

From the field: A professional's observations

Following are comments based on evaluations of various roof systems

by **Rene M. Dupuis, Ph.D., PE**

There are many observations to be made on a roof, especially if the roof system is somewhere between 5 and 15 years old. Too often, roofing professionals deal with roof systems that are new, or are at the end of their service lives and are in need of replacement.

Roof systems in their mid-lives can tell us a great deal about their character if we would only take the time to stop and observe how they are doing. This includes effects of time, temperature, wind, water, ultraviolet (UV) radiation exposure, air pollution, structural movement, rooftop traffic, interior building use, drainage, attachment, chemical contamination, mechanical damage, substrate condition and, finally, maintenance. Another variable (that falls under the heading of substrate condition) is whether the roof system being observed is a re-cover system.

Many of the above items were observed and noted in the Joint NRCA/Midwest Roofing Contractors Association (MRCA) Field Survey done on 109 modified bitumen roofs (see "NRCA/MRCA study the performance of modified bitumen roof systems," May issue, page 22). The report will be available shortly, and it documents how APP- and SBS-modified bitumen roof systems are doing

in the middle of their service lives.

This article presents the author's thoughts and comments on a number of different roof systems, viewed in a manner similar to the modified bitumen roof system survey.

Built-up roofs

The current inventory of built-up roofs (BURs) mainly consists of fiberglass, organic, asbestos and non-woven polyester felts. A vast majority of BUR membranes are asphaltic; however, coal tar membranes are the system of choice by many designers and contractors.

The use of modified bitumen sheets for flashing material on BURs has proven to be a good idea. Most BURs suffered from flashing problems in the past. Current field observations point toward improved service lives for BURs using modified bitumen flashing sheets.

The most frequent field problem observed with modified bitumen flashings is not with the performance of the modified bitumen material itself, but rather the manner in which it was installed and/or fastened. The time has come to standardize modified bitumen flashings generically, because they are widely available and heavily used. More attention needs to be paid to the finished detailing on curb flashings.

Some manufacturers rely too heavily on the use of plastic cement to finish detailing work.

Inadequate attachment is the most frequently cited condition for flashing on parapet walls. Too many times, the roofing contractor has attempted to use modified bitumen sheet membrane to cover up an existing wall problem, especially on parapets in excess of 2 feet (600 mm) in height. Some of the loss of attachment is due to the fact that a modified bitumen membrane has been installed over the interior face of a parapet wall that had never previously been sealed off. Moisture coming through the exterior face of the wall may be trapped, causing problems within the parapet wall itself. This is especially true in the northern parts of the United States, where freeze/thaw cycles can cause progressive damage to the mortar holding the masonry units together.

Drainage on many BURs has improved significantly in the past 10 years. The combined effect of building code changes and the design philosophy to drain a roof have become a reality on many roofs today. Although there are many dead-level roofs in existence, field observations indicate that they are diminishing in number.

The use of fiberglass felts has

greatly diminished the blistering problems the industry had experienced previously. Blistering is still found to occur over isolated instances of perlite board, as was previously reported in *Professional Roofing* (see "What's going on with perlite board in the field and lab?" February 1993, page 30).

We are also seeing a number of BUR systems that have been in service from 14 to 18 years suffer from low-profile blistering. These roofs were installed directly over polyurethane foam, which was a highly debated practice in the roofing industry from the mid-1970s through the early 1980s. In many instances, there is nothing that can be done with the numerous low-profile blisters that exist in the field of the roof. An owner can do nothing but visually inspect the roof, keep rooftop traffic to a minimum and repair ruptured or excessively large blisters.

Coal tar roofs of this era were also seen to suffer from the same blistering behavior. Again, nothing can be done if blisters are prevalent throughout the field of the roof, except for keeping an eye on the membrane for the blisters collapsing or opening up, and keeping rooftop traffic out of the blistered areas. While walking over a BUR that was installed in the late 1970s or early 1980s that had previously been in excellent condition, don't be surprised to find that there are a number of low-profile blisters now appearing.

The use of mechanical fasteners to attach BURs has significantly diminished uplift damage during high winds. It appears that the BUR segment of the industry has benefited greatly in this respect.

Splitting of BURs is another problem that the industry experienced through the very early 1980s. Again, the use of fiberglass felts has caused the splitting of BURs to be rare. Splitting of BUR membranes was, at one time, a reason for switching to other membrane systems, such as single ply, metal or sprayed-in-place polyurethane foam. Given the performance of mid-life fiberglass reinforced or polyester-reinforced mem-

brane systems, splitting has all but vanished as a performance concern.

