SELF-SEALING ASPHALT SHINGLES – TECHNICAL BULLETIN 1.0

SEAL STRIP DESIGN, EXPECTATIONS, AND FAILURE ANALYSIS

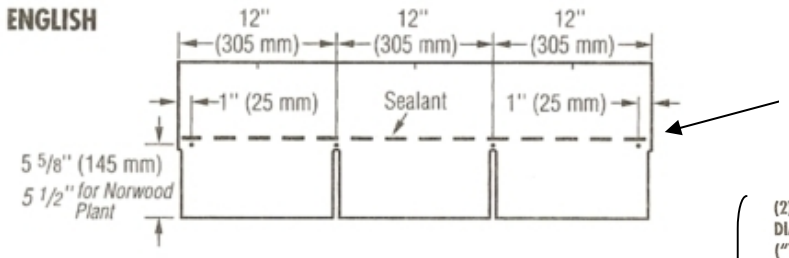
J. Lyle Donan, P.E., C.F.E.I.
President
Donan Engineering Co., Inc.

Conventional self-sealing asphalt roofing shingles are strictly designed for application on roof slopes of 2:12 or greater[1]; they are designed to resist the forces of gravity and wind using four or six nails per shingle[2], depending on the shingle design and roof slope, and the self-sealing asphalt sealant that is applied to the top or bottom of the shingles during the manufacturing process. In extreme steep slope applications or when applied during winter months (described later), many manufacturers will also require that their shingles be hand sealed at the time of installation. While proper shingle fastening and roof construction at the eaves, rake edges, and ridges is essential to the wind resistance of shingle roofs, the effectiveness of the shingle's asphalt sealant strip is of equally great concern, and it is here that we see so much misunderstanding as we encounter wind-damaged roofs and/or roofs that are not well sealed – from wind or other causes.

<u>What is the sealant strip on an asphalt shingle?</u>

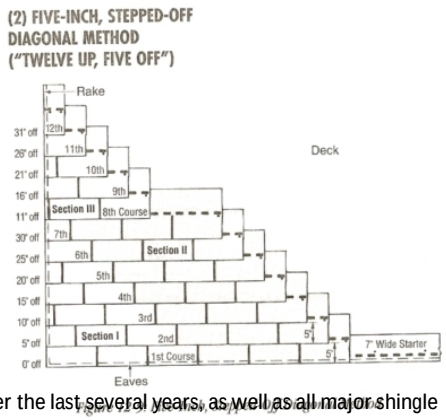
The sealant strip is a continuous or intermittent line(s) of asphalt that is applied lengthwise along the top middle of a conventional three-tab asphalt shingle, or it may be on the top middle or the bottom backside of a conventional dimensional (architectural/laminate) asphalt shingle.

Conventional Three-Tab Shingles



The dark dashed line in this drawing of a conventional three-tab shingle is the asphalt sealant strip.

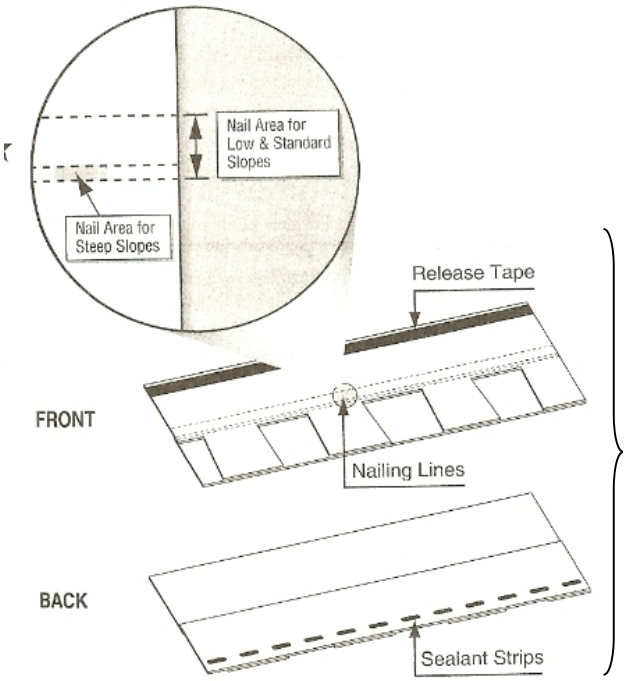
When properly installed, the bottom ("butt") edge of each shingle overlies the sealant strip on the top center of the underlying shingle course, as shown in this illustration.



