originally formed in Dublin, Ireland, this corporation later moved to Bermuda and still later to the United States. All stockholders were involved in the roofing industry in some way. The nations represented included Switzerland, Italy, England, Belgium, Canada, and the United States. This corporation provided an opportunity to exchange ideas, data, and information on all types of roofing materials and the problems being encountered around the world.

DEVELOPMENT OF MODIFIED BITUMEN ROOFING

Man's search for a perfect roofing material that will solve all problems on all types of jobs and under all conditions has led to extensive research for each type of roofing product. MB roofing has been a step forward; however, it should not be considered the ultimate solution. Many MB products marketed earlier have already been withdrawn from the market and my educated guess is that other products currently being marketed will soon follow. Field testing and thorough knowledge of any MB roofing is vital for long-term, satisfactory performance. Each type of modifier used produces strengths and weaknesses in the modified bitumen, just as each reinforcing material also adds some strengths while leaving some weaknesses in the finished product. When those factors are added to the types of surfacings available and the methods of application, the lists of materials available, each with strengths and weaknesses, is endless. To complicate matters further, there are many variables: bitumens vary in chemical composition; quality of modifiers may vary greatly; compatability of materials

must be considered carefully, and manufacturing procedures, especially quality control and thorough blending, may vary. All of these factors must be considered before specifying or installing an MB roof.

Composition of MB roofing
A partial list of modifiers, reinforcing plies, surfacings, and methods of application may help to explain the endless types of MB products available today. The lists are constantly expanding. It should also be pointed out that many MB products use more than one reinforcing sheet, more than one modifier in the bitumen, and some even use one type of MB as the top layers of the MB roofing membrane, while using an entirely different MB on the bottom (i.e., SBS MB on top and APP MB on the bottom, so that the MB roofing can be heat-welded in place with more ease).

Modifiers of bitumen
- Whale oil
- APP (Atactic Polypropylene)
- SBS (Styrene-Butadiene-Styrene)
- SBR (Styrene-Butadiene-Rubber)
- Soybean oil
- Coconut oil
- CPE (Chlorinated Polyethylene)
- Regenerated rubber
- Limestone filler

One manufacturer also installs polystyrene beads in the MB at the underside of the roofing sheet for spot-adhere application.

Reinforcing
- Fiber glass felt or mat (good tensile strength)
- Jute
- Polyester—non-woven or woven (high load-strain properties)
- Metals—aluminum, copper, stainless steel
- Polyethylene
- Polypropylene

Surfacing
- Granules—field- or factory-applied
- Ballast
- Gravel—loose or adhered
- Metals—aluminum, copper, stainless steel
- Acrylic coatings
- Aluminum coating

Some of these surfacings may require maintenance to retain their effectiveness (fire rating) or appearance. Compatability of all materials within the system must be carefully verified.

Methods of application
- Heat-weld—propane torch or hot air
- Cold adhesive
- Hot asphalt
- Self-adhere

Compatability of products is essential in this category.

Types of application
- Solid-adhered
- Loose-laid
- Partially adhered
- Protected membrane

In spite of the large number of potential products available, the most commonly available products currently being marketed are composed of either APP or SBS modified asphalt, polyester and/or fiberglass reinforcing and unsurfaced or surfaced with factory-applied granules or metallic skin. Thus, the quality of the component products used to manufacture the MB roofing becomes all-important.

Asphalts
Because asphalt has a varying and complex chemical composition and the type and quality of asphalt available is constantly changing, the manufacturer of MB roofing must be aware of the characteristics of the asphalt he is using at any given time. Asphalt is generally considered best for MB roofing if it is an unblown or blended asphalt because many of the light oils may be removed during air blowing. The blending process for the bitumen and the modifier must be thorough and complete.

Modifiers
Just as asphalts vary in quality, some modifiers may also vary. The manufacturer must monitor the quality of the modifier frequently to be sure the quality has not changed.

Material and application standards
Material and application standards are not yet available for MB roofing. ASTM is currently developing the necessary standards; however, completion of these standards is estimated to be several years in the future. Development of these standards is difficult at best because of the many MB products on the market and the different application methods available. MRCA has developed some recommended performance criteria[3] to be used in the interim and the Canadian Government Specification Board has produced a standard[4] for use in Canada.

Insurance
Insurance must be considered when any roofing product is being developed and one item not considered to this point is the insurance requirement both for the completed MB roof system and during installation.

