The National Fire Protection Association develops standards for fire safety regulations. NFPA 54 is the National Fuel Gas code and covers venting of combustion appliances. Any jurisdiction that has adopted NFPA 54 will require combustion vents for gas-fired appliances like furnaces, boilers, water heaters and fireplace inserts to comply with the 2-10 rule. Jurisdictions that use a different building code, like the International Residential Code or the Uniform Building Code will defer to the manufacturer's recommendations, which can differ by manufacturer, by the roof pitch and the distance from any vertical walls. So depending on the jurisdiction, there may be no way for you to know the minimum vent termination height. When that's the situation, you should disclaim proper installation. In fact, you should be disclaiming confirmation of proper installation of specialized systems anyway, except for what's required according to your Standards of Practice.

Newer heating systems with power-induced venting depend less on atmospheric draft and shorter vents will work well. Older systems that depend on natural venting, often called "atmospheric" venting, will be more strongly affected by the height of the vent termination.

If you see this condition on a roof, you should mention to the homeowner that stains on the roof indicate that they might have a problem that should be evaluated by an HVAC contractor.

When you have to remove a combustion vent to re-roof, pay attention when you pull it. If vent sections have not been fastened together with screws, then when you pull the vent you may separate the exhaust flue inside the living space. This can allow the toxic products of combustion to enter the living space, which can be dangerous or even fatal to people living in the home.

This furnace vent separated when the vent on the roof was pulled during re-roofing operations. These sections were never screwed together like they should have been. When the vent on the roof was replaced, a gap of several inches remained open in the attic space. This home was in the mountains of Colorado and the vent became disconnected during the winter.

The sections had been reconnected several days before this photo was taken, but ice visible on the underside of the roof sheathing was the result of frozen moisture from the furnace exhaust gas, which was discharging into the attic for about 10 days.

Even several days after the vent was re-connected, moisture levels in framing materials were still high, especially where bathroom exhaust vents terminated inside the attic. Mold fungi can become active at around 20% moisture levels, and mold colonies start to produce spores and grow at about 27%.

Combustion vents are sometimes very tall, especially on roofs with steep pitches. Combustion vents over 5’ tall should be braced.

If you see a short vent like this 4-inch cast iron you should try to determine whether it’s connected to a combustion appliance. If it is, it’s defective for two reasons.

The first reason is that it has no cap. This may allow the entry of pests or the accumulation of debris like nest-building materials or leaves.

The second is that it’s too short to draw adequately and may result in the products of combustion entering the living space.

If it’s no longer connected it should be sealed to keep out moisture.

Actually this is an old plumbing stack vent. It’s part of the drain, waste and vent system. You can never be sure unless you check.

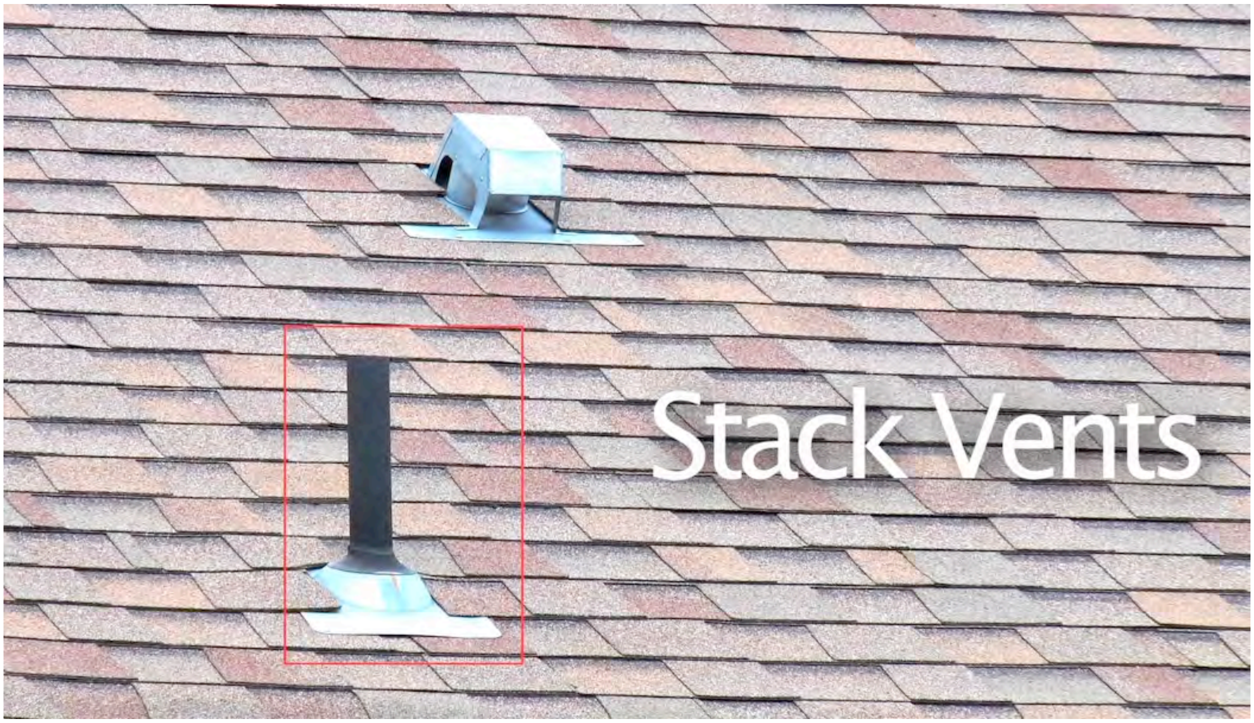
This is also a good example of bad flashing of all three vents.

You should also comment on deteriorated vents. Vents that have advanced corrosion should be replaced.

Lastly, combustion vents should not be used as water pipes. Someone routed the water supply pipe to the roof-mounted evaporative cooler through the jack for this furnace vent.

Along similar lines, roof vents should not be used as electrical conduit.

Stack vents



Plumbing stack vents are usually black plastic ABS pipe, but in some parts of the country you’ll see them made of lead.

Remember to check the rubber or plastic gasket sometimes called the “boot” that seals the pipe against the metal jack. As these boots get older, they dry out, crack and leak. You may find them missing entirely.

You’ll see some imaginative methods for replacing cracked boots. Here’s the “welcome mat” method.

Stack vents should terminate at least 6 inches above the roof.

A flashing detail common to different vent penetrations is that flashing is overlapped by shingles or tiles on the uphill side and overlaps them on the downhill side. This is true for most roof-covering materials. The exception is metal panel roofs, and that will be covered in detail in the video covering metal roofs.

