



Blistering and Off-Gassing of Urethane Foam Insulations

In a previous Technical Bulletin (Volume 46 in July 1996), CRCA addressed the phenomenon of blistering vs. built-up roofs. Although the reported incidences of blistering in hot applied roofing has decreased significantly since the introduction and widespread use of fiberglass ply sheets and porous cover boards, it is still reported to be a problem in some roofing applications. There have been reports of blistering occurring in roofs consisting of modified bitumen membranes over polyurethane foam. In attempts to explain the cause of this blistering, it has been suggested that off-gassing of the captive blowing agents is contributing to the observed blister formation and blister growth. It should be noted that although polyisocyanurate insulation has largely replaced polyurethane a rigid roof insulation material, the are similar in their chemical composition and both rely on captive blowing agent for their relatively high thermal resistivity .

This bulletin reviews the scientific research conducted on the subject, and offers some insights as to whether off-gassing is a likely contributing factor.

Membrane blistering over urethane board insulation was identified as a concern soon after the insulation was introduced into the market in the early 1970's. Efforts to find the cause were carried out by numerous organizations, including the Western States Roofing Contractors Association (WSRCA) and the Thermal Insulation Manufacturers Association (TIMA). This effort culminated in a testing program sponsored by the National Roofing Contractors Association (NRCA), and the MidWest Roofing Contractors Association (MRCA) and conducted by the Southwest Research Institute (SwRI). The testing was designed to provide data on the effects of applying hot asphalt to urethane and urethane composite board insulation and determine what gases, if any were released during the application of hot applied built up roofing membrane. Foaming of the asphalt, a precursor to blister formation, had been widely observed when it was applied directly to the foam insulation. A report submitted by SwRI in early 1980 addressed the first key issue concerning blistering over polyurethane insulation — to define what gases were the source of the observed foaming and subsequent blistering.¹

The authors of the research addressed two aspects of the problem. The first was to define the source of the gas which was observed as foaming or bubbling of the asphalt leading to blister growth and the second was to define the “transient temperature distribution of the asphalt and surface layers of the insulation.” The latter impacts the rate of diffusion of the unknown gas into the asphalt, or insulation, the viscosity of the asphalt, and the composition and pressure within the gas bubbles that formed.

A special apparatus was built to detect and measure the gases liberated when hot asphalt was applied to the surface of various insulation materials. Gas chromatography revealed that the only major gases evident were hydrocarbons from the asphalt and water vapour. Although Freon-11, the captive blowing agent in use at the time, was detected, it was not present in amounts sufficient to be identified as the gas causing the blisters to form. These results were in agreement

with earlier research that had been carried out by two leading foam insulation manufacturers — Owens Corning Fiberglass and the Celotex.^{2,3}

Based on this information obtained from this testing, and additional information provided by Dr. L. Parker of Shelter Insulation, Inc., Dr. Ulric Lindholm, Director of Materials Science at SwRI, proposed a specific model to explain the mechanism of bubble and subsequent blister formation. In summary, Dr. Lindholm, asserted that “all insulations or substrate materials under normal conditions have surface or near-surface moisture available which can be converted to vapour on contact with hot bitumen.”⁴ He added that because urethane was such a good insulation, and because of its low water permeability, any water vapour that was generated at the interface of the insulation surface and mopping asphalt would be driven by diffusion into the asphalt rather than the substrate, or insulation. This water vapour would either escape through the asphalt into the atmosphere or be trapped in the asphalt layer as it cools. Since the temperature gradient in the insulation board is decreasing from the hot surface, diffusion of gases, such as Freon, from the interior of the insulation toward the hotter asphalt is highly unlikely because the time available is not sufficient and the diffusion would have to occur against a strong temperature and pressure gradient. He concluded that the source of gas to form bubbles must originate at the surface of the insulation.