[1] All known building codes, those that are current and those that have been published over the last several years, as well as all major shingle manufacturers strictly state that asphalt shingles are not to be installed on roof slopes less than 2:12.

[2] While staples remain an acceptable shingle fastener on manufactured housing, staples are not an approved shingle fastener in most current residential building codes.

Conventional Dimensional Shingles



The asphalt sealant strip on many dimensional shingles is located on the backside of the shingle, near the bottom, so that when the shingles are assembled on the roof, the bottom of each overlying shingle seals to the top center of the underlying shingle.

The National Roofing Contractors Association (NRCA) offers the following description of asphalt sealant strips:

"Commonly, asphalt strip shingles and laminated shingles contain adhesive, self-sealing strips. A self-sealing strip gives an asphalt shingle increased wind resistance by securing the leading edge of the shingle. A self-sealing strip is generally composed of an asphaltic-based, heat-sensitive adhesive that is designed to adhere to the overlying or underlying course of shingles. A modifier, similar to SBS-modified bitumen, may be added to the adhesive to make it tackier, allowing the adhesive to seal at lower temperatures. Typically, individual shingles, such as "T-Lock" shingles, do not contain this type of adhesive self-sealing strip."[3]

How do they work?

The sealant strips are a special formulation of asphalt that is designed to soften or "malleate" when initially exposed to warm temperatures and then to form and cure, creating strong adhesion between the overlying and underlying shingle as temperatures cool. Unfortunately, major shingle manufacturers, the National Roofing Contractors Association (NRCA), and the Asphalt Roofing Manufacturers Association (ARMA) are consistently vague on how much time shingles must be exposed to temperatures above a certain threshold before adequate adhesion will occur. Consider a few examples of what is published on this important topic:

[3] The NRCA Roofing and Waterproofing Manual – Fifth Edition

ARMA

"Most asphalt shingles are manufactured with a thermally activated asphaltic sealant which bonds the shingles together once applied to the roof and exposed to a few weeks of sufficient heat from sunlight. In order to ensure wind protection until warmer weather occurs, during winter, asphalt shingles can be hand sealed with an asphaltic roofing cement approved by the shingle manufacturer to provide additional protection from wind blow-off. Normally every tab is sealed down with one or two 1-inch diameter spots of asphalt roofing cement, for laminated shingles, at least three spots of sealant are used. The top six courses of the roof and all rake courses are especially susceptible to wind blow-off if they are not sealed."[4]

Owens Corning

"Your shingles contain strips of asphalt sealant that require direct warm sunlight for several days in order to seal properly. If your shingles are installed during a period of cool weather, they may not adequately seal until the season changes or the weather warms, and if your shingles never receive direct sunlight or are not exposed to adequate surface temperatures, they may never seal. Prior to sealing, your shingles are more vulnerable to blow-offs and wind damage. This is the fundamental nature of shingles and not a manufacturing defect, and we are not responsible for any blow-offs or wind damage that may occur prior to thermal sealing having occurred. After your shingles have sealed, however, they will be covered under this warranty if they experience blow-offs or wind damage in winds up to the levels listed in the chart at the end of this warranty. HOWEVER, FOR ALL SHINGLES, THE COVERAGE AGAINST SHINGLE BLOW-OFFS OR WIND DAMAGE IS IN EFFECT FOR A PERIOD OF FIVE (5) YEARS ONLY FOLLOWING THE DATE OF INSTALLATION, AND NOT FOR THE FULL WARRANTY PERIOD OF THE SHINGLE."[5]

GAF

"All self-sealing shingles, including GAFMC's, must be subjected to warm sunlight for several days before full thermal sealing can occur. Shingles installed in fall or winter may not seal until the following spring. Shingles which are not exposed to direct sunlight or to adequate surface temperatures may never seal. Failure to seal or shingles that blow off under these circumstances result from the nature of self-sealing shingles, not a manufacturing defect."[6]

What does this mean?