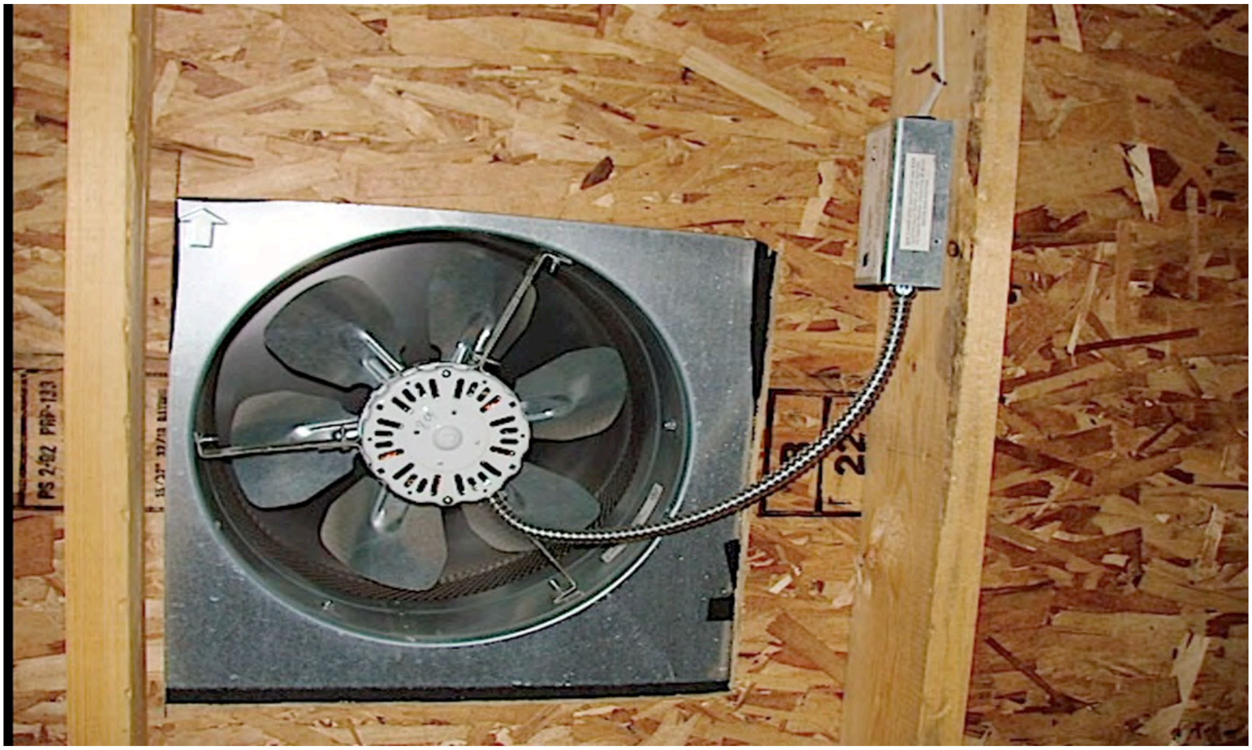
Vents that depend on sealant alone to prevent moisture intrusion are improper installations.

In cold climates you may see vents that have been bent by sliding snow. This is more common on metal roofs.

In some areas subject to frost, as of 2006, the IRC requires a minimum diameter of 3 inches for any portion of the plumbing vent extending above the roof. This is to help keep the opening from freezing over. You should check local requirements before you call a 2-inch vent a defect.
Here’s a vent with 2-inch pipe, and here’s what it looks like with a 3-inch pipe.

You should also pay attention to the location of vents in the roof. Installing a vent in a valley is always a bad idea due to the increased potential for leakage. When you find this condition it should be mentioned in your report.

There is one more type of vent you’re likely to see, and this is for a powered attic ventilation fan installed between rafters.



These vents may be round or rectangular, but you’ll recognize them by their size. Here’s what the fan looks like from inside the attic.

GUTTERS and DOWNSPOUTS

If runoff from the roof is allowed to discharge next to the home foundation, serious structural problems can develop. Saturated soil can lose its ability to support the weight of the home, seepage can undermine the foundation, or if the home is located in an area with expansive soils, soils expanding in volume can damage foundations.

This foundation was undermined by runoff from a downspout that terminated next to the exterior wall, leaving the foundation unsupported for large areas. The unsupported part of the foundation wall is bridging the area where there’s no support. If too much of the wall loses support, it may break and settle.

Gutters

The most common drainage system in residential construction is gutters hung from the roof edge attached to downspouts.

The gutter problems you find may be related to the materials from which the gutters are made, to the quality of installation, to environmental conditions, to mechanical damage, or to some combination of all four.

Vinyl gutters are lower end components and usually don't last long
Galvanized steel gutters are common, and you'll see them all over North America. If they're painted, it may be difficult to tell steel gutters from aluminum just by looking but you should be able to tell the difference by tapping them with your finger.

Vinyl gutters are generally less durable than other materials. They're deteriorated by UV radiation from sunlight and they become more brittle with cold.

Copper gutters generally last a long time compared to steel and vinyl.

Installation

Problems with installation range from improperly-sloped gutters to gutters that are loose or poorly attached. You may be able to identify improper slope by standing water in the gutter or the accumulation of sediment in portions of the gutter away from the downspouts.

You can check the slope from the ground by looking at the margin between the bottom of the gutter and the bottom of the fascia. It's easier to see in this composite photograph showing both ends of the same gutter section.

Debris

Metal gutters are subject to corrosion, especially if debris has been allowed to accumulate. Debris holds moisture next to the metal, so watch for corrosion in gutters which have overhanging tree branches. You may find advanced corrosion by probing. Corrosion often starts at seams.

On homes with steeper roofs, gutters may need to be installed using stand-offs to help ensure that runoff doesn't overshoot the gutter.

Environmental conditions

In areas with snowfall, it's not unusual to find gutters bent from sliding snow, especially on homes with metal roofs.

Another type of gutter is one installed into the roof itself; usually a foot or so back from the edge. The installation method for these is crucial because leaks will allow moisture into the framing or home interior where it can cause decay or other damage.

Roofs with these gutters are easy to spot because the roof slope will not extend clear to the edge of the roof. You can see it easily at this hip.

Do not probe these gutters. If you puncture the gutter, you may be responsible for damage caused by leakage.

Another place to watch for damage is where downspouts from upper roofs discharge onto lower roofs, increasing the chance of leakage and shortening the lifespan of the roof-covering material.

Downspouts

Downspouts should connect to the gutters securely and be free of debris. They should have some device like an extension or splashblock that will carry runoff away from the foundation before discharging it to the soil. Clogged downspouts will cause runoff to overflow the gutter.

You can see how settling caused by drainage discharged next to the foundation has cracked the brick in this 100 year-old home.

You'll sometimes see downspouts tied into perimeter drains, and this can be a problem when the ground is frozen. Ice may prevent the system from working. When this happens, homeowners may disconnect the downspout, which may never be re-connected.

You'll see alternatives to conventional downspouts like chains. The idea is that chains are durable and runoff will simply run down the chain. How far from the foundation runoff is discharged depends on the length of the roof overhang.

Interior downspouts

In-roof gutters sometimes connect to downspouts installed inside the exterior walls. In older homes, these downspouts were made of metal, which eventually corroded and leaked. Internal downspout leakage can

sometimes go unnoticed for a long enough to do considerable damage. Look at these systems carefully and use a moisture meter to check materials surrounding the internal downspouts.
One advantage of internal downspouts is that heat from the home can help keep them free of ice.

ATTIC VENTILATION SYSTEMS

Roof structure ventilation

Well-ventilated roof structures use air movement to exhaust heat from the attic or roof structure to the outside. Poor roof ventilation can shorten the long-term service life of certain types of roofing materials, especially those, which contain asphalt like black felt underlayment and asphalt shingles. Since it also influences moisture levels in the attic and comfort levels in the home, we'll include ventilation in this General Roof Inspection course.

