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# Blistering in SBS Polymer Modified Bituminous Roofs

*by K.K.Y. Liu, R.M. Paroli and T.L. Smith*

**This Update, based on an IRC study, describes causes of blistering in styrene-butadiene-styrene (SBS) modified bituminous roofs, suggests ways to prevent it and recommends methods to deal with it.**

Roofing membranes for low-slope application are generally asphalt- or polymer-based.[1] Bitumen has been used as a roof waterproofing agent for many years. To make bitumen tougher and more elastic, a synthetic polymer is usually added. The resulting mixture is called modified bitumen. Modified bituminous sheets are made by combining the modified bitumen with reinforcements such as glass and polyester fibres.

Two types of modifiers are commonly used: atactic polypropylene (APP) and styrene-butadiene-styrene (SBS). SBS is a rubber-type modifier that gives bitumen the ability to stretch and resist damage, and improves its cold-temperature flexibility.

In asphalt-based roofs, blisters occur frequently. Blisters are pockets of entrapped air and/or moisture in roof membranes. They can occur between the cap and the base sheets and/or between the base sheet and the substrate (Figure 1). Blisters range from barely detectable spongy spots to bloated humps several square metres in area. Not only are blisters unsightly, but they can also shorten the service life of a roof, by increasing the membrane's vulnerability to physical and chemical degradation. Their sloping sides can also change the direction of water flow on a roof and cause ponding.

Blisters are the most common problem with built-up roofs (BUR)[2], and they may occur even more frequently in modified bituminous roofs. Field research indicates that blistering is more common with SBS- than APP-modified membranes.[3]

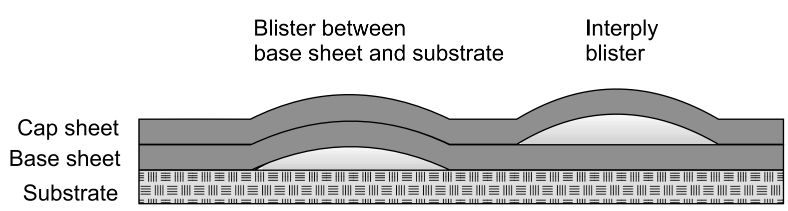


*Figure 1. Blistering locations in modified bituminous membranes*

The National Roofing Contractors Association (NRCA) and the Institute for Research in Construction (IRC) collaborated on a study of blistering in hot-applied SBS-modified bituminous roofs.[4] Samples were taken from roofs in various areas of the United States. Gas contents of the blisters were collected in canisters, and the gas composition was determined by chemical analytical techniques at IRC. Membrane samples were removed from several roofs containing blisters and their mechanical behaviour was characterized by tensile tests. Physical properties (such as softening point and contact compatibility) of the mopping asphalts between the cap and the base sheets were also studied.

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### *Causes of Blistering*

Blisters form in a hot-applied modified bituminous membrane for the same reason as in a BUR: voids built into the roof. Voids can result from skips in bitumen mopping, entrapped debris, uneven substrates, unrelaxed membranes, or entrapped gases resulting from moisture in the materials. During the heat of the day, air and moisture trapped in the void expand. The pressure developed in the void stretches the warm flexible membranes and displaces them to form a blister. During the night, the membranes cool, become stiff, and resist returning to their original shape. This process creates a partial vacuum within the blister, and more air is drawn into the blister through micro-cracks in the membranes. The blister is now slightly bigger and ready to start another cycle the next day. As in BUR, the blisters grow when the volume of air drawn into them during the night is higher than that forced out of them during the day, and when the increased pressure overcomes the strength of the peripheral bond of the blister. The presence of water vapour accelerates blister growth according to this same cyclic pumping action.[6-8]

### *Content of Blisters*

The gas within the blisters in the SBS-modified bituminous membranes was composed of air, water vapour, and a negligible amount of volatile organic compounds (VOCs).[4] The relative humidity (RH) within the blister ranged from 50% to 75%. These values are similar to those of blister gas sampled from BUR.[5] Because the volume expansion of water from liquid to vapour state is very large (~1250 times), a minute amount of water in a small void can produce sufficient vapour pressure to force the void to grow into a blister. The presence of water is especially serious at high temperatures when the bitumen becomes soft and the pressure in the blister is high.

### *Blisters and Membrane Strength*

Mechanical testing on both the cap and base sheets from intact (watertight) blisters showed that the membrane strength was not affected by the blister.[4] The existence of an intact blister may not reduce the membrane strength, but the presence of a ruptured blister in one sample reduced the strength of the cap sheet by more than 50%.[4] Since the ruptured blister contained a large quantity of water between the plies, the trapped water might have migrated into the cap sheet through the ruptured area and weakened the interfacial bond of the reinforcement and the bitumen. The base sheet of the same sample remained intact and its strength was not affected by the presence of water.

Blisters have been observed in membranes with different strengths and different reinforcements. Membrane strength does not appear to be a major factor in blister formation.