The precise amount of time a shingle must be exposed to a certain minimum temperature before it should seal properly is unclear.

[4] ARMA Technical Bulletin – Cold Weather Recommendations for the Application of Asphalt Roofing Shingles
[5] Owens Corning Standard Limited Shingle Warranty (US and Canada)
[6] GAF Smart Choice System Plus Limited Warranty

However, it is clear that the industry has great concern about installing self-sealing asphalt shingles in cold weather for fear that they will not seal down in time to prevent otherwise avoidable damage, or that they may never seal as designed, as experience suggests.

Consider the dilemma – self-sealing shingles can't seal down unless they're exposed to sufficient heat for a sufficient amount of time. This heat will only be present in many parts of the U.S. and Canada in late spring, summer, or early fall. However, it is common sense that roofs are installed year round; therefore, it is also common sense that many asphalt shingle roofs are installed during a time of year when they have little to no chance of self-sealing. In turn, unless the roofing contractor takes labor-intensive hand-sealing precautions, these roofs are then unsealed and susceptible to wind uplifting, creasing, or possible blow-off – damages that are likely to occur during non-severe weather and which are not attributable to a manufacturing defect.

There is both good and bad news.

The good news: When warm weather eventually arrives and the shingles get warm enough that the sealant strip malleates and tries to bond to the overlying or underlying shingle, they *might* seal properly.

The bad news: Since the shingles were exposed to the elements for perhaps several months prior to warm temperatures, and were therefore drying out during that time (an inherent quality of all asphalts), they may or may not ever reach the full amount of adhesion the manufacturer intended.

More bad news: While lying unsealed on the roof, the shingles were inherently prone to having dirt, leaves, seeds, twigs, or other common roof debris becoming lodged between the successive shingle courses. If this occurs, the shingles may not lay flat or may not make direct contact with the sealant strip; therefore, when warm temperatures do occur, they have no chance of adhesion, irrelevant of temperature. The following photographs illustrate this condition:

So how do you prevent this from occurring? It's simple. Only install a self-sealing asphalt shingle roof during a time of year when you are guaranteed abundant warm weather. However, since roofs are installed year round, there is only one recommended option to prevent this from occurring – hand sealing.

Hand Sealing

Hand sealing is understandably unappealing. It is incredibly slow and labor-intensive, which is synonymous with greater expense. *However, manufacturers not only recommend hand sealing if shingles are installed in unseasonal weather, they require hand sealing if shingles are installed on "steep" roof slopes, where the roof slope is greater than 60 degrees (21:12).* Why? Because on steep roofs the force of gravity no longer keeps enough compression (pressure) on successive shingle courses, which is a key factor in proper shingle adhesion when the sealant strips become warm and attempt to bond to the overlying or underlying layer of shingles.

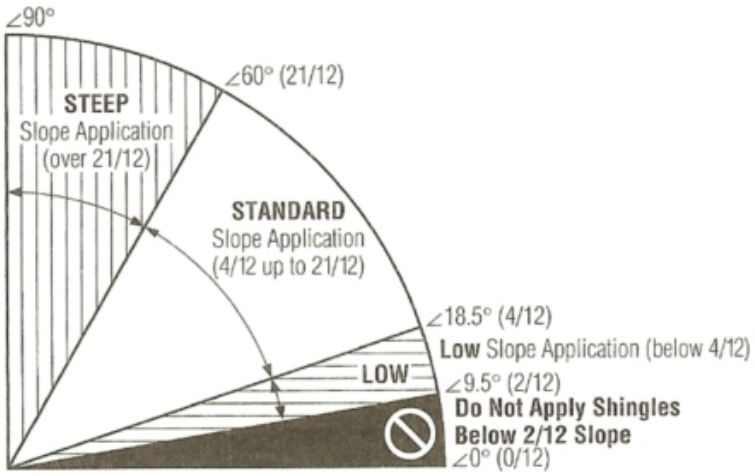
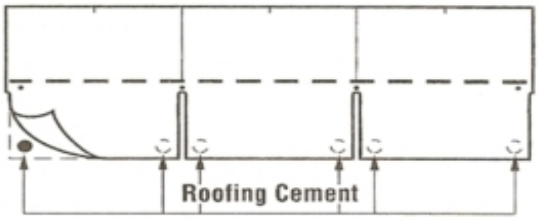


Figure 15-1: Slope definitions.

