SPECIAL REPORT 95-19

CRREL

Roof Blisters

Cause and Cure

Charles Korhonen and Brian Charest

July 1995

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Abstract

Blisters are a major problem of built-up roof membranes. They are caused by voids built into the roof during construction. They develop into the characteristic dome-shaped humps by a breathing action driven by thermal cycling. A small pressure relief vent was patented by CRREL as a cost-effective way to repair blisters. Though these vents cannot prevent blisters from forming, they can lengthen a roof's service life by repairing the blisters before they break. Two demonstration projects were conducted to transfer the blister vent technology to the military community. Most participants in the demonstration projects found the vent easy to use and that it performed as designed. The main objection to the vent was its price.

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US Army Corps
of Engineers
Cold Regions Research &
Engineering Laboratory

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July 1995

Prepared for
OFFICE OF THE CHIEF OF ENGINEERS

PREFACE

This report was prepared by Charles Korhonen and Brian Charest, Research Civil Engineers, Civil and Geotechnical Engineering Research Division, Research and Engineering Directorate, U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), Hanover, New Hampshire.

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This report was technically reviewed by Alan Greatorex of CRREL. The authors wish to thank all the personnel from the various DoD test sites that were involved with this study and who provided the excellent feedback that was received.

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Roof Blisters
Cause and Cure

CHARLES KORHONEN AND BRIAN CHAREST

INTRODUCTION

Since 1974, when the National Roofing Contractors Association began surveying its members to identify recurring roofing problems, blistering has been the most commonly reported problem on bituminous built-up membrane roofs. In 1993, bituminous built-up roof systems accounted for nearly 31% of the $12.4 billion commercial roofing market. Of this market $9.6 billion, or 77.5%, was attributable to roof failures (LaValley 1994). Since blistering is a large problem, accounting for 24% of all deficiencies reported for bituminous roofs (Cullen 1993), it is safe to assume that blistering is a large cause of roof failures and associated reroofing expenses each year.

Blisters are spongy, dome-shaped areas caused by gases expanding beneath or within roof membrane plies. Their effect is to shorten membrane life by dramatically increasing its vulnerability to physical damage and to weathering. The sloped sides of a blister will cause aggregate surfacing to roll down hill, exposing the remaining flood coat and felt to increased embrittlement by ultraviolet rays. Dropping tools on blisters or stepping on them can easily burst them, allowing direct access for water entry into the roof system.

In 1988, after measuring pressures within some blisters and physically examining many others, the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) developed and patented a miniature pressure relief vent designed to be inserted into the top of blisters to deflate them and prevent them from returning. This vent was seen by many as the perfect way to extend the life of a blistered roof and to minimize any risks associated with blisters. In 1989, Cor-A-Vent, Inc. (16250 Petro Drive, Mishawaka, Indiana 46544) obtained the rights to manufacture the vent and in 1990 they introduced the blister vent to the roofing market.

Acceptance and use of the vent by building owners and roofers has been slow. In a potentially huge U.S. market containing thousands of built-up roofs, most of which are expected to have at least some blistering, vent sales have not been impressive, amounting to only several thousand per year. (Cor-A-Vent reportedly gives more samples away as part of their advertising than they sell.) Part of the problem of poor sales, at least initially, can be attributed to the newness of the vent—few people were aware of it, and there can be a natural resistance to try anything new. A high selling price also presents a barrier to widespread use. In addition, the notion that a reactive maintenance approach (repair broken blisters) as opposed to a proactive one (repair them before they break) was the appropriate solution to blisters further dampened potential sales.

In an attempt to transfer this new technology to the military community, CRREL, as part of the Corps of Engineers Facilities Engineering Application Program (FEAP), conducted two demonstration projects, one that compared contractor to in-house vent installation in 1990 and another that supplied vents directly to various DoD installations for their evaluation and use in 1992. Valuable information was developed from both demonstrations.

This paper traces the development of the blister vent by reviewing the cause of roof membrane blisters, details the findings from the two demonstration projects, and recommends how to overcome some of the barriers to its use.