Roofing materials absorb sunlight as heat. This heat is then released both upward into the open air and downward into the roof structure.

Cools the roof
Keeping the attic space or rafter bays cooler helps keep roofing and underlayment cooler and extends their long-term service life.

Cools the living space
Evacuating heat before it reaches the living space helps keep the home cooler and more comfortable and reduces cooling costs.

Removes moisture
The third benefit of roof ventilation is that it can remove excessive moisture
vapor. Excessive moisture vapor can cause problems like mold, decay, corrosion or roof sheathing expansion.

Oriented strand board, commonly known as OSB, is typically used for roof sheathing and leaves the mill with a 3 or 4 percent moisture content, so it’s very dry.

Installing sheathing and roofing it over too soon in a climate with high humidity can cause this problem. Roof sheathing needs time to adjust to local humidity levels. Another way to say this is that roof sheathing needs to reach equilibrium moisture content with the homesite environment before roofing materials are installed.

VENTILATION SYSTEM TYPES

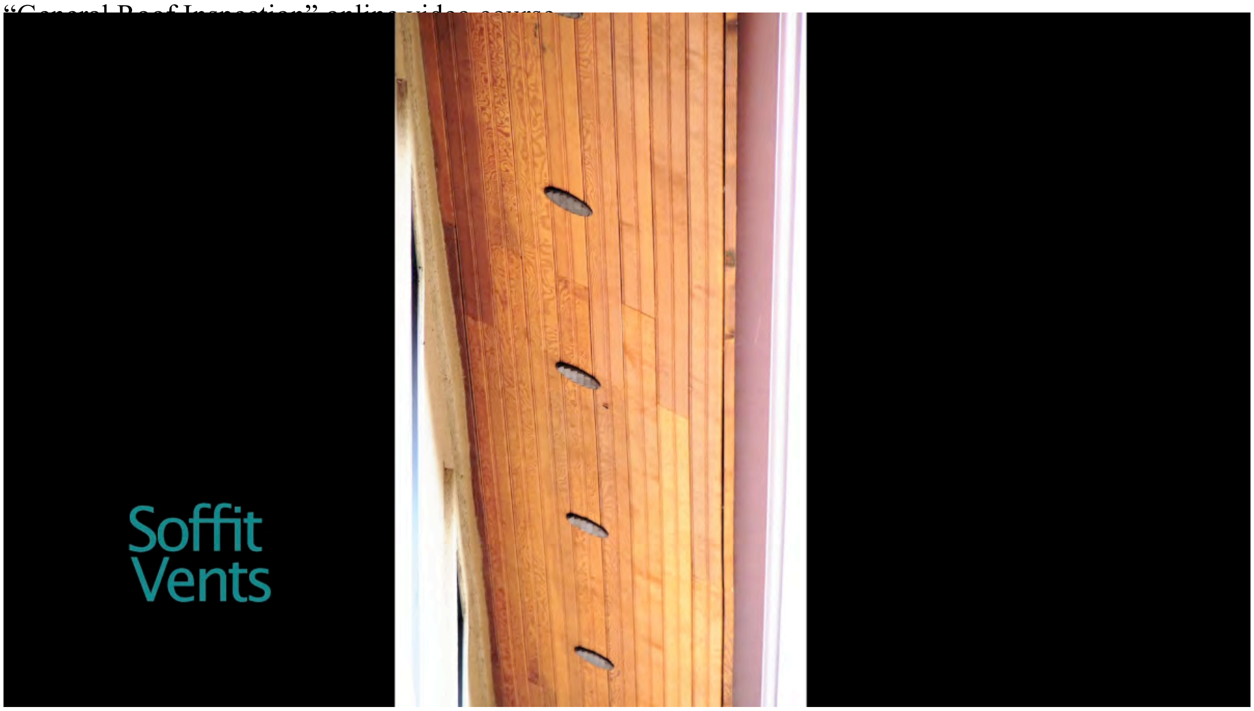
Roof structure ventilation systems can be divided into two basic types: active and passive.

PASSIVE SYSTEMS

Passive vents require no electricity, but their effectiveness often depends on their being properly designed for a specific home.

Well-designed passive ventilation systems have an intake device located low in the roof and an exhaust installed near the ridge.

In a balanced system, the net opening of the intake will be approximately the same as the net opening of the exhaust.

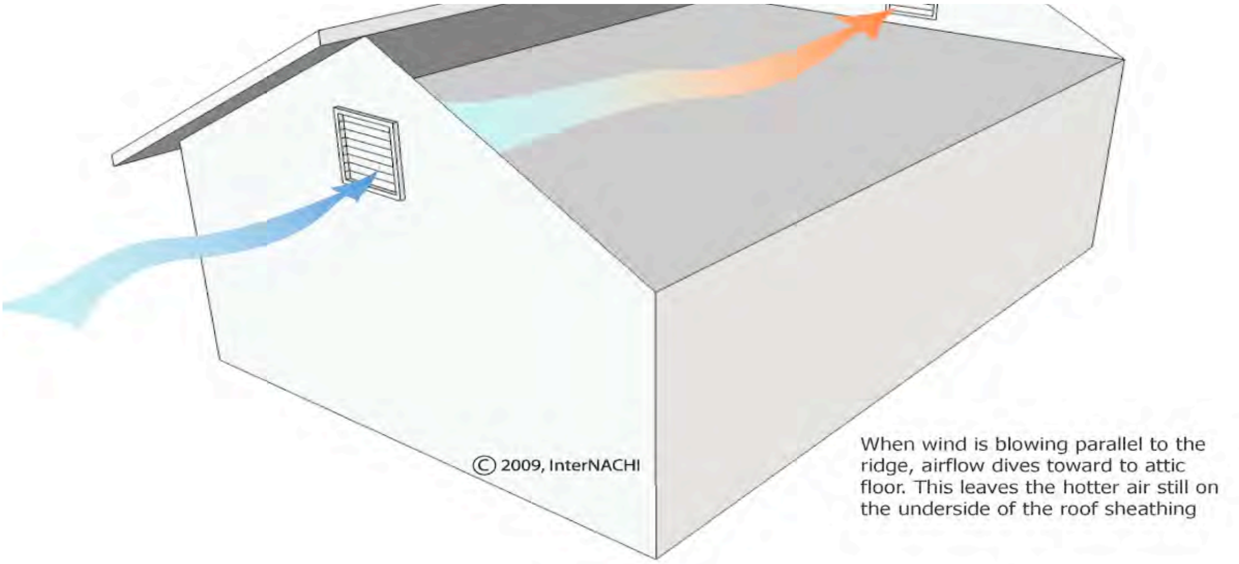


You may see individual vents each serving a rafter bay or continuous vents like you see here.