The following hand sealing procedure is based on Asphalt Roofing Manufacturers' Association (ARMA) recommendations:

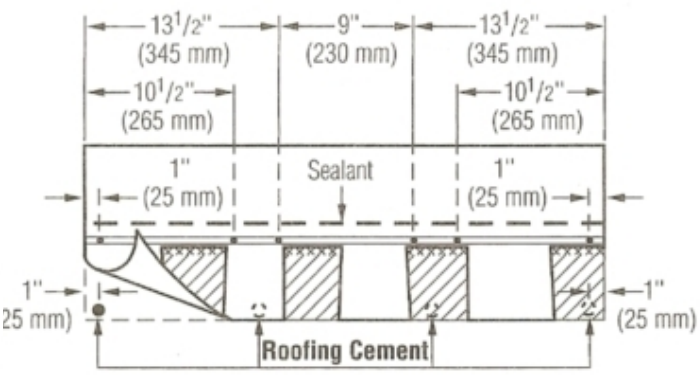
1. Choose a sunny day because warm shingles are more easily raised enough to apply the cement without damaging the shingles. In cool weather, the cement should be stored in a heated area so it can easily be applied. The cement may be applied with a caulking gun if tubes are used, or with a small trowel or putty knife if used from a pail.
2. The amount and position of the cement are typically the most important features for a good seal. Seal the tabs by carefully lifting the tab just high enough to apply two spots of cement, each about the six of a quarter (twenty-five cent piece), near the corner of each tab. The spots should be located so that when the tab is pressed into place, the cement reaches the tab edge but is not exposed.

   CAUTION: Avoid excessive use of cement so as to prevent the formation of blisters or a lumpy appearance on the roof.
3. To make certain that all tabs are sealed, decide upon a predetermined pattern of sealing before starting the job. A recommended pattern to follow in sealing three-tab shingles is to start at one rake or hip of the roof, and beginning at the eaves, seal three tabs. Then seal the three tabs of the course above it, and continue in this manner until the ridge or hip is reached. Repeat this procedure starting at the eaves with three tabs adjacent to the ones just sealed. Continue until all tabs are sealed.



Apply 1" (25 mm) spots of asphalt roofing cement under each tab corner.

*Use **four** nails and six spots of asphalt cement on steep slopes.*



The above three-tab and dimensional shingle illustrations not only show where and how much hand sealant is to be applied in either cold weather, on steep slopes, or in known high-wind areas, but they also show the proper location and number of nails that are to be used when installing shingles in steep slope applications. This is especially important on steep roofs clad with dimensional shingles, where six nails per shingle are required as opposed to only four on roofs of 60-degrees or less. Additionally, on steep roofs clad with dimensional shingles, it is ***imperative*** that the nails penetrate both the top and bottom portions of the shingle where the two pieces of the shingle are adhered together (the approximate middle of the shingle's width), because nails are key to preventing the shingles themselves from separating under the unrelenting force of gravity as shown in the following photograph. Note this is an installation error and not wind damage.

Assuming asphalt shingles are properly installed and sealed, how can I expect them to perform?

When the sealant strips throughout an asphalt shingle roof are properly adhered *and* the shingles were installed correctly, a shingle roof system is a long-term formidable adversary to potentially damaging wind. While the basic product in this market – the 20-year three-tab – is routinely offered with a limited wind warranty of 60 miles per hour from the manufacturer, we frequently see these roofs performing quite well when exposed to winds above this metric. Indeed, this design is so effective that many manufacturers offer shingles whose limited wind warranties offer coverage up to 130 miles per hour. That's wind equivalent to an F2 tornado or a Category 3 hurricane on the Saffir-Simpson scale!