THE CAUSE

Blisters develop from voids built into the roof either between the plies or between the bottom of the membrane and an impermeable substrate (Korhonen and Bayer 1986, Korhonen 1989). Voids can result from skips in the bitumen mopping, entrapped debris, bitumen bubbling, or curled felt edges. Tight quality control on the job can minimize many of these problems, but regardless of how carefully work is done, a perfect, void-free membrane is difficult to fabricate even under the best of conditions. Thus, some blistering is likely in any bituminous built-up roof system.

Blisters grow from the expansion of the gas (air or water vapor) within a void under the intense heat of the sun. The mere expansion of this entrapped gas does not account for large blisters, however. What makes small voids grow into the characteristic bloated humps several inches high to a few feet across is a breathing action driven by thermal cycling. Pressure changes within membrane voids that cause blister growth are documented elsewhere (Korhonen 1989), but they are summarized here to explain why blisters grow in size.

Blisters cycle from positive to negative pressures on a daily basis. As shown in Figure 1, a blister typically goes from over-pressure during the heat of the day to under-pressure during the cool of the night. What's more, the pressures that do develop are considerably below what might be calculated from theoretical considerations, suggesting that a blister is not air-tight. Indeed, instead of fully containing pressures, air most likely leaks through microscopic cracks in the bitumen moppings and along the felts themselves since felts can be microporous. This leads to the conclusion that blisters inhale and exhale daily.

It is this cyclic breathing that explains why blisters continually grow larger. However, growth is possible only when the volume of air sucked into the blister at night exceeds the volume of air forced out of the blister the following day; the internal positive pressure that is created is great enough to break the peripheral bond at the edge of the blister.

Contrary to popular belief, blisters do not grow day-by-day during the hottest part of the year. That is because blister growth is very much dependent upon relatively cool night air as well as on high daytime temperatures. During the cooling phase, the raised membrane must stiffen so as not to subside when a vacuum forms. If the membrane stays warm and pliable and is unable to maintain its shape, it deforms, reducing the vacuum and thus the volume of air drawn into the blister. With less inhaled air, the blister is less likely to expand the following day, no matter how hot the day may get (Korhonen 1989). The optimum growing conditions occur when the days are hot and the nights are cool, which corresponds to spring and fall.

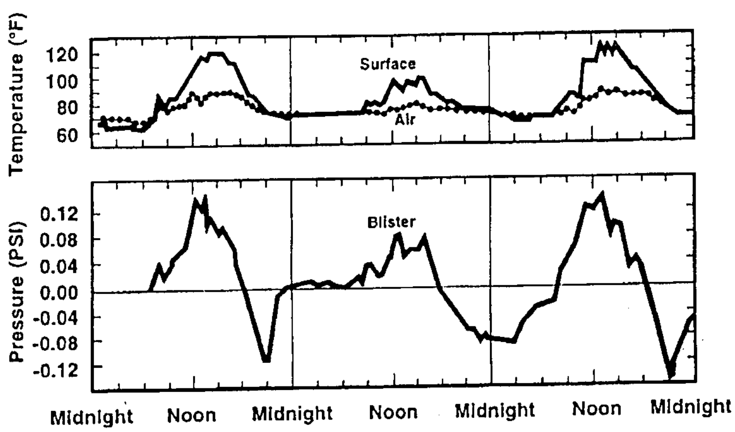

Figure 1. The top graph shows the air and blister surface temperature and the bottom graph shows the pressure difference between the inside of a blister and the atmosphere. Note how small the pressures are.

WHAT TO DO

Very few options are available for dealing with existing blisters. The Roofing Industry Educational Institute's "Roof Maintenance" manual (RIEI 1980) provides guidance for repairing blisters. The number one repair procedure is to do nothing. If a blister is intact and unbroken, the manual suggests leaving it alone, because blisters that hold pressure do not leak. In addition, blisters should not be intentionally punctured but rather should be monitored over time so they can be repaired if individual blisters continue to get worse (and they will). Eroded bare spots on blisters should be coated with a cold-process recoating/resaturant and sprinkled with gravel if needed.

When a blister bursts, the usual repair process is to remove the entire raised portion of the blister and patch the remaining void with alternate layers of bitumen and successively larger diameters of felt. Alternately, an x can be cut into the blister, the corners of the cut peeled back, the resulting cavity filled with bitumen and the corners pressed back into the bitumen. The blister would then be patched as before.