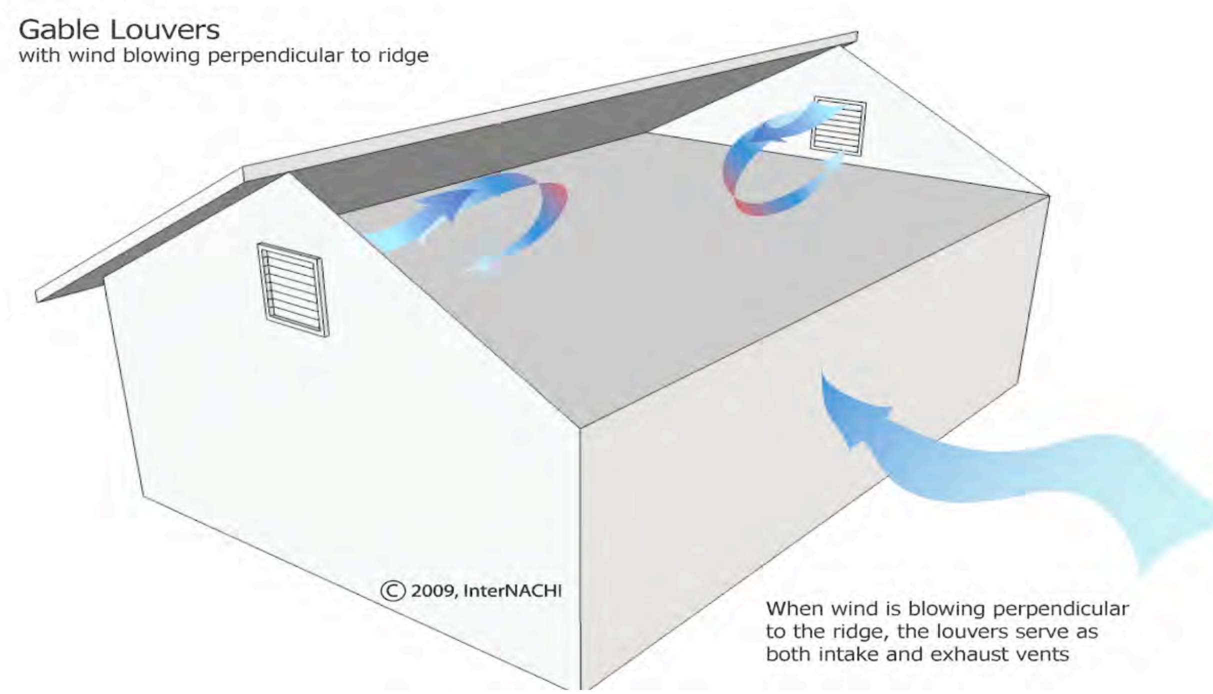
As you inspect the attic, make sure that the soffit vents are not blocked by insulation. This is especially common in attics with blown-in insulation. If you find blocked vents, comment on them in your inspection report. If the insulation is not held back, you should see baffles installed to create an air space.

It's important that baffles extend through to the exterior so that they actually allow air flow into the attic. Once the siding and soffits are complete, you won't be able to confirm this visually. Unless you can actually feel air flowing from the baffles, you will not be able to confirm functional air flow, and you should disclaim it.

Gable vents

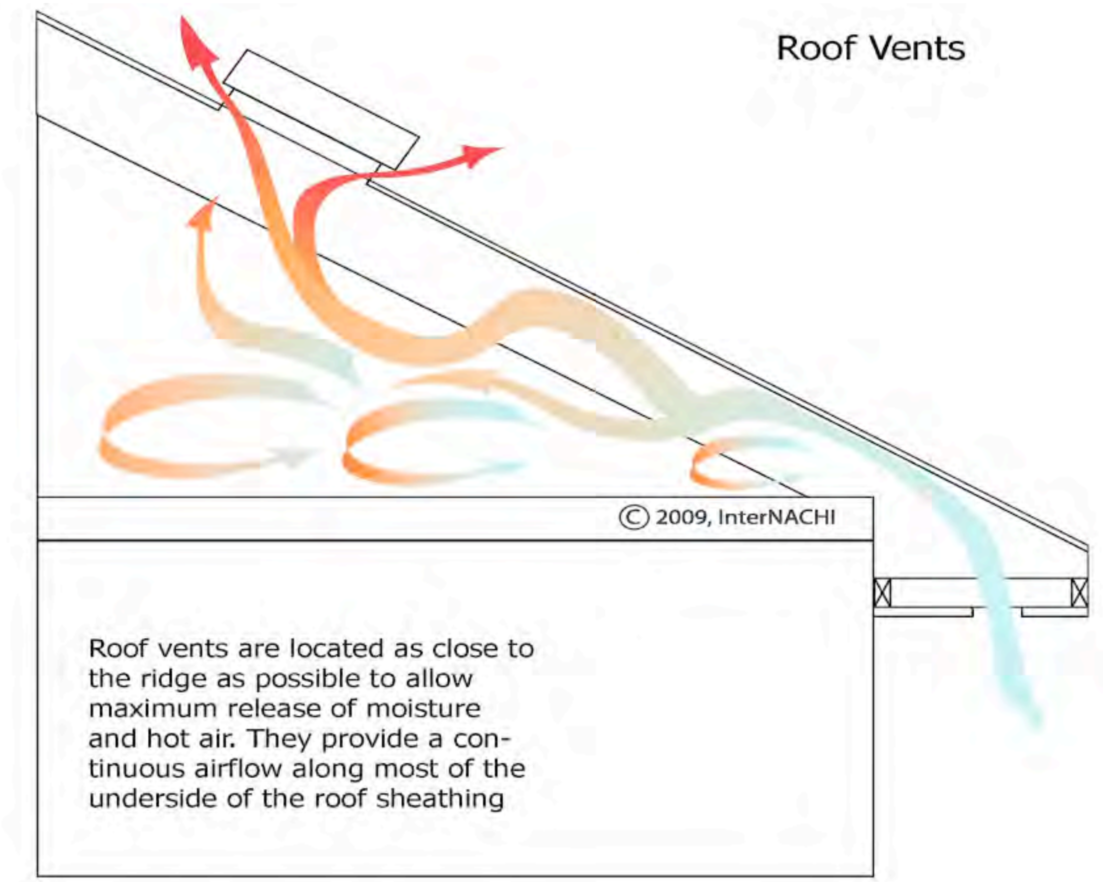


Gable vents are installed in the gabled ends at opposite ends of the attic. They're most effective when the vents align with the prevailing winds. This allows high air pressure on the upwind side of the home to push air into the attic and low pressure on the downwind side to pull air out.



When prevailing winds blow perpendicular to the vents, the gable vents act as both intake and exhaust. Less air exchange takes place, attic ventilation is not uniform and so it’s less effective.

Roof vents



Roof vents, sometimes called “turtle” vents, should be installed near the roof peak. This illustration shows cool air entering the soffit vents. It rises along the underside of the roof sheathing absorbing heat before exiting the attic through the roof vent.

Sometimes the roofers forget to cut the underlayment. Roof vents do not work unless the underlayment is cut out.

Wind turbine

Occasionally you’ll see a turbine vent. Turbines use a series of specially-shaped vanes that catch wind and spin the turbine. As the vanes spin, they create an area of low pressure which pulls air from the attic.

While they're not as effective as ridge vents, they do provide a low-cost alternative in areas with consistent wind speeds of at least 5 MPH.

That's the power cord for the evaporative cooler you see improperly routed through the turbine vent into the attic.