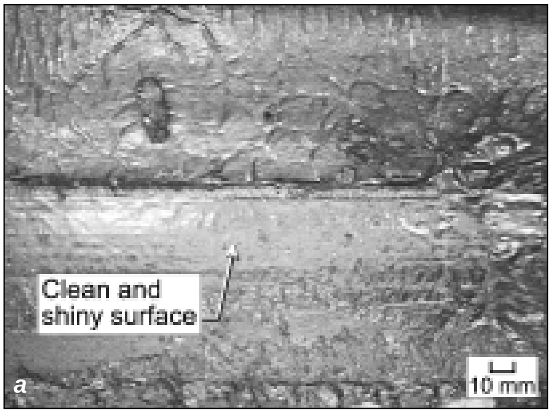
### *Effect of Properties of Mopping Asphalts*

A blister grows by overcoming its peripheral bond. Therefore, good bonding between the sheets is necessary to resist blister growth. The mopping asphalt and the membranes must also be chemically compatible for good interply bonding. Contact compatibility between the mopping asphalt and the modified bituminous sheet can be checked using a standard laboratory test.[9] Incompatibility can often be detected in the field when an oily film forms on the contact surface between the mopping asphalt and the modified bituminous sheet.[10] Although contact incompatibility does not cause blisters, it can reduce interply bond strength, facilitating blister growth. Poor asphalt quality may also lead to a weak interface, promoting growth of interply blisters.

Mopping asphalt type does not affect blistering if the asphalt is applied at the correct temperature. However, asphalts with a high softening point (e.g., ASTM type III and IV) tend to “flash cool” more rapidly on application.[10] If the application temperature is not high enough, mopping skips and void formation may occur. Therefore, the worker should exercise extra caution when mopping with asphalts that have a high softening point.

### *Effect of Good Workmanship*

Good interply bonding is important to resist blister growth. During hot application, the asphalt should flow readily to “wet” the surface of the sheet and remain hot enough until the cap sheet is put on. Otherwise, the bonding between the sheets will be poor, and blister growth will be encouraged. Figure 2a shows the underside of the cap sheet of a blister. It is shiny and clean, with almost no asphalt adhered to it. Since the interfacial bonding between the asphalt



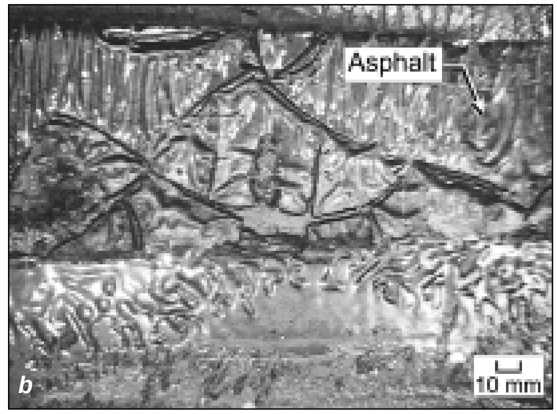




*Figure 2. Poor interply bonding due to low application temperature (a) Cap sheet, (b) Base sheet*

and the base sheet appeared to be good (Figure 2b), the temperature of the mopping asphalt was initially high enough. It is suspected that the asphalt cooled rapidly during the mopping process, so that the temperature fell below the equiviscous temperature (EVT) range of the asphalt before the cap sheet was put on. To minimize temperature drop, the cap sheet should be applied as soon as the asphalt is mopped.

The mopping asphalt should be applied uniformly. In Figure 3, the discontinuities seen in the asphalt were likely the result of mopping skips caused by the lack of uniformity in the mopping process. The mopping asphalt in this sample was found to contain foreign bodies (sand, fillers, aggregates or other contaminants). These foreign bodies may make the asphalt more difficult to handle and harder to mop uniformly. As a result, skips occur in the mopping, and become voids. It is important to remember that mopping asphalt is primarily an adhesive between the modified bituminous sheets, and adhesives work best applied in thin layers.

Uncoated spots are also potential origins of blisters. The “star-like” uncoated patterns in Figure 4 were likely the origins of the two adjoining blisters. The centre of the pattern was bare, with almost no asphalt adhering to it. The “legs” (or stalactites and stalagmites) bridged the cap and the base sheets inside the periphery of the blister. These “legs” were likely formed by the yielding and stretching of the mopping asphalt at the periphery of the void, during the expansion of the blister at high temperature. One possible cause was the presence of liquid parting agent at the interface of the cap and base sheets. Liquid parting agent was sometimes applied in the past to the ply and base sheets to prevent sticking in the roll, but is rarely used now. Another possible cause was that the membrane was not flat when it was rolled out during mopping. The cap sheet bonded well to the base sheet at the flat areas but voids were left between the sheets at the raised, uneven areas. These voids may not be noticeable during installation but they grow with time.

