

# History of

## POLYMER MODIFIED AND COLD PROCESS ROOFING

### ABSTRACT

Modified bitumens (primarily asphalt) have found many uses in practical roofing applications. This article will present recent history and applications as high performance mastics, waterproofing, high performance mopping asphalts, and roll roofing. The most recent application has been high performance cold-applied adhesives for insulations and built-up roofing.

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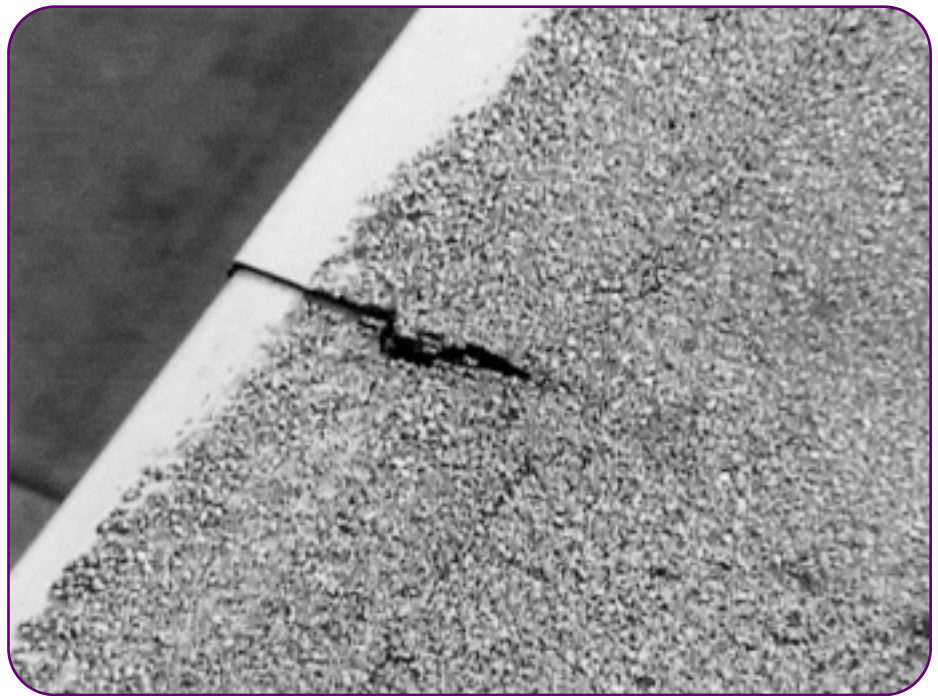
### History

Many articles have been written on SBS (sequenced butadiene-styrene) and APP (atactic polypropylene) polymer modifiers as they relate to roll roofing. However, there is significant history with respect to polymer blending as a performance enhancement in cold roofing mastics in the late 1960s and early 1970s. A few manufacturers were blending SBS polymers with traditional roofing mastics to impart elastomeric characteristics for use at those roofing joints that demanded higher performance to maintain watertight integrity. Specifically, pitch pocket penetrations as well as edge fascia metal joints were a constant challenge. (See *Photo 1*.) The coefficient of expansion and contraction of these details exceeded the limits of the typical fiber reinforced mastic. Such mastics would soon exhibit cracks and splits that accelerated after a nominal amount of field exposure. As roofing chemistry became more sophisticated, various formulations and viscosity ranges (for horizontal and vertical applications) were developed for specific uses, such as pourable sealers (pitch pocket mastics) and elastomeric sealants/mastics for high movement joints and terminations. Recently, second and third generation product improvements have removed asbestos fibers and lowered VOC content.