Roof breather vents have at times been promoted as a means of relieving internal roof pressures that lead to blisters. Unfortunately, as Figure 2 shows, such vents only communicate with the insulated space of a roof and, as discussed earlier, blisters only occur at or above the top surface of the insulation. Furthermore, pressures large enough to lift up the roof membrane do not occur within the insulated space of a roof (Korhonen 1989). Consequently, roof breather vents do not prevent membrane blistering.

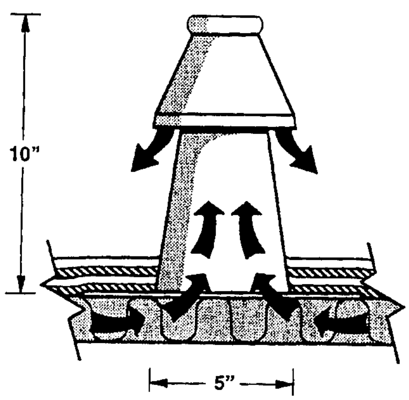

Figure 2. Cutaway view of roof breather vent. Note its size and that it vents only the insulated space of a roof.

The only way to stop an existing blister from growing larger and becoming a maintenance headache is to depressurize it. The cut-and-patch approach achieves this goal but ends up being costly in time and money. An average of one hour is required to repair a single blister, which for material and labor can easily exceed $30. Simply poking a hole in a blister might work, but the hole must be left open until the blister collapses unto the roof, which may take several days or weeks, and, therefore, is not a recommended approach.

The blister vent serves both to relieve pressures and prevent leaks. As shown in Figure 3, the vent consists of a hollow, threaded shaft covered by a special membrane enclosed in a plastic housing. It allows gases to escape but inhibits water from leaking into the roof.

Blister vents are easy to install. The installer merely cleans the area of gravel and dust, adds a primer to the surface, pokes a hole into the blister, applies sealant to the underside of the vent, and threads the vent into the hole. Once installed, the vent causes the blister to deflate and the raised portion of the blister eventually to collapse onto the roof. In this position the roof membrane is less susceptible to damage.

The question has arisen as to whether a deflated and collapsed blister might reseal itself to the roof. The answer is no, at least not of its own volition.

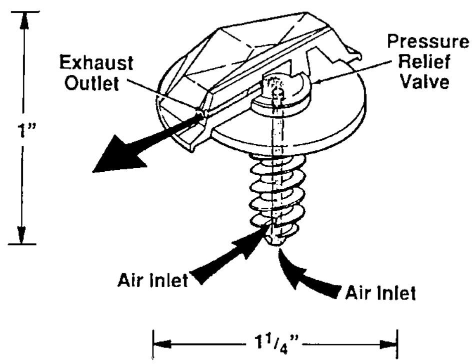

Figure 3. Cutaway view of the blister vent. Note its small size.

Several blisters were cut open the year after they had been repaired with the vent and, though found to be watertight and flat, they were not well bonded to the roof. The original, once-raised portion could be easily cut away from the roof. In conjunction with this test, several other collapsed blisters were coated with a resaturant to determine if it would penetrate the blister wall and reseal it to the roof. A year later the blisters were sliced with a knife but could not be delaminated from the underlying roof membrane without causing damage. What long-term effect adding such a coating has on roof maintenance is unclear at this point. More study should be done with this interesting finding.

TECHNOLOGY TRANSFER

CRREL conducted two demonstration projects under authority of the Corps of Engineers Facilities Engineering Application Program, one in 1990 and the other in 1992, to increase awareness of the new blister vent technology, to show its benefits, and to learn of barriers to its use.

The 1990 project, at Fort Devens, Massachusetts, was conducted to demonstrate how easily vents could be installed by an outside contractor and by in-house maintenance workers. In both cases, no prior training or on-site assistance was provided to installers. An 8-minute CRREL videotape was all that was used to self-train the contractor and in-house maintenance staff, and both found the vent easy to use, averaging about two minutes per vent installation. Each blister vent was installed for $12 by the contractor and $9.55 by the in-house staff workers, which included $8 for the vent in both situations. Had the blisters been repaired by the usual cut-and-patch method, the cost per blister would have jumped to an estimated $35. The savings add up rapidly as blister numbers increase. The alternative of doing nothing until problems arise can be even more costly, as reroofing a failed, leaking roof can be prohibitively expensive.