However, there is a catch… Since the sealant strip is an asphaltic compound, and since asphalt deteriorates with time and exposure, the effectiveness (adhesion) of a seal strip inherently decreases with time. The rate of this gradually deteriorating performance fluctuates widely from one shingle design to the next and from infinite natural variables, but manufacturers are generally consistent on this subject when they prescribe what their warranties will and will not cover. The consistent trend in the industry is that premium shingles are warranted against wind damage for a period of ten years and most conventional dimensional and three-tab shingles are warranted against wind damage for five years, beginning from the date of their installation – irrelevant of the shingle's design, cost, or application.

The effectiveness of the asphalt seal strip diminishes with time.

Irrelevant of how well it was installed and sealed, the older an asphalt shingle roof becomes, the more prone it is to being damaged from wind.

As a consequence of the effects of aging, countless asphalt shingle roofs eventually suffer damages from winds that are far below what could be classified as "severe." In fact, it is logical that if an asphalt shingle roof is left in service long enough, beyond its functional lifespan, it is a statistical certainty that it will become damaged from wind. Unfortunately, such damages are then not really due to wind, but should instead be blamed on a missed opportunity to replace the roof before its acceptable resistance to everyday (non-severe) wind first expired.

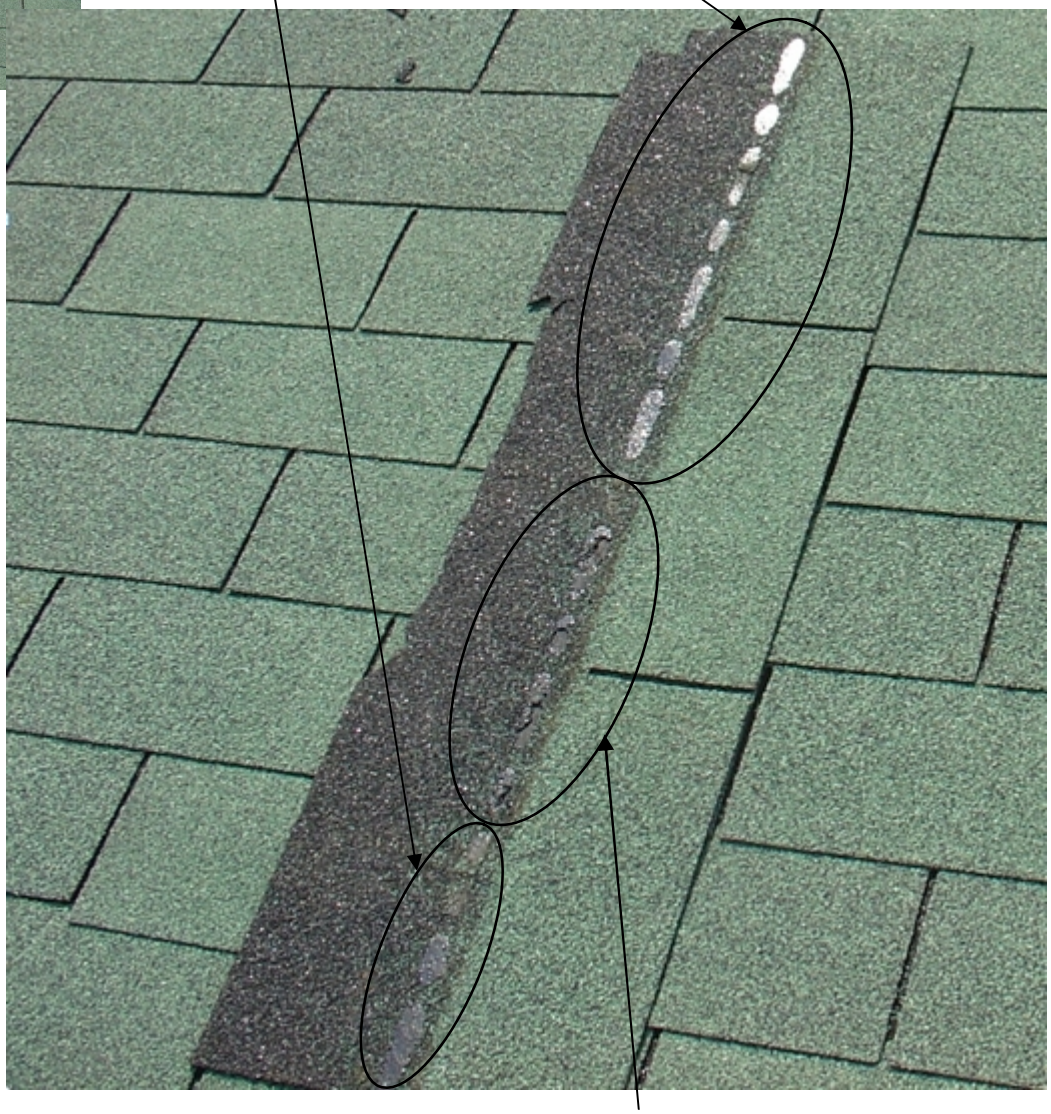
How do you know if the sealant strips are or were properly sealed (performing as designed)?