But, to quote Dr. H.O. Laaly, “Why modify bitumen? Isn’t it a good enough waterproofing material already? Certainly. But because of the improvements that can be made in a bituminous material’s durability and extensibility (especially at lower temperatures) by adding polymers (rubber and plastics), the physical proper-

ties of the resulting polymer modified bitumen surpass any other material for the cost.”<sup>1</sup>

Dr. Laaly’s query is appropriate. Both coal tar pitch (CTP) and asphalt-based roofing systems have over 100 years of field experience. It is true that the industry has tried to “tweak” the venerable BUR with two-ply (Bond-Ply/Dual-80) configurations. Remember those failures in the early 1970s? (See *Photo 2*.) Reinforcements have evolved from the true rag felts to pulp, glass, and more recently, to heat-stabilized polyester blends and combinations of glass and polyester. In all these configurations, the waterproofing media has been basically unchanged — coal tar pitch or air-blown asphalt.



*Photo 1: Damage due to expansion & contraction of fascia edge is a routine problem with BUR systems.*



*Photo 2: Dual 80 or Bond-Ply assemblies blistered profusely.*

Prompted by problematic field performance, early roofing research at NBS (National Bureau of Standards; now NIST — National Institute of Standards and Technology), identified issues such as splitting, blistering, lack of cold weather flexibility, and fire resistance. Justification for continued use of the well-regarded built-up roofing required a more pragmatic investigation. Recommendations for actual performance criteria were published as *NBS 55 Criteria*.

## Waterproofing

Below grade, moisture is kept from interiors by essentially the same system configurations as BUR applications. The major difference is in exposure. The materials are not subjected to the same environmental exposures that work to compromise bituminous roofing performance. Additionally, at below-grade locations, thermally-induced movement is practically nonexistent because of the constant temperature of the soil and back-fill medium.

Modified, below-grade products were developed for different reasons. It was very hazardous to work with hot bitumens in confined areas and to achieve the desired bond to vertical surfaces. (See *Photo 3*). Polyurethane-

modified CTP formulations of trowel-grade waterproofing materials were in use throughout the 1970s and could be applied without the danger of burns. However, adequate ventilation or respirators were required due to the rapid solvent release of the materials. The CTP-based polyurethanes have disappeared from the marketplace due to environmental and health and safety concerns. The volatiles are intoxicating fumes and the CTP-based bitumen is a known carcinogen. Many manufacturers of below-grade waterproofing materials currently offer polyurethane-modified, asphalt-based formulations.



*Photo 3: Workers can be exposed to heavier-than-air fumes from waterproofing products.*

Based on application criteria, they are provided in horizontal and vertical viscosities. Most products have a low VOC that are compliant with air quality regulations and worker safety concerns.

These materials are usually applied with a notched trowel to achieve the appropriate thickness for waterproofing integrity. The products, when cured, offer excellent MVT resistance and crack spanning capabilities. On larger crevices, depending on the specific manufacturer, pre-treatment of the crack with fabric reinforcement or an elastomeric sheet is required. (See *Photo 4*.)

## Hot-applied Waterproofing

To meet the needs of extensive lightweight slab construction, hot-applied modified asphalts appeared in the construction market in the mid 1970s. Unlike roofing asphalts, these materials were blends of non-blown asphalts and elastomeric polymers, primarily SBS. The advantage over conventional waterproofing configurations for on-grade waterproofing of plaza decks is that multiple layers of reinforcing felts are not needed. Unlike roof deck constructions, the concrete pours are stable. Typically, the hot-applied modified waterproofing systems are reinforced with a single layer of compatible, heat-stabilized, polyester fabric.

Depending on the surface characteristics of the substrate to be treated, priming may be recommended. Specific details for static and dynamic cracks and joints are dependent on the manufacturer. Most manufacturers limit applications to structural concrete slabs and foundation waterproofing. Individual manufacturers, on a case-by-case basis, may accept some lightweight deck constructions.

Unlike conventional roofing or waterproofing asphalts, the hot, modified asphalts must be carefully heated and agitated in special oil-jacketed kettles. Temperatures in excess of 425 degrees F. (218 degrees C.) will cause severe damage to the asphalt-polymer matrix and coking will result. Hot spots from the conventional roofing kettle's heat transfer tubes will cause severe charring and damage the chemical and physical characteristics of the bitumen. However, oil-jacketed kettles are more expensive and accommodate less bitumen than common roofing kettles.