Word of the Fort Devens success was disseminated through technical reports, conference attendance, and magazine articles and via avenues previously established by FEAP. Despite these efforts, it became clear that few people within the Army had been reached with the technology. Thus, a second demonstration, different from the first, was planned.

In 1992, a program was devised to reach more building owners in hope that others would learn from the individual experiences thus gained. The program made vents available free of charge to any interested DoD installation. In exchange, the installation was to provide an evaluation of the vent by answering a short CRREL questionnaire (Appendix A). The vent manufacturer participated in the program by matching any vent purchase with an equal number of free vents. In all, 5000 vents were made available to the program: 2500 purchased by CRREL and 2500 donated by the manufacturer.

Eighteen installations volunteered to test and evaluate the vent (Appendix B). Of these, seven installations returned the CRREL questionnaire, providing an assessment of the vent. Though evaluation response was low, the information gained by conducting the demonstration added to that provided by the seven installations answering the questionnaire has proven useful in assessing the potential market in the Army and determining the strengths and weaknesses of the vent. On the question of the market, we had originally hoped for five installations at which to test the vent. We anticipated having to contact many locations before finding five that would participate in the program. To our amazement, nearly all installations contacted were interested. As word of the program circulated, unsolicited requests began to come in. Therefore, instead of distributing a lot of vents to a few installations, we decided to send fewer vents to many installations. The need for and the interest in the blister vent appeared strong.

The results from this demonstration were quite encouraging. At the seven installations answering the questionnaire, 13 roofs were treated with anywhere from 3 to 300 vents, depending on the number of blisters present. Approximately 600 vents were used and installed. Respondents described their experiences with the vent as one of pleasant surprise. On average, each vent was installed in two minutes, which included preparing the roof surface and installing the vent. The vents were installed by in-house maintenance staff in all but one case, where the roof was maintained by permanent contract personnel. The only training anyone received was to watch the CRREL videotape. All installers agreed that the installation process was easy and that blister breakage was not a problem. The only time blisters were reported to have broken was when the roof membrane was dry and brittle.

To date all vents appear to be performing flawlessly. The consensus is that the vents are most effective when the roof has not deteriorated to the point where it has become brittle. The vents should be applied when blisters are small. Other comments suggested that a simple installation tool could be devised to speed up installation even more, even though all respondents were pleased with the already simple installation process.

When the respondents were asked if additional vents might be purchased or if the vent would be recommended to others, the answer came back very clearly that the selling price of the vent was an issue. Technically, the concept and performance of the vent was not questioned. However, though blisters may be a costly maintenance item, even when nothing is done to repair them, the usual response indicated little desire to purchase additional vents unless they sold for significantly less than their current $8 selling price. (Incidentally, feedback from potential vent users in the private sector indicated the same feeling about price.) A roof with 100 blisters would require $800 in vents. Projected to an installation level, with numerous roofs involved, the large number of vents required represents a significant investment. Thus, the largest barrier to more use of the vent seems not to be with the technology but with its current price.

CONCLUSION

Blisters are a leading cause of problems on bituminous built-up roof membranes (LaValley 1994). They weaken the roof membrane, accelerate its aging, and increase its vulnerability to puncture. They shorten roof life.

Blister vents are the only proactive alternative to cutting out and patching blisters. Once installed, the vents stop blister growth by deflating the blister and causing its raised portion to collapse onto the roof where it is less likely to be damaged. Blister vents can postpone the cost of reroofing when used early. Although the vents cannot prevent blisters from happening, they can lengthen the service life of a roof.

Despite the positive impact that wide use of the vent could have on built-up roof maintenance costs, the vent is underused, primarily because it is viewed as being too expensive, but also because of a lack of awareness of the vent in the roofing community and a reactive attitude towards repair.

RECOMMENDATION

More effective use should be made of the roof blister vent. In the DoD community, and probably elsewhere, too few are aware of the vent, and those that are choose not to use it, primarily due to cost, even though economics suggests that blister vents are cost-effective. To increase use, an extensive education project informing potential users of the true cost of blisters must be undertaken, or the price of the vent must be reduced, or both. Since most people who are aware of the vent agree that it is technically sound, reducing its selling price significantly seems to be the logical first step toward overcoming current resistance to use of the blister vent. However, selling price alone is not expected to be enough, so concurrent efforts to advertise and demonstrate the vent are also needed.