Continuous ridge vent

One of the most efficient ventilation methods is the continuous soffit vent combined with the continuous ridge vent. To form the ridge vent, a slot is cut out of the roof sheathing along the ridge. A fibrous material is installed over the top of the slot and held in place by a cap. The fibrous material will keep out insects while still allowing air to flow. The cap holds the fiber in place and diverts air. Different manufacturers produce ridge vents in different configurations. In general, this is how they look installed on a home.

Occasionally you'll find a ridge vent with nothing installed to keep insects out. This is a defective installation.

This grey fabric is one type of barrier, but you will see other types.

By the way, that’s the vent for the bathroom exhaust fan improperly terminated inside the attic. Bathroom and laundry vents should terminate at the outside, not just beneath the ridge vent and not under the insulation. Looking to see where the bathroom exhaust vents terminate should be something you do automatically. It should be a habit.

Although thermal buoyancy- which is the tendency of hot air to rise- will evacuate hot air from an attic space or rafter bay, ventilation is much more effective if air is actively pulled out of the upper vents by other forces like air pressure differentials.

When ridge vents have baffles, the baffles divert wind blowing across the roof upward. This creates an area of low pressure just above the opening, creating an air pressure differential between the attic space and the exterior which helps pull air out of the attic.

This effect is lost if the prevailing winds blow parallel to the ridge.

At the inspection, you may not know the direction from which prevailing winds blow. A home may have a well-designed system which is poorly oriented to the wind. In this case it may be out-performed by a more poorly-designed system better-oriented to the wind.

You don't have to know exactly how well the ventilation system performs, but knowing how systems are designed to perform might help if you find a problem that may be related to poor attic or roof ventilation. End

Continuous ridge vent

You'll find different types of continuous ridge vents installed. Whatever the type, you should check to make sure that the cap is securely fastened since longer nails are required because of the additional thickness.

This ridge vent was improvised using sections of soffit vent. Obviously the fasteners did not hold well enough.

Adequate ventilation

Most home inspection Standards of Practice require you to comment on the adequacy of attic ventilation. The most commonly accepted formula for determining adequate ventilation is a minimum of 12 square inches of net free area for every 150 square feet of attic space. 12 square inches might be an opening 3 inches by 4 inches.

"Net free" means that louvers or other devices that reduce the actual size of the opening cannot encroach upon the opening.

This minimum can be reduced if a low-perm vapor barrier is installed on the warm side of the attic floor, meaning beneath the insulation. If this is the case, the formula changes to 12 square inches of net free area for every 300 square feet of attic space. So with no air barrier it's 150, with an air barrier, it's 300.

An example of a commonly installed low-perm vapor barrier would be plastic attached to the underside of the ceiling joists before the ceiling was covered with drywall.

RADIANT BARRIERS

Radiant barriers are materials that are thermally reflective. They reflect heat. They often look like foil bonded to cardboard.

Here's an example. You may see sheets stapled to roof framing in the attic.
Stapling sheets to the bottoms of rafters will trap hot air in the rafter bays.

Installing them beneath solid roof sheathing is also unacceptable.

This roof originally had wood shakes installed. When they were replaced with asphalt composition shingles, a radiant barrier was installed on top of the spaced sheathing before a solid roof deck was installed as a substrate for the shingles.

Heat radiated downwards by the roofing materials will be trapped and increase the temperature on the roof. This condition can contribute to premature failure of roofing materials, especially asphaltic underlayment and asphalt shingles. It will also void the shingle manufacture’s warranty. If the radiant barrier installation instructions conflict with the shingle manufacturer’s instructions, the shingle manufacturer’s instructions should take precedence.

A better installation would be to fasten radiant sheets to the attic floor. The amount of heat radiated to the living space will be reduced, but the attic ventilation system will still be able to evacuate hot attic air to the outside.

Generally, shingle manufacturer’s requirements are that the underside of the roof sheathing has to be ventilated for the warranty to be effective.

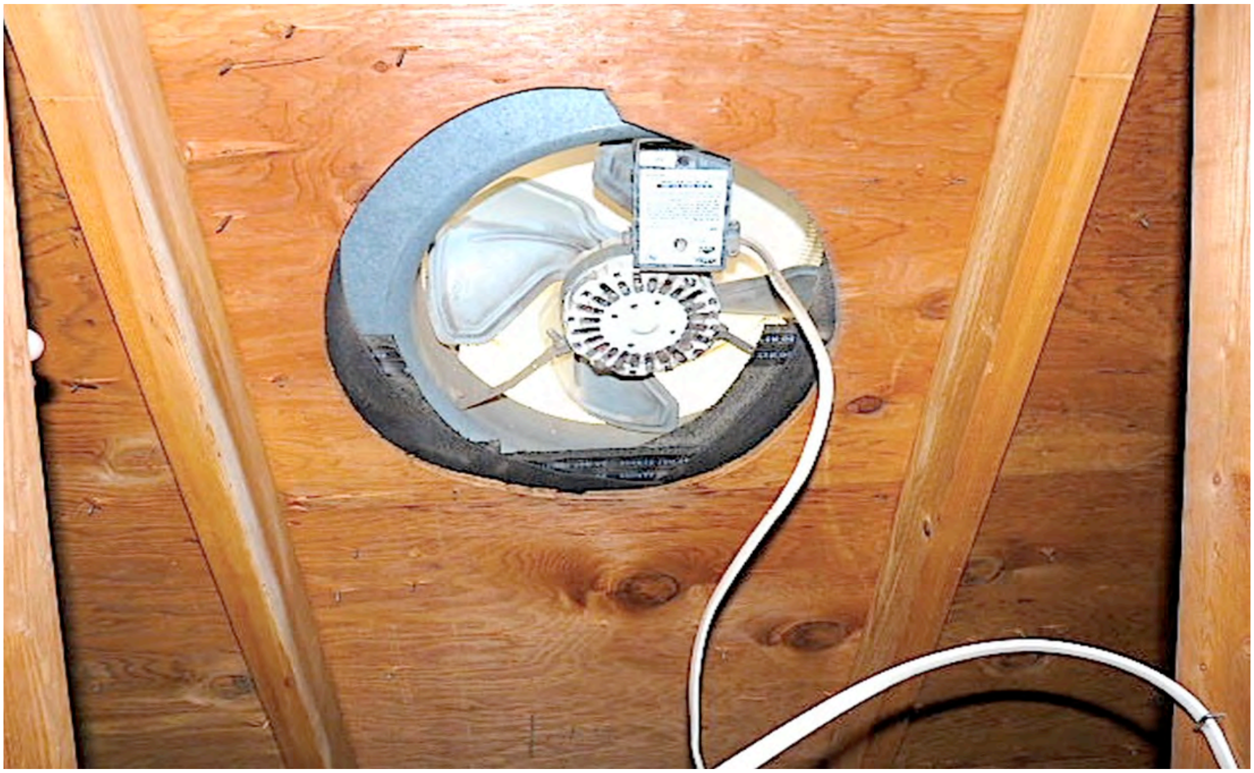
ACTIVE VENTILATION SYSTEMS

Thermostatically-controlled fan

"Active" ventilation systems require some kind of power to operate.

Two types of powered ventilators are pretty common: attic fans and whole house fans.

Attic fans are usually automatically controlled by a thermostat. These are often installed in a gabled end, as you see here. That's the adjustable thermostat circled in yellow.