Some State Department of Transportation divisions accept hot modified bitumen materials for bridge deck repair as well as other concrete joint remediation. A special applicator wand with a flat flange is used to force and spread the material into the deck joint. Although the adhesion of modified asphalt materials is superior to that of hot asphalt, priming is usually recommended but, unfortunately, seldom observed.

## Hot-Melt Modified Adhesives

A popular term today is "kettle-modified bitumens." This description gives the unfortunate impression that the roofer's kettle is the batch mixer and delivers bitumen that has better performance characteristics than typical roofing



Photo 4: Pre-treatment of cracks on slab to be waterproofed.

asphalt. In fact, unstable hybrids can result if Type III asphalt is mixed directly with the hot-melt adhesives.

The current generation of asphalt hot-melts is derived from the success of the modified product developments in the waterproofing industry. However, unlike the strict heating parameters required (oil-jacketed kettles) for hot-melt waterproofing bitumens, current hot-melt roofing adhesives are not as sensitive to heating as their predecessors. Standard roofing kettles can be used to melt the kegs to apply at EVT. The modified bitumen adhesive can be installed with traditional means and methods, such as a roofing mop or felt-laying machine. The key to temperature flexibility is the result of the use of SEBS (sequenced ethylene-butylene-styrene) polymers or blends of SBS and SEBS.

## Modified Bitumen Roofing Systems

The unique benefit of using compatible hot-melt modified bitumens with MB felts is that all components of the system are elastomeric. Although the commonly accepted recommendation for MB ply installation is to use Type III or IV asphalt, system elongation, cold bend flex temperature, and strain energy are superior with the use of hot-melt adhesives and SBS modified plies and surfacing sheets.

## Roofing Adhesives

In the late 1960s, one manufacturer developed a modified asphalt adhesive to adhere a Neoprene® flashing membrane to a built-up roof. This Neoprene® membrane was the elastomeric flashing component of an extruded aluminum fascia system. Interestingly, a natural gum rubber compound was used as the base elastomer within the bitu-

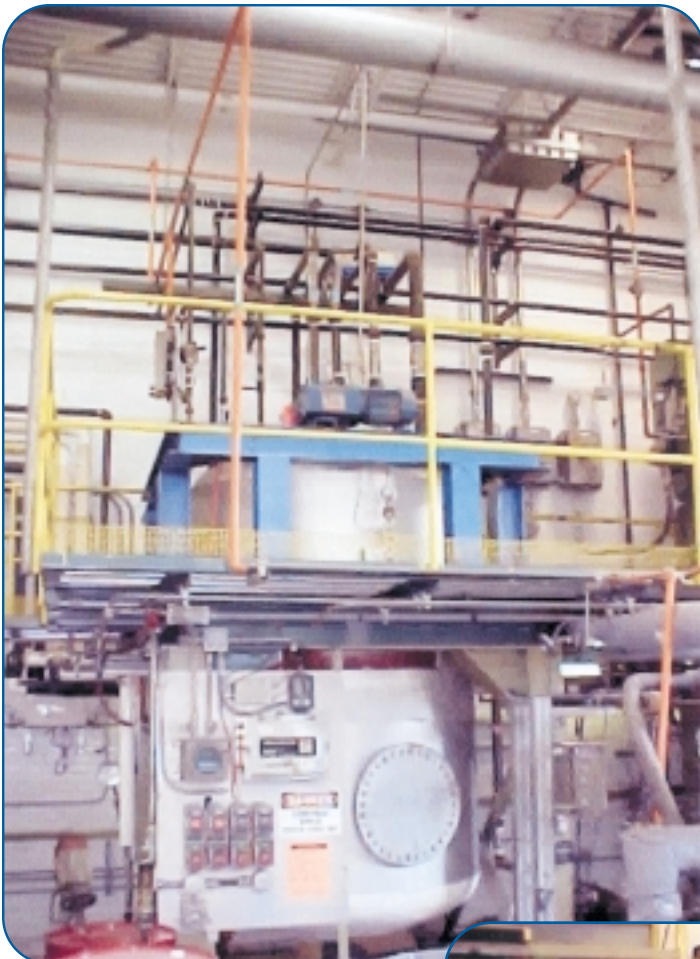


Photo 5: A nitrogen blanket in the mixer prevents curing of adhesive during the manufacturing process.