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APPENDIX A: QUESTIONNAIRE

The following questions were in the questionnaire that was sent to all Army installations receiving the free blister vents for evaluation and use.

1. How many roofs were the vents installed on?
2. How many vents on each roof?
3. Who installed the vents? How many people?
4. What were the impressions of the installers regarding ease of installation?
5. How long did installation take?
6. How many (or what percent) didn't seemed to vent properly?
7. How many blisters broke?
8. What do you think the vents are worth? What do you think a reasonable selling price would be? Less than $5? $5–10? $10–15? More than $15?
9. Any comments, tips, or ideas to improve the vent or the installation method?
10. What is your overall impression of the vents and would you recommend them?

APPENDIX B: RESPONDENTS

The facilities that received vents, their point of contact, and related information are provided in Table B1.

Table B1. Roof blister vent disposition.

Facility	POC	Date sent	No.	Location
*1. HQ 83D Arcom	Barney Kempter	9 Sept 92	500	Ohio
2. Ft. Bliss	George Lambert	15 June 92	100	Texas
3. Ft. Campbell	Mr. Donald Terrell	8 Aug 93	100	Kentucky
4. Ft. Carson	Robert Tucker	5 May 92	500	Colorado
5. DCSC-WIC	Robert White	10 Sept 92	1000	Ohio
*6. Ft. Devens	Joseph Tammaro	5 May 92	200	Massachusetts
*7. Ft. Gordon	Pat Arthur	16 June 92	100	Georgia
8. Ft. Greely	James Mellott	26 Aug 93	100	Alaska
9. District Japan	Mr. Taira	6 Oct 92	100	Japan
10. Yokohama, Japan	John M. Senna	17 May 93	100†	Japan
10A. Yokohama, Japan	John M. Senna	23 June 93	100	Japan
11. Korea	Virgil Beers	17 May 92	100	Korea
*12. Ft. Leonard Wood	Stanley Martin	16 June 92	100	Missouri
*13. Loring AFB	James Page	2 Nov 92	100	Maine
*14. Ft. Snelling	Lonnie Voter	27 Apr 92	200	Wisconsin
*14A. Brainerd AFB	Lonnie Voter	7 Dec 92	500	Wisconsin
15. Ft. Mead	Donald Jones	11 Aug 93	100	Maryland
16. Ft. Richardson	Jeffrey Garnes	28 Aug 93	500	Alaska
17. Ft. Rucker	Ron Leatherwood	15 June 92	100	Alabama
18. Ft. Wainwright	Charles Ruerup	26 Aug 92	100	Alaska
Remaining	CRREL		<300	
Total:			5000	

* Facilities that responded to the questionnaire.
† Vents were never received.

The complete mailing addresses and telephone numbers for the people and installations involved in this study are listed below.

Barney Kemter
HQ 83D ARCOM
P.O. Box 16515
Bldg 306 DCSC
Columbus, OH 43216-5004
(614) 692-4117

Robert Tucker
HQ FT Carson
Building 304
Fort Carson, CO 80913-5023
(719) 579-2856

Facilities Division
Directorate of Install. Support
Attn: Pat Arthur
Fort Gordon, GA 30905-5060
(706) 791-3483

For the Commander
Directorate of Install. Support
Attn: ATZC-ISE-J, Bldg 777
(George Lambert)
Fort Bliss, TX 79916-5058
(915) 568-6110

Robert White
DCSC-WIC
Facilities Engineering Division
Building 308
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Columbus, OH 43216-5000
(614) 692-2774

James Mellott
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(907) 873-3259

Mr. Taira
US Army COE District Japan
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Lonnie Voter
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(205) 255-2988

SGT James Page
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(907) 353-9148

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Blisters are a major problem of built-up roof membranes. They are caused by voids built into the roof during construction. They develop into the characteristic dome-shaped humps by a breathing action driven by thermal cycling. A small pressure relief vent was patented by CRREL as a cost-effective way to repair blisters. Though these vents cannot prevent blisters from forming, they can lengthen a roof's service life by repairing the blisters before they break. Two demonstration projects were conducted to transfer the blister vent technology to the military community. Most participants in the demonstration projects found the vent easy to use and that it performed as designed. The main objection to the vent was its price.

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