You may also see them installed between rafters as you see here. The white conductor should be stapled to the framing member nearest to the fan.

Whole-house fan

Whole-house fans are large fans, usually 24 to 30 inches, installed in the ceiling of the top-most floor in a central part of the home. Hallway ceilings are a common location. They may be controlled by a thermostat, a timer or a manual switch.

Whole-house fans pull hot air from the living space and exhaust it to the outside through the attic space. They're typically used with a downstairs window open or with a window-mounted cooling appliance like an evaporative cooler to create a flow of cool air through the home.

If they're used improperly, whole-house fans can cause dangerous backdrafting.
"Backdrafting" is a term used to describe the conditions that result when air is pulled into the home through an exhaust flue.

As a whole house fan pulls air from the living space and exhausts it to the home exterior, the air pressure in the home is lowered, and replacement air, called "make-up air", is pulled into the home through the path of least resistance. If no source of fresh air is provided like an open window make-up air may be pulled from exhaust flues that serve combustion appliances like water heaters. This means that the toxic products of combustion like carbon monoxide can be pulled into the living space.

Backdrafting is more likely to occur in homes with atmospheric furnaces that have no exhaust fan.

It's also more likely to happen in tightly-built homes that have no system for providing make-up air. An example would be a heat recovery ventilator, also known as an "HRV".

It's a good idea to include in your library of narratives one which describes the potential dangers associated with whole-house fans and recommends providing a source of outdoor air, like an open widow or an evaporative cooler installed in an open window.

An air-conditioner will not provide outdoor air since all it does is cool the air that re-circulates through the living space.

COLD CLIMATE ZONES

Cold climates can be roughly broken down into three different types:

Type 1 occasionally experiences snow and cold, but it's generally warm enough that deep snowpack and chronic ice-related problems don't develop.

Type 2 climates experience day and nighttime outside temperatures below 30 degrees for extended periods. These areas get significant amounts of snow, and it stays on the roof for weeks at a time or longer. Ice dams in these areas are caused primarily by heat leaking from the living space.

Type 3 climates are high elevation, like in the mountains, and they're cold and snowy. In addition to heat leaking from buildings, ice dams are caused by intense solar radiation from sunlight combined with dramatic temperature fluctuations from day to night.

Homes located in cold climates can have roofing problems different from homes in warmer parts of the country. Factors that effect roofs are not limited to temperature only.

We'll cover the details in a few minutes, but first, here are the primary factors that effect roofs in cold climates:

Snow load

Consider the depth of snow, it's moisture content and how long it stays on the roof. Wetter snow is heavier and the freeze-thaw process combined with the snow depth can influence the rate at which runoff is produced, at which ice dams are created and the rate and extent to which runoff pools behind ice dams.

Temperature

Outside temperature influences the rate of snow accumulation, the melting rate of snow, and the rate at which ice from runoff forms and accumulates.

Wind

In addition to what we normally think of as wind damage, in cold climates, wind can effect roofs in a couple of other ways. Convection causes wind to speed up as it passes over mountains. As it drops down from the mountains into valleys and onto the plains it compresses, which causes it to become warmer, so that areas affected by this condition can experience milder weather than might otherwise be expected. The other way that wind affects roofs in cold climates is that it may blow all the snow off the roof before it has a chance to melt or freeze.

ICE DAMS

Ice dams form when snowmelt runs down a roof and freezes when it reaches the cold roof overhang or "eve". Runoff can also freeze at parts of a roof that are shaded by trees or structures like skylights, chimneys or dormers.

Over time, frozen runoff can cause ice layers accumulate and create a dam. The outside temperature generally needs to be below about 22 degrees for runoff to form dams at the eves. Snowmelt pooling on the uphill side of a dam can be kept liquid by heat escaping from the home and by being insulated from the cold by the snowpack above.

Eventually, this pooled meltwater can seep through the primary roof-covering material and underlayment and leak into the roof structure and sometimes into the attic or home. When you see stains on sheathing down near the eves, the problem may be leakage from ice dams. A condition in which blown-in insulation has blocked soffit vents is a good indication that this dark staining was caused by ice dam leakage.

In addition to moisture damage, ice dams have the potential to cause structural damage. Ice weighs about 57 pounds per cubic foot. Snow can weigh almost as much as ice or as little as 4 pounds per cubic foot. Snow on roofs that has been compacted by freeze-thaw cycles typically weighs between 10 and 25 pounds per cubic foot. Ice dams that extend out past roof edges and have large icicles hanging from them can add a significant structural load to the eves that the eves are often not designed to support.

In areas with large amounts of snow accumulation, ice dams can develop as a result of a combination of two different effects.

The greatest effect is from heat generated in the living space moving up through the ceiling, attic and roof structure to melt snow on the underside of the snowpack. The degree to which heat from the home will melt snow on the roof depends on the level of thermal insulation, the effectiveness of the roof structure ventilation system and the outside temperature.

The second effect has to do with exposure to intense solar radiation during the day, combined with cold nighttime temperatures. Although this may have only a mild effect at lower elevations, it can have a strong effect at higher elevations.

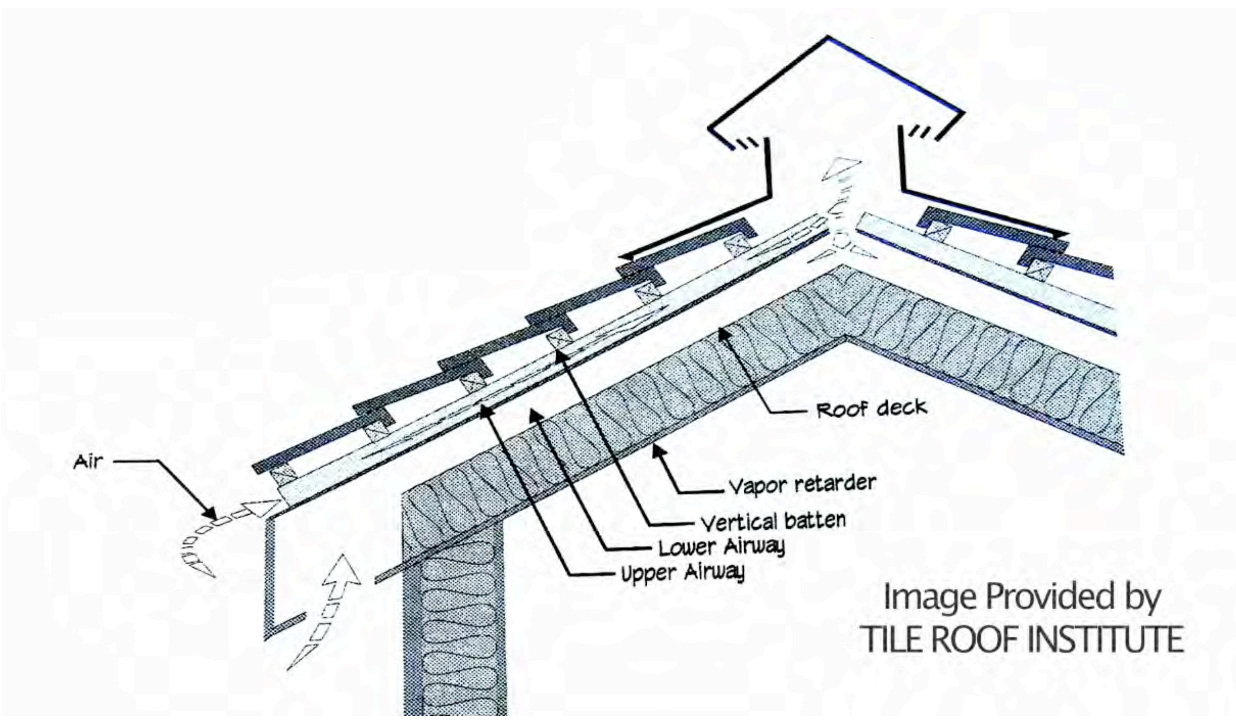
Latitude will also have an effect on solar radiation intensity. Homes located farther north will be effected during the spring, while homes farther south will be effected during the late winter.