The same conclusion was drawn by other industry experts who reviewed the finding of the SwRI report. Dr. J. Thomas, of the University of California reviewed the fundamentals of blister formation and growth, relating laboratory and field research on urethane to these basic concepts.⁵ His data also pointed to water vapour as the prime component of the gases trapped in blisters, noting that escaping gas from the insulation and hydrocarbons from the asphalt itself constitute a minor percentage of the gases in a blister.

A later and extensive research study on the phenomenon of blistering over polyurethane foam insulations was conducted by researchers at U.S. National Institute of Standards and technology (N.I.S.T.).⁶ The two phase study was designed to investigate the causes of bubbling and frothing of hot asphalt when applied to polyurethane foam boards. In the field phase of the study, gases in the blisters were analyzed to determine their composition and to ascertain whether the release of captive gases, air, or other gases from within the cells of the foam contributed to the formation of the observed bubbles, and whether the application of hot asphalt resulted in the release of gaseous decomposition products that contributed to the formation of blisters. Asphalt was applied to several different foam products with differing facer types. Hot asphalt was applied to faced boards and boards with their facers removed. Asphalt was also applied to facers in an “as received” condition, facers that had been “oven dried,” boards that were in an “as received” condition and also boards that were “oven dried.”

The results of this study were mixed. Data indicated that the observed bubbling might be due to the release of moisture from the surface of the foam insulation, the release of moisture from the facing of the foam, and/or the release of air, fluorocarbon and other gases from within the cells of the foam. The latter was based on observed frothing on specific board samples that had been oven dried. However, definitive evidence on the release of air, fluorocarbon and other gases was not obtained within the study.

As part of this large study, gas samples from roof blisters in existing membranes applied to

polyurethane were analyzed to determine their composition. It was found that the major constituents of the blisters were nitrogen and oxygen, with small amounts of chlorofluorocarbon. Because the gases in these blisters were analyzed a year or more after the roof had been built, it could not be determined whether the fluorocarbon extend the blisters during construction, due to off gassing, or due to aging (by diffusion) at a later time.

Destructive decomposition of the foam resulting from contact with hot asphalt was deemed to be an improbable cause of the blistering as the measured contact temperature of the asphalt to the foam was lower than that at which decomposition is expected to occur. However, in the report, the authors did theorize that if the walls of the foam cells were sufficiently weak, the expansion of the gases resulting from heating by the asphalt may be sufficient to break the walls and allow the gas to escape. Although, the study did not test this hypothesis, it is generally accepted that the quality of the formulation of the foam and the manufacturing process influence the geometry and strength of the cells. Poorly manufactured foam can result in the collapse of cells and the release of the foam's captive blowing agent during installation or in service, or their rapid diffusion out of the foam.

In the spring of 1998, the National Roofing Contractors Association and the National Research Council of Canada's Institute for Research in Construction released a report on their investigation of the cause of blistering in modified bitumen (MB) roofing systems. As part of this investigation, the gas within blisters found on several existing MB roofs were sampled and analysed to determine its composition. The investigation revealed that the gas consisted of principally of air and water vapour. Although trace elements of volatile organic compounds were detected, the researchers concluded that the composition was not appreciably different from that of ambient air, and that the amount was too small to have caused the observed blistering.⁷

A review of the research to date indicates that water vapour near or at the surface of the foam insulation is the most likely cause of the bubbling, and subsequent blister formation. The source of this moisture may vary. It may be in the ambient air, in the facer of the foam, or in the foam insulation itself (urethane foam is manufactured by a chemical process that involves a water-isocyanurate reaction). As Dr. Lindholm stated, "all insulation or substrates under normal conditions have surface or near surface moisture available which can be converted to vapour." To prevent the occurrence of a vapour trap between a vapour impermeable insulation (closed cell foam) and the impermeable roof membrane, a means of venting the gas (air and water vapour) out should be provided. This can be achieved by the installation of a venting layer. This venting layer may be a porous and vapour permeable cover board, as is recommended by CRCA, and other recognized roofing industry organizations, or in some instances may be provided by the properly designed or engineered foam facer.^{8,9}

References:

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