The preliminary performance criteria issued by the National Bureau of Standards in 1974 (Building Science Series No. 55) called for a roof membrane to have a 200-pounds-per-inch (22.6-newton-meter) strength at 0 F (-18 C). The industry has followed this criteria for 20 years, and it appears that the issuance of this document in 1974 has lead the way to improve the performance of BURs.

However, the roofing industry has always had the capability to provide a surprise or unexpected mode of failure. Splitting failures have been observed in fiberglass systems, and, in rare instances, at 45 degree angles. This has also occurred with coal tar roofs, using mechanically fastened insulation as a substrate. There are still some things that we do not know about BUR systems today.

Coal tar BURs still use tarred, organic felts and perform well. The use of fiberglass reinforcement is also widely used. The recent addition of a coal tar modified bitumen sheet now gives contractors and designers a spectrum of design.

Modified bitumen

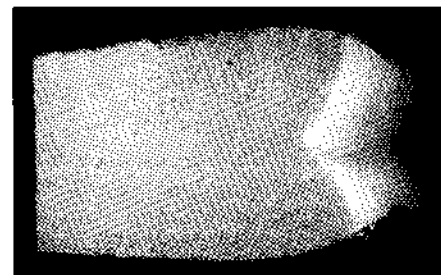
An article was recently published in *Professional Roofing* magazine that describes a report written by the NRCA/MRCA Modified Bitumen Task Force (see "NRCA, MRCA study the performance of modified bitumen roof systems," May issue, page 22). The story includes background information on the research project and provides a synopsis of the conclusions and recommendations concerning field performance, design, materials, application, maintenance and repair.

EPDM membranes

The performance of EPDM as a roof membrane material is now well-established. The majority of EPDM roofs observed was not having membrane problems, but were, if anything, experiencing other types of roof system problems. For example, older, ballasted EPDM roofs were

seen to suffer from wind scour in the corner areas, and experience a cracking and splitting of flashing materials.

Because the earlier EPDM roofs used uncured neoprene as a flashing material, many flashing failures have been experienced with these roofs. The industry switched to uncured EPDM flashing in the mid-1980s, which, to date, appears to be working quite well. The older EPDM roofs, which used uncured neoprene flashing, seemed to have gone through a rash of flashing failures at about the

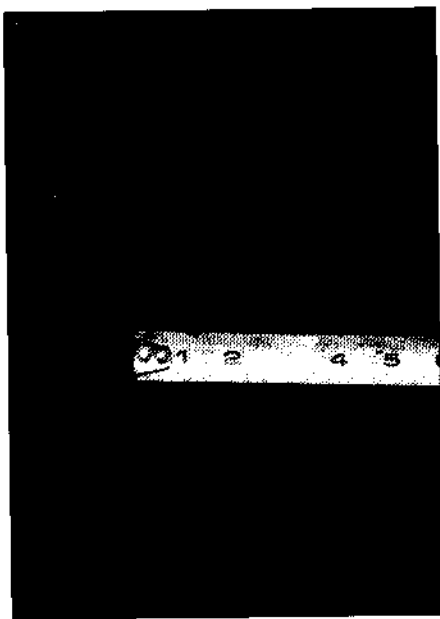


Edge view of 3-inch-thick (76-mm-thick) polyisocyanurate foam insulation board showing cavitation. The sample was taken from a roof less than 6 months old.

5- to 7-year range of service life.

However, we still see some of the older systems with the original uncured neoprene in place, but slowly failing. There is a possibility that many of these roofs are now beyond their original 10-year warranty, and an owner may benefit from repair work to these flashings, especially if the rest of the roof is performing.

One critical ingredient of any EPDM system is the lap (seam) adhesive. The industry switched from neoprene adhesive to butyl adhesive in 1985-86. While neoprene adhesives were not noted for their high peel strength, they were easier to use than the butyl adhesives. The butyl adhesives offer more strength and have better resistance to moisture breakdown than neoprene, but they still need to be applied with more diligence than neoprene. Butyl adhesives need to be properly stirred in the pail and applied thick enough, and a window of time is required to allow for flashing-off of the solvent and a tackiness to develop.



Shrinkage of polyester reinforcing in 2-year-old SBS-modified sheet. Contraction occurred shortly after installation during summer heat.