minous matrix. Other components of the recipe included thixotropic agents, fillers, and solvent blends to keep the gum rubber in suspension until the material was applied. Many applicators dreaded the assignment to install this flashing because of the “strings” that came from the adhesive’s container. With a little wind, the material would float over the application site. Alas, adhesion was tenacious!

### Insulation Attachment

Insulation application is another use that has involved urethane modified bitumens. Early attempts to use cutback-formulated adhesives were marginally successful. Dick Fricklas and C.W. Griffin mention, “Cold-applied adhesives are so unreliable that in 1978 three major manufacturers withdrew their approval of this method for bonded roofs. Hot-mopped steep asphalt, correctly applied with the insulation boards tamped firmly into the hot, fluid bitu-

men, provides excellent adhesion. But getting the insulation boards down into the hot asphalt in the few seconds available before it congeals into a nonbonding solid makes this a highly risky method, especially on steel decks, where the mopping requires extra care to limit its weight and keep it centered on the steel deck flange.”<sup>2</sup> Those of us familiar with pro forma standards realize that hot asphalt is not an acceptable adhesive on steel decks for a number of reasons. Those cited above by Griffin and Fricklas, as well as the added fuel contribution and wind up-lift resistance based on FM Global criteria, have almost eliminated the use of adhesives on steel deck constructions for a number of years.

### New Developments

An improved family of modified bitumen adhesive products has evolved from the solvent-based group to products that meet stringent environmental VOC requirements and field performance criteria. Moisture vapor in the atmosphere catalyzes the chemistry of the material cure in these newer formulations. Compounding these products requires special manufacturing mixers that function in a moisture-free environment. A nitrogen blanket is introduced to purge the mixing vessels of moisture-laden atmospheric air. (See Photo 5.)

FM Global does not specifically approve the use of any adhesive to bond the first layer of insulation directly to a steel deck. However, in many cases, testing (Photos 6 and 7) proves performance equal or superior to that of mechanically attached insulations. Often, there may be below-deck electrical conduit or con-



Photo 6: FM 1-52 Field Pull Test.



Photo 7: Uplift pressure is 202.5 lbs/sq. ft. based on 4 sq. ft. test panel.

struction noise considerations that may influence the specifier to consider a high performance insulation adhesive. FM Global does approve specific cold process modified bitumen adhesives to be employed on concrete decks and as a methodology for second layer insulation applications on all deck types. As with all roofing assemblies, compatibility of components is an issue. The manufacturer's recommendations must be followed for specific approval purposes.

### Cold-Process Roofing

Cold process (BUR) roofing had its beginnings in the mid 1970s with asphalt cutbacks employed as the adhesive between coated base sheets. (See *Photo 8.*) The application was developed for those projects where kettle locations were restricted or the fumes were highly objectionable. The theory and practice were along the proven asphalt built-up roof assembly whereby the bituminous compound (CTP or asphalt) provided the waterproofing integrity, and the roofing felts provided tensile strength to the system.

Roofing asphalt was one of the first "hot melt" adhesives commonly used. At ambient temperatures, asphalt is a hard, waterproof substance. At its melt point, asphalt is a viscous, tenacious adhesive. In the process of cooling, it will bond to almost any construction material if its application temperature (in excess of 425 degrees F. [218 degrees C.]) does not melt the other materials.