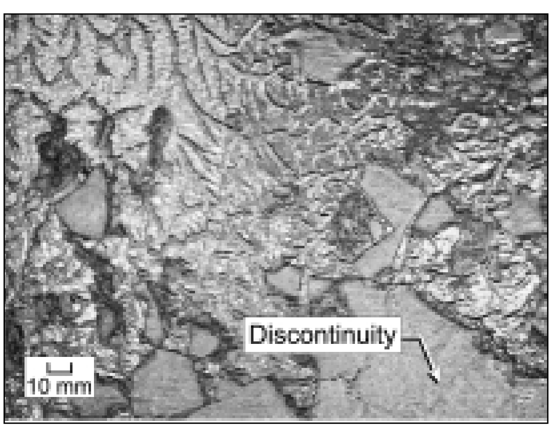



*Figure 3. Discontinuity in mopping asphalt due to non-uniform mopping process*

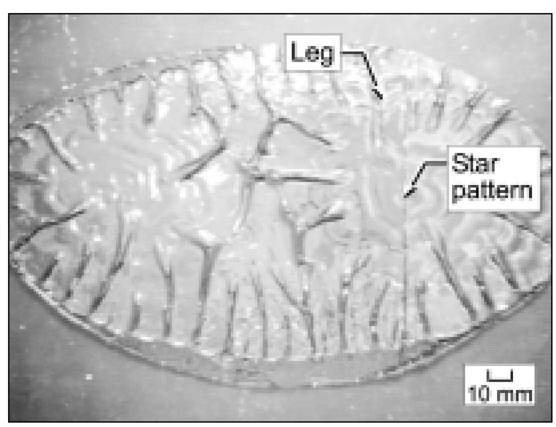



*Figure 4. Uncoated spots are potential origins of blisters.*

## How to Reduce Blisters

The following recommendations suggest ways to reduce blistering in SBS-modified bituminous roofs:

**To minimize formation of voids:**

- Allow rolls to relax before installation;
- Remove excess parting agent, for example, sweep off excess sand from sheets before application;
- Prevent mopping skips by applying asphalt at EVT range (or higher if recommended by the manufacturer);
- Take special care at laps.

**To minimize entrapment of moisture:**

- Keep all materials dry during storage and installation;
- Minimize delay during installation.

**To ensure good bond between plies:**

- Apply asphalt at EVT range (or higher if recommended by the manufacturer);
- Minimize mopping weight (asphalt is an adhesive so more is not better);
- Ensure contact compatibility between the mopping asphalt and membrane;
- Take precautions in cold weather to maintain EVT range during application.

## How to Deal with Blisters

A few blisters do not generally lead to problems, as long as the blisters remain intact (watertight) and do not become too large. If a blister is ruptured, water can attack the reinforcement/bitumen interface and degrade the membrane strength. It is, therefore, important not to break blisters. People should avoid stepping on them, particularly when the membrane is cold. If rupture occurs or the blister becomes too large (~1.5 m), repair is recommended.

Blisters can sometimes pull the seam apart. If one third or more of the seam width has been separated (i.e., a shear pull), repair is recommended.[11]


## Summary

Blisters in SBS polymer-modified bituminous roofs originate from voids and grow from the expansion of entrapped moisture. To reduce the likelihood of blistering, it is necessary to exercise great care during installation to minimize voids and moisture, and to ensure good bonding between the plies.


## References


1. Paroli, R.M., Liu, K.K.Y., and Simmons, T.R. *Thermoplastic polyolefin roofing membranes*. Construction Technology Update No. 30, Institute for Research in Construction, National Research Council of Canada, Dec. 1999.
2. Cullen, W.C. *Project Pinpoint analysis: ten year performance experience of commercial roofing 1983-1992*. National Roofing Contractors Association, 1992.
3. Smith, T.L. Understanding and coping with blisters. *Professional Roofing*, Sept. 1995, p. 62.
4. *Investigating the cause of blistering in SBS polymer modified-bitumen roofing membranes*. Research Report, National Roofing Contractors Association, 1998.
5. Rossiter, W.J. and Mathey, R.G. Risk of blistering of built-up roofing membranes applied to polyurethane foam insulation. *Thermal Insulation: Materials and Systems*, ASTM STP 922, ASTM, Philadelphia, 1987, pp. 431–448.
6. *Blistering in built-up roofs*. Technical Bulletin Vol. 46, Canadian Roofing Contractors Association, July 1996.
7. Korhonen, C. *Blistering of built-up roof membranes*. Special Report 86-29, US Army Corps of Engineers, Cold Regions Research and Engineering Laboratory, Oct. 1986.
8. Paroli, R.M. and Booth, R.J. *Ways to reduce blistering in built-up roofs*. Construction Technology Update No. 4, Institute for Research in Construction, National Research Council of Canada, 1997.
9. Standard test method for contact compatibility between asphaltic materials (oliensis test), ASTM D 1370-84. *Annual Book of ASTM Standards*, Vol. 04. 04, 1996.
10. Baxter, D. A tale of blister. *Contractors Guide*, July 1998, pp. 24–31.
11. *ARMA/NRCA/SPRI Repair manual for low-slope roof systems*, 1997.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