Neoprene adhesives went down quite quickly and were not so dependent on the amount of "open time" that was required prior to splicing the sheets together. However, the neoprene adhesives are subject to moisture degradation. This does not mean that neoprene was an inappropriate adhesive; it was the only adhesive used at that time.

Older EPDM roofs that used neoprene adhesives may have some laps that are today in a tenuous condition. It is quite easy to pick apart an old neoprene splice in an aged EPDM roof, if it has been subject to ponded water and the lap sealant has weathered away. Roofing professionals may want to re-cover this area or try to overlay the laps.

Ballast can break down

Many times, the ballast on an EPDM roof begins to split apart with many sharp-edged fractures developing in the stone aggregate. Of course, the stone originally met the specification for being well-rounded, washed, river gravel of a nominal $\frac{3}{4}$ -inch (19-mm) to $1\frac{1}{4}$ -inch (38-mm) diameter. The newly installed ballast looked very

clean and harmless. After years of lying on a roof, being exposed to high temperatures, moisture and freeze/thaw cycles, one begins to see a lot of gravel ballast break up and become a puncture tool.

It is not unusual to be faced with the dilemma that the new ballast currently available is worse than the original well-rounded gravel ballast that was installed some time ago, even with the older ballast suffering from fracturing and containing many sharp stones. If an old, ballasted EPDM roof has performed quite well, the best thing to do is to stay off of it as much as possible. When traversing the roof (e.g., to conduct a semi-annual inspection), vary the path taken. If periodic maintenance is needed, consider installing walkways.

Mechanically fastened

There are many varieties of mechanically fastened single plies currently in the industry's roof inventory. There are EPDM membranes, both reinforced and non-reinforced, CSPE, CPE, as well as a variety of reinforced thermoplastic membranes using PVC or combinations thereof. Within the thermoplastic membranes, there are mechanically fastened systems, which are unreinforced, as well as heavily reinforced membranes sometimes referred to as coated fabrics.

The weathering behavior of the EPDM sheet has generally been quite good. The problems that they have experienced are primarily due to seam failures and fastener problems that are more likely initiated by wind. Of course, there are many adaptations of installing an unreinforced membrane using various mechanical fixation devices. Some of these devices have survived the test of time; others were slowly withdrawn from the market or are no longer actively promoted by the manufacturer.

The mechanically fastened reinforced EPDM membrane can be installed fairly quickly, but has, in some instances, presented lap problems to the installer. The adhered

lap is the weak link, especially soon after installation. The wind force immediately loads the lap through the reinforcement in the sheet. Older, bar-fastened EPDM systems normally require maintenance in the corner areas and any areas of the roof that experience a lot of wind.

The reinforced, heat-weldable single-ply membranes generally do not have lap problems, but have suffered from repeated wind action, tearing loose from the plate and fastener at the edge of the sheet adjacent to the lap. Some of the mechanically fastened, heat-weldable systems have not withstood the combined effects of UV radiation exposure and ponded water. Various formulation changes have been made over the years; whether improvements have been made or not, only time will tell.

The thinner, heat-weldable, mechanically fastened systems (below 40 mils [1 mm] in thickness) have generally done better resisting wind forces. This is probably because of the presence of the heavy reinforcement. Surprisingly, some of the earlier PVC systems using a heavy reinforcement have not only withstood wind forces, but, in fact, are weathering quite well, especially when compared to the thicker (more than 40 mils [1 mm] in thickness) unreinforced PVC membranes.

Shrinkage

As mentioned previously, EPDM has proven itself to be quite capable of withstanding the weathering forces on a roof, and that ordinarily, any problems encountered with an EPDM roof are more than likely system related (e.g., fasteners, laps).

By comparison, no other membrane has ever come into such wide use without experiencing weathering problems as a material; it almost seemed as if EPDM itself was immune from any material problem. However, a number of EPDM roofs are now experiencing shrinkage problems. The shrinkage problem is sometimes referred to as tenting or contraction by manufacturers. If the problem exists, it can readily be seen

at points of perimeter flashing or parapet wall attachment. The occurrence is not uniform and may be related to a number of sheets, showing a lifting or tenting away from the point of attachment. Essentially, the membrane is tightening up, thus causing a pulling away action.

The age of EPDM roofs experiencing shrinkage problems ranges from 5 to 12 years. A number of these roofs are already out of warranty; owners are somewhat at a loss as to what is happening and how the repairs should be made.