Cold process adhesives do not function in this manner. The materials are applied at ambient temperature or slightly heated to facilitate application through spraying. Rarely does the application temperature reach 100 degrees F (38 degrees C.) See *Photo 9.* A cold asphalt cutback is modified



*Photo 8: Typical application rate is 2.5 to 3 gallons of adhesive per square per ply.*

with calcium carbonate, a variety of reinforcing fibers, and other thixotropes. The solvent is typically blended, low-VOC mineral spirits that actually soften the heavy asphalt coating on the felt rolls. As the solvent evaporates from the system, the multiple layers are fused together with the remaining solids within the adhesive.

When a typical roof cut is examined, the core appears to be homogenous. It is difficult to discern the



*Photo 9: Warming the material facilitates spray application and increases production.*

ply lines. Early formulations from all manufacturers contained asbestos fibers for fire resistance and "wetting" qualities. When it was apparent that asbestos was a component with negative health and safety implications, research efforts accelerated to find substitutes for this natural mineral fiber. Unfortunately, there was no global substitute that would replace the physical performance attributes and cost benefits of asbestos. Manufacturers ultimately found a number of other substitutes to deliver the same performance characteristics as the single-ingredient asbestos.



Photo 10: Special refillable 475-gallon containers eliminate disposal of used material containers.

## Evolution to Modified Plies . . .

Interestingly, not all coated base sheets were equal when it came to cold process applications. Some roll manufacturers used “softer” asphalt in their coating process. This required extended cure intervals on the roof when used with cold-process adhesives. These systems were often very fragile to any type of foot or mechanical traffic. Often the roof bled profusely or was not able to sustain even minimal traffic for some weeks. If an acrylic or aluminum coating is specified, most manufacturers recommended a cure of at least 30 days. This would require some additional preparation in the form of washing or priming due to the accumulated surface contaminants. The more common finishing method was to broadcast ceramic granules or specific roofing aggregates into a “flood” coat of adhesive.

Glass felts began to replace the earlier organic-based materials, and another issue developed. Immediately after initial installation, glass felts developed buckles and fishmouths between plies. Apparently, there was a “memory factor” caused by the tension of the roll as manufactured. When the roll was applied into a cold adhesive, the adhesion or “grab” was not immediate, as it would have been with hot bitumen. For those contractors in the West, the solution was simple: “fly” the sheets in. This was a technique used for decades in the application of the popular “cap sheet” roof, whereby the mop man back mopped (applied hot asphalt to the back of the cap sheet), and then two men would “fly” the sheet into place. This was done after the rolls were measured and cut into 18' lengths, stacked, and allowed to “relax.”

Relative to installation techniques and from a performance standpoint, this method worked well. However, unlike other California innovations, the trend did not travel east.

Currently, there are engineered, coated sheets available that combine glass fibers and polyester fabrics that allow for a continuous, rapid installation. Often the coating asphalt on these ply sheets is unblown asphalt or is slightly modified to address compatibility issues with the adhesives.

Cold process adhesives can be delivered in tanker trucks, refillable totes (475-gallon refillable containers [2,160 litres]), or barrels (Photo 10). The material is then pumped to the roof with pneumatic or hydraulic spray delivery systems (Photo 11). For space-restricted projects, materials can be provided in 5-gallon (22.7 litre) pails. The materials can then be brush or squeegee-applied. On production projects, contractors often use propane-powered heat-exchange units to





*Photo 11: Larger containers facilitate shipment and increase job-site production.*

warm the material prior to application so as to improve the spraying characteristics. The theory and practice of cold-applied BUR remains: the adhesive softens the coating on the roll and fuses the plies together as the solvent evaporates from the solids of the adhesive.

### **Final Evolution? Cold Applied MBs**

Modified bitumen membrane roofing has its origins in central Europe in the late 1960s and became available in the U.S. market by import by the mid 1970s. In a cursory literature search, it is easy to find the historical timeline of MB ply rolls and surfacing sheets in the North American market.

European manufacturers began to invest capital in new domestic manufacturing plants based on increased domestic demand and the high cost of container shipping. In a progression of torch-applied products using isotactic polypropylene (IPP), and finally settling on a specifically formulated atactic polypropylene (APP),<sup>3</sup> we saw the introduction of metric measure to the U.S. roofing market. Although we still measured roof area in “squares,” roll goods were 1 meter wide x 10 meters in length. Thickness was 3, 4, or 5 mm.