Part of the problem is that snow will only hold about 2 to 5% moisture. When additional moisture is added to snow, the snow can't absorb it and gravity forces it downward. As solar radiation melts snow and the meltwater seeps down through the snowpack, a small percentage of that meltwater re-freezes. As it re-freezes, it releases enough energy to melt some of the surrounding snow, continuing the process of creating more meltwater.

Pooled water penetrates the roof covering at headlaps and sidelaps. Once it has penetrated the roof-covering material, it can freeze and become part of the ice dam. As meltwater turns to ice, it expands and can loosen fasteners. If the ice and snow load at the overhang become too heavy it may fall, taking roofing material with it, or it may grow so heavy that the eve framing fails. Preventing the formation of ice dams with good thermal insulation and effective roof structure ventilation is a lot more practical than trying to deal with them once they've already formed.

COLD ROOF SYSTEMS

Cold roof systems are recommended for areas in which homes are subject to ice dam formation. Cold roofs are those that are ventilated well enough to keep snow on the roof from melting when the outside temperatures is below about 22 degrees. High levels of thermal insulation and vapor retarders are important features of cold roofs. Cold roofs are especially beneficial at higher elevations, where solar radiation is more intense and thinner air is less effective at holding heat near the ground. At higher elevations, the temperature of a cold roof exposed to a clear night sky will be lower than that of the surrounding air.



Here's one method of cold roof construction. It consists of both upper and lower airways and a vapor retarder installed on the warm side of the insulation. Both airways help carry away any heat leaking from the living space before it can reach the roof.

At higher elevations, when the sun stops shining on the roof, the roof quickly returns to the temperature of the surrounding air. When this happens to a cold roof, water at the underside of the snowpack freezes into small crystals. This forms what is sometimes called "ripened snow". This permeable layer forms a flow path through which melt water can run off the roof. This is as opposed to a normal roof that forms impermeable ice dams at the roof edge.

When you inspect roofs in colder climates, look for the following problems:

- In homes with cathedral ceilings, look for airways are too small or are blocked.
- In attics, especially those with blown-in insulation, look for ventilation intakes like soffit vents blocked by insulation.
- Ventilation inlets or exhaust vents that are too small.
- Ridge vents clogged with snow or debris.
- Inadequate levels of thermal insulation.
- Air leakage from the living space that allows heat and moisture to enter the roof structure.
- Or mechanical equipment that blows warm air onto the snow.

SLOPE CONSIDERATIONS in COLD CLIMATES

Steep-slope roofs

Steep roofs should be designed to keep the snow on the roof, especially over areas where snow sliding off the roof might damage items, features or people. To hold snow in place, roof-covering materials that are more slippery, like metal, tile and slate will need snow retention devices, also called "avalanche preventers" or "snow-guards".

Snow guards need to be spaced closely enough so that they won't be overloaded and tear free or allow snow to slide, or. Spacing will be specified by the snowguard manufacturer or a structural engineer. Lower quality snowguards may tear free under lighter loads than those of higher quality. There are a lot of different types and they vary in how effective they are, so make sure before you install that the snowguards are high enough quality to do the job and be sure to install them according to the manufacturer's instructions.

Low slope roofs shed water more slowly, so they are more vulnerable to the creation of ice dams than steep-slope roofs.

Flat roofs that drain to components like scuppers or downspouts that can be blocked by ice are at risk in cold climates.

These roofs should drain to a low area with an overflow drain that’s installed so that heat from the structure prevents ice from forming and creating a blockage. Ice blockages are a contributing factor to many roof collapses in cold climates.

HAIL DAMAGE

Hail is big business. The cost of repairing hail damage in the United States averages about $1 billion a year.

For every $100 of homeowner premiums collected by the insurance industry, $30 goes to paying for wind and hail damage. That’s compared to $16 for fire damage, and $11 for water damage.

Hailstorms can also be lethal. In 2002, a hailstorm in China’s Hunan province killed 25 people and injured hundreds more.

Hail damage is identified by inspecting the roof and home exterior. Those performing inspections are most likely to be members of either the insurance, roofing or home inspection industries.

Even though hail damage in the U.S. is widespread and costly, there is a lack of uniform criteria for identifying wind and hail damage among these industries. Although severe hail damage is easy to identify, roofs may be damaged to a lesser degree and inspectors from different industries sometimes disagree about what is and isn't hail damage.

The goal of the hail portion of this certification course is to provide detailed, accurate criteria for the identification of hail damage.

If inspectors from these industries use the same criteria in identifying damage, then there's a good chance of reducing disagreement and also reducing confusion on the part of homeowners about who to believe.

Damage recognition will be different for the different roof-covering materials, so in the general course we'll stick to hail characteristics common to the major steep-slope residential roof-covering materials.

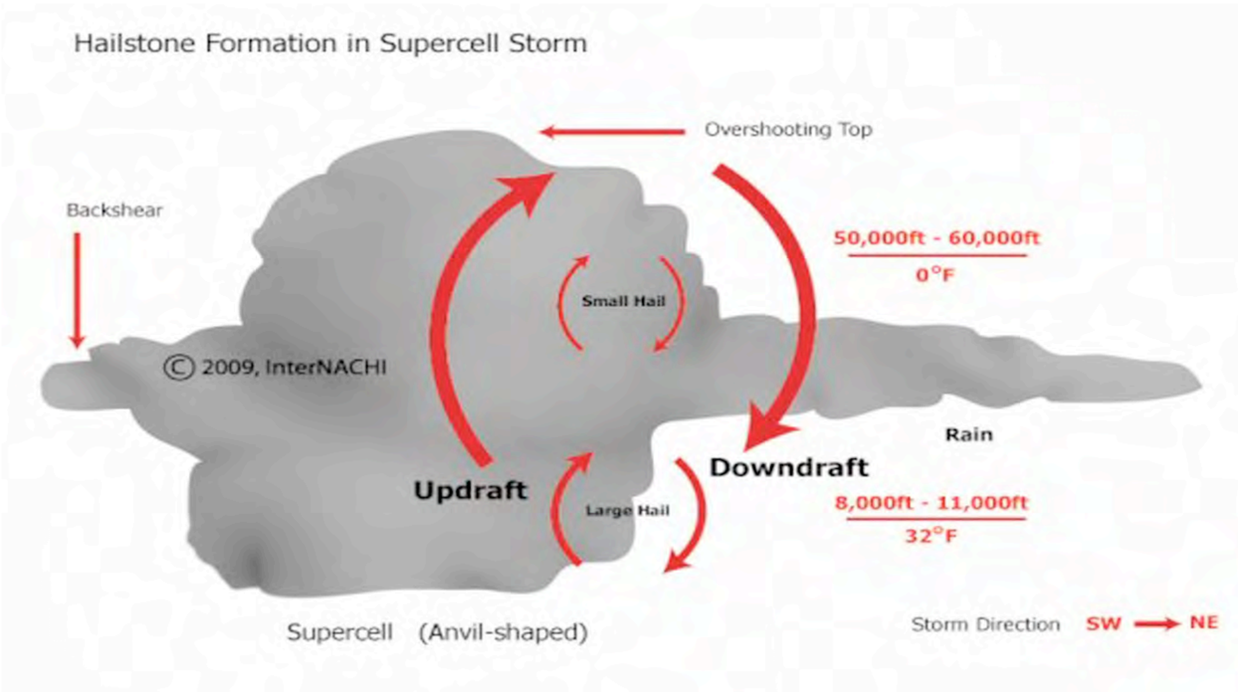
We'll cover hail damage specific to each of those materials in the InterNACHI courses on asphalt shingles, wood, tile, metal and slate roofs.