Here's a basic test… If the shingle's sealant strip has adhered as it was designed, you'll have a hard time pulling the shingles apart with your fingers. In order to separate the shingles you'll need a pry tool such as a putty knife to wedge between the shingle layers and physically break the asphalt sealant strip. However, do not do this unless you're prepared to hand seal the shingles when you're finished. Assuming that they'll reseal is not wise – and it may be totally false. Even if they partially reseal, they'll never reach the amount of adhesion they had before the seal strip was broken.

When the sealant strip has reached design adhesion, the bond between the underlying and overlying shingles is so strong that forcefully pulling shingles apart, as may be expected in severe wind, will

actually cause the shingles to physically delaminate. The following photographs illustrate both insufficient and sufficient adhesion of the asphalt sealant strip on a relatively new wind-damaged roof.

In these areas, the smooth and slick texture and reflective appearance indicates that the sealant strip failed to adhere as designed.



In this area, the shingle physically delaminated when it was torn from the roof by wind. This delamination indicates that, at least in this area, the shingle's sealant strip reached a design level of adhesion.

Another way to illustrate the amount of adhesion an asphalt seal strip is designed to achieve is to intentionally pull apart the top and bottom pieces of a dimensional shingle. As these two pieces are sealed together in the factory, the adhesion between them is a carefully controlled design quality. Pulling them apart delaminates the shingle as shown in the following photograph, where the delamination indicates that the material was suitably glued together by the asphalt adhesive. This exercise illustrates that not unlike two pieces of metal welded together, the weld is stronger than either piece individually.

Seal Strip Failure Analysis in Shingle Damages from Wind

Analyzing asphalt shingles for wind damage requires not only knowing about the purpose, design and long-term functionality of the asphalt sealant strips, but also a basic understanding of how shingles should be nailed and how wind affects roof geometries. However, for the purposes of this bulletin, we'll focus on identifying basic types of wind damage and understanding what role the asphalt sealant strip played in the damages.