To obtain an Underwriters Laboratories (UL) Class A roof, if required, MB roofing may require one of a number of top-surface treatments depending on the particular MB roofing product being used. Some manufacturers are experimenting with chemical and composition changes within the manufacturing process to obtain a Class A fire rating, while other manufacturers are testing various types of field-applied surface treatments to accomplish this goal. When a Class A rating is required, a careful check should be made to be sure that the system you propose has been tested and approved by UL. One caution: once the system has been classified as Class A, no substitutions may be made, including the substitution of an identical material by a different manufacturer unless approved in writing by UL.

Uplift resistance
Uplift resistance of a proposed MB roof system must also be approved in writing by Factory Mutual (FM) on certain installations. While FM is working on loss prevention data sheets for all single-ply roofing, the sheets have not yet been issued.

Application fire safety
Fire during the application of torch-applied MB roofing is probably one of the most discussed topics today and yet, it is one of the easiest items to correct or minimize. There are two rules that, if followed, will sharply reduce the possibility of fire during application:

- Do not torch MB roofing directly over any fiberboard product (roof insulation, tapered edge strip, cant, etc.). A fire in fiberboard products is not easily found and may smolder for hours

before bursting into flame long after the roofing crew has left the jobsite. Most, if not all, MB manufacturers, no longer allow torching directly to any type of roof insulation.

- Manufacturers and suppliers should not sell any torch-applied MB roofing to any roofing applicator, large or small, until they have been thoroughly trained in the application techniques and procedures. Each applicator should be provided with a list of torching safety rules.[6]

OBSERVATIONS

MB has become a significant addition to the roofing products available in the United States and it is the fastest growing product available. It provides several advantages when compared to either BUR or other types of single-ply roofing. These advantages include:

- Some of the equipment used in application and manufacture of MB roofing requires minor or no modification when converting from BUR to MB roofing.
- Installation is less labor-intensive than BUR and is competitive with most single-ply roofing.
- Safety from burns is decreased in comparison to BUR,and safety from the dangerous chemicals used in many other types of single-ply products is eliminated or reduced.[5]
- New and improved products are constantly being developed to add to and improve MB roofing. New products from Venezuela and China are currently under consideration for use in the United States.
- MB roofing is resistant to some chemical attack, may have excellent ultraviolet resistance, and is less susceptible to damage from traffic on the roof than most other types of roofing.
- Because MB roofing is manufactured largely in a controlled environment using manufacturing machinery that permits closely controlled manufacturing tolerances, MB roofing is less susceptible to weather conditions and is able to be manufactured to closer tolerances than could be obtained in a BUR that is manufactured at the jobsite. Tolerances during installation at the jobsite, however, become even more essential to maintain because of the single-ply or two-ply nature of MB roof being installed.
- By choosing one modifier or mixing two or more modifiers during manufacture, products especially suitable for high temperatures, low temperatures, or any range of temperatures may be selected. The method of installation (heat-weld, hot asphalt, etc.) desired for a particular job may also be easily selected.

And yet, as with any type of product, there are many cautions that must be observed to obtain a satisfactory installation. Remember that all products appearing to be similar in nature and composition are not equal. Compatability of all components is essential. Quality control, both during manufacture and installation, is a must. Each area of the United States has its own climate that must be considered when choosing the proper MB roofing.

As competition among manufacturers and roofing contractors increases, both have a tendency to cut corners to obtain a competitive advantage. New, high performance MB roofing has been and is being developed. Let us use it as it was intended to be used.

REFERENCES

[1] Shell, "Roofing, Improved Bituminous Felts with Cariflex TR," (England, 1980) p. 1.

[2] Phil Daniels, "MB Roofing—the U.S. Experience," *Roofer Magazine* (January 1984) p. 14.

[3] "Recommended Performance Criteria for Modified Bitumen Roof Membrane Systems (Prefabricated and Reinforced)," Midwest Roofing Contractors Association, MB-30, November 1983.

[4] "Standard for Membrane, Modified Bituminous, Prefabricated, and Reinforced, for Roofing and Waterproofing," Canadian Government Specification Board, 37-GP-56M, July 1980.

[5] "One-Ply Systems: A Reference Guide to Safety and Health Hazards," United Union of Roofers, Waterproofers and Allied Workers, Safety and Health Program.

[6] "'Tipsheet' For Torching Safety," *RSI* magazine, August 1986, p. 36.

Figure 1 *One of the first mixing tanks*

Figure 2 *An early propane torch*