There are a number of factors that may contribute to the shrinkage, ranging from manufacturing to relaxation time allowed on the roof before installation. If the tenting or bridging along the roof edge is more than 3 feet (1 m) long and the membrane has pulled away more than 2 inches (50 mm) from the wall, repairs should be made. The shrinkage forces may not be significant; the debate continues on whether the shrinkage or contraction ever stops or whether it diminishes with time.

Some of the tenting problems may in fact be due to poor attachment at the wall. If poor attachment exists, then the first order of business is to establish a good anchorment.

Insulation problems

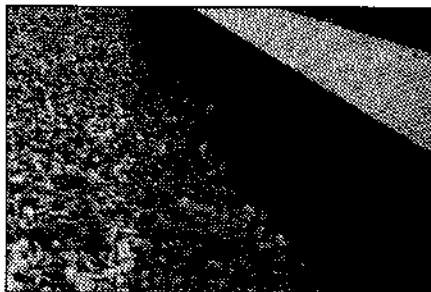
Recently, there have been a few field problems reported with newly installed polyisocyanurate insulation. The insulation boards are showing a collapsing or cavitation-type behavior at the edge of the board; there may also be related shrinkage.

When a single-ply membrane is installed, the contractor begins to notice that the single-ply membrane in the area of the insulation board joints seems to be collapsing or trapping water if it has recently rained. This behavior has been noted on a few jobs throughout the United States; the age of the problem jobs reported ranges from 3 days to 3 months.

There are several theories as to why this is happening, and some of it may be related to the change in blowing agents that has taken place in manu-

facturing. This was done as part of an international effort to replace CFC blowing agents with HCFC blowing agents or coblown CFC/CO₂ agents that will not damage the ozone layer. There has been a great deal of research done by NRCA, the Polyisocyanurate Insulation Manufacturers Association and other sponsoring organizations at Oak Ridge National Laboratories, Oak Ridge, Tenn., regarding the behavior of polyisocyanurate insulation using the new blowing agents.

If you are installing new insulation board and it appears that the machine edge of the insulation board has collapsed slightly or looks less than square, it is probably best to take a closer look at the material. Keep the inventory stored as close to warehouse conditions as possible, and retain several boards in the warehouse for future reference in the event a dimensional stability problem occurs.



View of 9-year-old ballast 45 mil (1 mm) EPDM, showing 8 inches (203 mm) of tenting because of shrinkage.

Throw away details

Reroofing older buildings is always an experience. One does not anticipate new buildings to be designed with a throw away detail. It seems that the advent of single ply has caused many building designers to come up with cost-saving ideas for the new construction project that really challenges the next person who has to design and install a new roof.

A good example of a throw away detail is to build a parapet wall with a piece of gypsum board and light-gauge steel studs, and then glue a single ply of flashing material to this. Once the gypsum board has become

wet or mechanically damaged (e.g., being kicked in along the edge of the roof), the building owner is faced with a fairly expensive effort to rebuild the parapet wall and flashing system.

Another example of a throw away detail is to allow for a large gap to exist between the steel deck and parapet wall with the general contractor simply installing a ½-inch (13-mm) plywood nailer to bridge the gap. A ballasted single ply may survive this type of detail, which is hidden below the insulation board.

However, when it is time to reroof the facility and the owner wishes to go to a fully adhered system of another type, the roofing contractor has no choice but to tear up the ½-inch (13-mm) plywood plate, and rebuild the edge detail the way it should have been. It is apparent that the building boom of the late 1970s and early 1980s, in conjunction with the existing single-ply details of that era, now lead to some expensive retrofit detailing.

Some plant owners with ballasted roofs now find the need to hang additional loads for the manufacturing line from the supporting steel roof structure. One way to achieve two goals is to reroof an older ballasted roof, which weighs 10 to 12 pounds per square foot (psf) (50 to 60 kg/m²), and convert back to a lightweight, fully adhered system with a nominal 2 psf (10 kg/m²) roof load. The owner gets back 8 to 10 psf (40 to 50 kg/m²) of dead-load capacity for the building, and a new roof at the same time.

However, these large steel structures normally do not have an expansion joint and have poor deck-to-wall details to begin with. Many of the larger steel roof structures were built without structural expansion joints over a 400- to 500-foot (120- to 150-m) run. These buildings were basically designed to operate with a loose-laid roof membrane.

Converting them to accept other roof system details is a challenge. **PR**

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