Traditionally, the rubber-modified membranes used SBS or SEBS block copolymers that are specifically blended with other components within strict time and temperature parameters prior to coating a reinforcing carrier of fiberglass, polyester, or a combination of both fabrics. Surfacing options include colored ceramic granules, embossed metal films, or smooth surfaces to later receive liquid, reflective coatings. These products are typically assembled with Type III or Type IV asphalts. Cold process modified bitumen, as well as hot-applied roof systems, can receive Energy Star®

ratings by approved, field-applied coatings.

There are torch grades of SBS membranes, but they are usually thicker than the hot-applied membranes. The additional thickness is to protect the reinforcing fabric from heat damage during installation. Polyester carriers (or reinforcements) are easily damaged by torch applications and most “Torch Grade” SBS MBs have glass reinforcements. Most torched MBs use the APP modified, which melts at a higher temperature than the rubber modified materials.

As restrictions increase with respect to open flames, kettle odors, and congested roof areas, the popularity of cold-applied systems is growing. Many MB manufacturers offer specially-formulated,

low-VOC, modified bitumen roll adhesives.

Unlike the solvent-actuated mechanism of traditional cold-process adhesives, cold-applied MB systems rely on



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the high-performance, low, or no-solvent adhesive to bond the MB plies to the substrate and themselves. The MB sheet is actually a waterproof membrane, unlike its predecessor, the roofing felt.

## Self Sticks

Self-adhering modified membranes have come and gone on the North American roofing market. Early offerings were slight modifications of waterproofing membranes intended for non-exposed applications. Although protective coatings were recommended as UV barriers on exposed roofing applications, maintenance was an issue. They were sensitive to physical damage, especially in warmer climates. New generations of self-adhering, modified membrane systems are under consideration by some advocates. These satisfy the environmental concerns at the point of installation as well as the use of recycled raw materials. As new code requirements evolve related to wind and fire resistance (as well as odor and other health and safety issues), the industry will respond to testing and evaluating these new options.

## SUMMARY

The latest *NRCA Annual Market Survey* shows that modified bitumen roofing is here to stay. In fact, it appears that MBs have advanced at the expense of other systems. Additionally, this was the first report that delineated cold-process systems as a recognized category. Unlike other “new and improved” product and system offerings, cold-process and modified bitumen systems have evolved over the last 35 years. Although each system has its advantages and disadvantages, the economic movement to “something that works” is quite evident if the trend is studied.

- Modified mastics are used in elastomeric applications such as pitch pocket sealer and at dynamic perimeter joints.
- Hot-melt modified adhesives complement the performance characteristics of the reinforcing fabrics and polymers used in MB ply and surfacing sheets to deliver a truly elastomeric membrane assembly.
- MB adhesive technology has also come a long way, from cutback asphalts that had a poor performance history to the intricate chemistry of radial and block co-polymers and moisture curing mechanisms that are now challenging the concept that mechanical fastening of insulation is the only acceptable practice.
- Cold process BUR has an excellent track record in all North American climates.<sup>4</sup>
- Cold process MB systems are moving into the roofing mainstream as contractors become more comfortable with application techniques. Cost considerations become less of an issue when the application is odorless and performance is exceptional. Application techniques and informational seminars have been demonstrated at previous RCI conventions and regional meetings.

MBs, mod bits, modifieds, and modified bitumen roofing systems are time tested and field proven. A check with one’s favorite manufacturer will provide specific recommendations and system histories.

Future direction of these systems belongs in the category of “green” and “sustainable design.” Products under development and in current evaluation utilize moisture-cure, urethane technology. Recycled components will meet current trends mandated by public funding requirements.

These families of products will be solvent free and offer high performance characteristics. Unlike roofing systems that have entered the industry from other application channels, MBs have evolved and have improved through usage and acceptance. ■

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