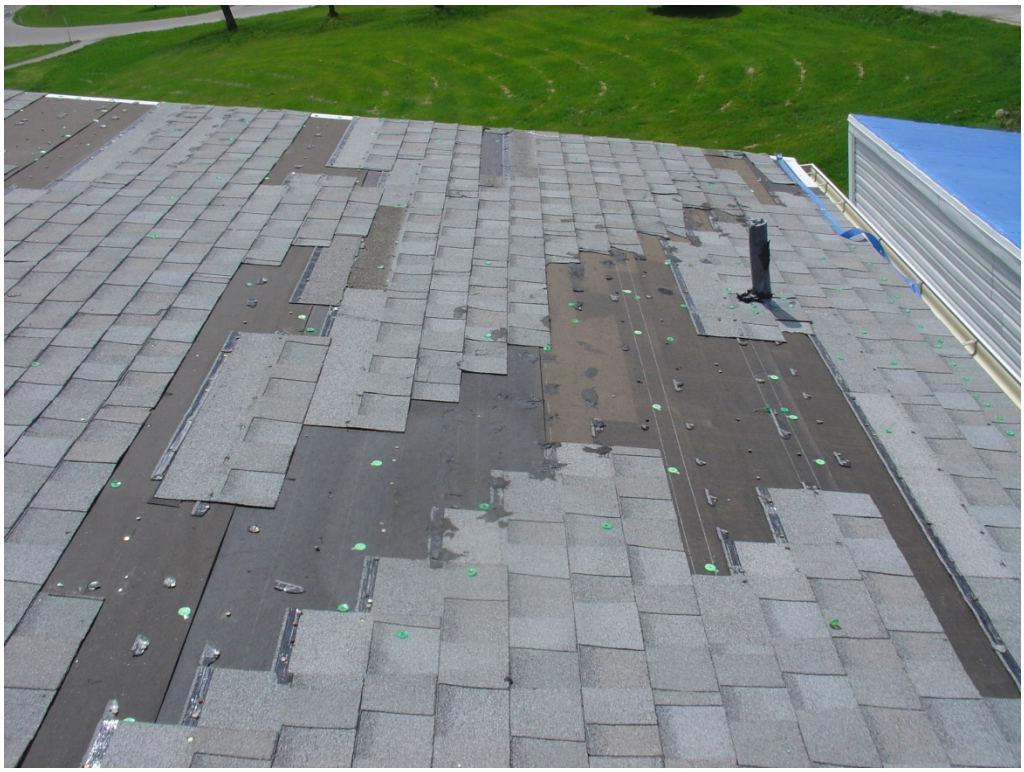
Visually Obvious Wind Damage

When truly severe winds occur, the resultant damages to asphalt shingle roofs are often visually obvious – regardless of whether or not the shingles were well sealed prior to the severe wind. In such cases roofs will lose large numbers of shingles. Since winds create locally greater forces of uplift at roof corners, eaves, rakes, hips and ridges, we generally encounter greater amounts of damage in these

areas; these areas are often synonymous with the locations of initial roof failure. Of interest, if an asphalt shingle roof is well sealed and installed prior to exposure to a truly severe wind, the damages it sustains are often large chunks of missing shingles as opposed to broken shingle tabs. Generally speaking, random creased, torn, and missing shingle tabs from wind are more synonymous with shingles that are either losing their design adhesion (perhaps age-related deterioration) or shingles that never reached their design adhesion.

Winds passing over a roof create locally more intense forces of uplift at roof corners, eaves, rakes, hips, and ridges. Severe winds that were parallel to the ridge of this roof induced damage along the rake that extended into the field of the roof.

Severe winds passing over this roof caused widespread shingle loss, often in patches, because the shingles were well sealed – holding them together as they peeled and tore from the roof during the storm.



A poorly-sealed dimensional shingle roof that encountered strong, but not severe, wind.

Subtle Wind Damage

Wind does not always result in such eye-catching damage to asphalt shingle roofs. In fact, we usually don't see such dramatic damages in everyday asphalt shingle failure analysis. Instead, most of the damages incurred are less extreme; we often see scattered missing shingles, shingles that are creased from uplift and have either partially resealed or remain unsealed, or unsealed shingles without evidence of wind damage…yet.

Numerous creased shingles (highlighted with arrows) indicate that they've flapped back and forth repetitively in the wind, probably over a long period of time. Eventually these shingles will tear and blow away, even under mild winds not associated with severe weather.

The creases illustrated in the above photographs are classic examples of unsealed shingles that have been repeatedly uplifted and stressed from wind. The repetitive bending creates linear creases that are parallel to the bottom edge of the shingles. As shown in these photographs, if the entire shingle is being lifted from wind, the cracks will occur close to the bottom edge of the overlying shingle. However, if only part of the shingle is unsealed or insufficiently sealed, the cracks are usually oblique to the shingle's corner, as shown in the following photograph:

Repairing Subtle Wind Damages

While shingle damages from wind justifiably warrant concern and diagnosis, the occasional missing or loose shingle, creased or not, does not necessarily mandate a roof replacement. In fact, because this is such a common condition, the industry considers the occasional loose or missing shingle a maintenance issue. We therefore should not be surprised to see such distresses over the lifespan of many asphalt shingle roofs.

The following excerpt from CertainTeed's Shingle Applicator's Manual offers a step-by-step process for replacing shingles. Similar processes may be found on the World Wide Web, in asphalt shingle installation guides or in do-it-yourself home repair journals.

REPLACING SHINGLES

The need to replace a relatively small number of shingles can happen at any time during the life of a roof.

- A recently installed roof might show signs of damage that occurred during installation especially if the roof was applied during very cold or very hot weather. During a cold weather installation, product brittleness could result in cracked or broken shingles, while during hot-weather, personnel and equipment can easily dislodge granules or asphalt (scuffing).
- At any time during the life span of a roof, damage can result from overhanging trees, windstorms, or installing an antenna or other device that penetrates the surface.

Replace damaged shingles as follows:

1. Carefully break loose the seal of the tabs of selected shingles in three courses:
   (1) all tabs of the shingles to be removed,
   (2) the tabs of shingles immediately above the shingles to be removed (that overlay the shingles to be removed), and
   (3) the tabs of shingles in the second course above the shingles to be removed.

   IMPORTANT: In hot weather it is more difficult to break loose the sealant from the tab; in cold weather, simply use a simple pry like a wide-blade putty knife. In hot weather, it may be necessary to slice the sealant with a knife and carefully separate it from the tabs to avoid causing damage to the remaining shingles.
2. Remove each nail from any shingle to be removed by inserting a pry under the shingle at the site of the nail and gently raising it slightly. Push the shingle down along the shank of the nail and then pull the nail out completely.
3. Using the same technique, remove the nails from the shingles in the course above that also penetrate the damaged shingles.
4. Slide out the damaged shingles.
5. Insert a new shingle of the same design and color for each shingle removed. Depending on the age of the original shingle, colors may vary slightly, but natural aging will minimize the difference.
6. Reinstall the nails in the proper positions of the replacement shingles taking care not to lift the tabs of the remaining old shingles any higher than is necessary to hammer the nails flush.
7. Install replacement nails in the old overlying shingles where they were removed to permit the damaged shingles to be removed. Again use care when lifting overlying tabs.
8. Hand-seal all loosened tabs with an accepted asphalt adhesive.
9. **If waterproofing shingle underlayment, such as WinterGuard,™ is under the shingles removed:** fill all nail holes with a **rubber-modified asphalt cement** such as Monsey "MB Roof Cement," Karnak "No. 81 Roof Cement," or equivalent. Do not use an excessive amount of cement. Use a putty knife to squeeze in only enough to fill the hole.

Other Considerations

Nail pops:

Regardless of seal strip performance, be wary of the roof that has many nail pops! While nail pops may occur for a variety of reasons, when they cause the overlying shingle to become raised, they may not only puncture the shingle or cause its seal strip to fail, but because they elevate the overlying shingle's profile, they also make a roof inherently more prone to wind damage.

Vertical Racking:

Regardless of seal strip performance, be concerned about a roof that contains recognizable parallel lines, usually spaced approximately three-feet apart, which correspond to rack lines from when the roof was being installed. As a rule of thumb, if you can see these lines in the roof, the shingles along these lines are loose. And if they're loose, they're inherently prone to wind damage – with or without "severe" winds.

Acknowledgements

We wish to thank the following organizations for the material they make available which has been incorporated into this document:

- CertainTeed Corporation
    - CertainTeed's Shingle Applicator's Manual – Seventh Edition
    - CertainTeed's Shingle Technology Manual – Seventh Edition
- GAF Materials Corporation
- Owens Corning
- The National Roofing Contractors Association
- The Asphalt Roofing Manufacturers Association

About Donan Engineering

Donan Engineering Co., Inc. is a forensic engineering and fire investigation company headquartered in Louisville, Kentucky with offices throughout the central United States. The firm conducts forensic investigations on several thousand commercial and residential roofs per year, and is routinely called upon by insurance companies, attorneys, manufacturers, contractors, and property owners for training and investigations on all types of roofs and structures.

Donan Engineering Co., Inc.
11321 Plantside Drive
Louisville, Kentucky 40299
800-814-7503
www.donan.com