First, lets talk about how hail forms.

The uneven heating of the earth's surface creates wind as warm air rises, pulling replacement air in behind it. Rising air is called an "updraft" and the process is called "convection".

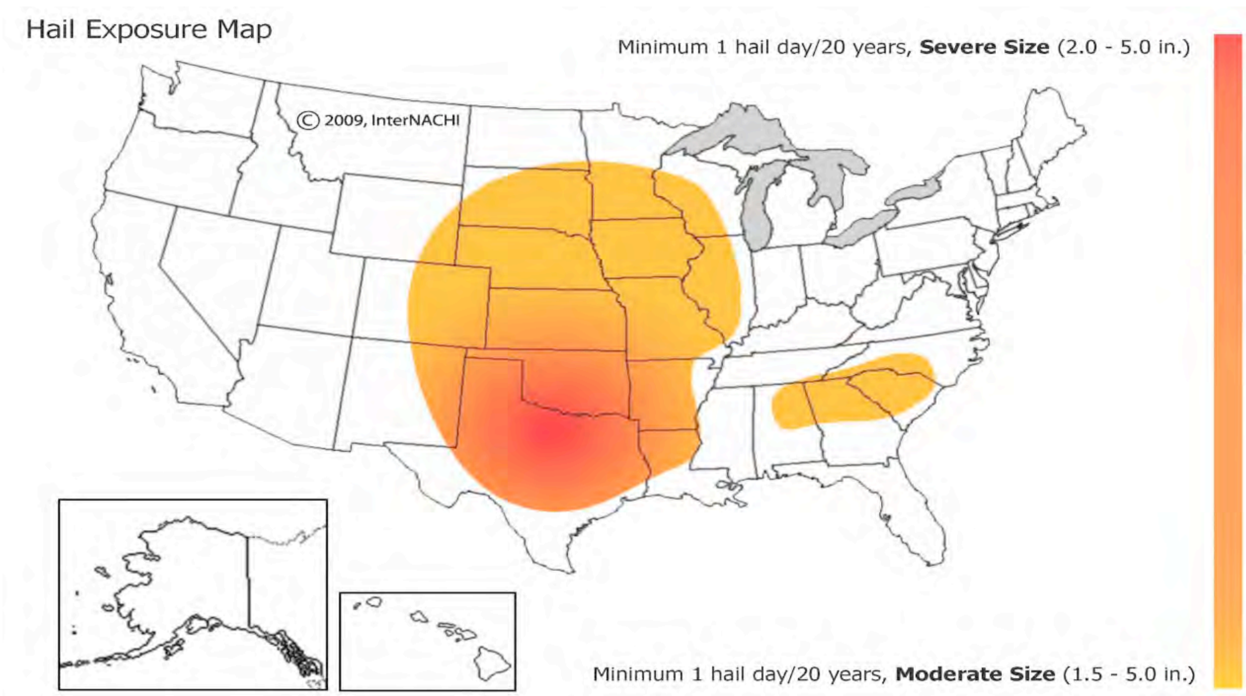
This tornado began as an updraft. Eventually, the updraft began to rotate, and the tornado was born. Although updrafts are associated with a number of different types of storms, we're concerned with one particular type called a "supercell". In addition to tornadoes, supercells can produce hail.

Hail is composed of balls of ice called "hailstones".



Hailstones are formed inside storms when updrafts carry dirt and dust particles high into the cold, upper parts of storm clouds. Super-cooled water clings to the particles, then freezes, forming tiny ice balls. Once the updraft weakens, the ice balls fall until they're lifted back into the clouds again by another updraft. As this process is repeated, the ice balls accumulate layers of ice and get bigger. Once they become too heavy to be supported by wind, they fall from the sky as hailstones.

Hail Damage: Where and When?



Although hail can fall anywhere on earth that conditions are right, the majority of hail damage in the U.S. occurs in the midwest from South Texas north to Minnesota and from Colorado east to Illinois. Another band of high hail damage potential runs east to Virginia.

The hail season generally starts in the southern US in late March and continues through August. Storms typically moved from Southwest toward the Northeast.

DEFINING HAIL DAMAGE

For insurance purposes, hail damage to roofing-covering materials is defined as either "functional damage" or "cosmetic damage".

Functional Damage

Functional damage is damage which, diminishes the ability of a roof to shed water or reduces its expected long-term service life.

Functional damage will vary with different types of roof-covering materials. Wood roofs will show functional damage differently from asphalt or tile roofs.

Cosmetic Damage

Damage which doesn’t meet the definition of “functional” is considered “Cosmetic”.

Cosmetic issues may be discoloration or damage, which doesn’t affect the lifespan of the roofing material or reduce its ability to shed water. Cosmetic damage is that which only affects the appearance of a material or affects its functionality to only a minor degree. Some examples would be:

- minor localized granule loss from hailstrikes to asphalt shingles, or
- hail dents in metal vents, gutters or downspouts.

Cosmetic issues will also vary with the type of roof-covering material installed.

Insurance companies may or may not pay for cosmetic damage.

An example of when an insurance company might pay for cosmetic damage is when the damage results in a financial loss to the policyholder or if required by state or local law. When cosmetic damage will be paid for will also vary somewhat by the policies of various insurance companies and how each policy is written.

A “loss” is usually interpreted to mean a loss in the home’s value. This might be an expensive copper roof, which was badly dented by hail. It might vary by location. If the copper roof were in a highly visible portion of a high-end home, damage would be more likely to be paid for than if it were on a portion of a second story roof, which was barely visible from the ground.

Even when it’s paid, payment may be half of the replacement cost, or even less. Copper roofs last so long that hail impact dents are an expected part of their history and character.

As the on-site inspector, you will not be making the decision as to whether the hail damage is covered by the insurance policy that’s the job of the desk adjuster. You will need to know enough about what constitutes hail damage to provide information in your report adequate to allow the desk adjuster to make a good decision.

Now let’s take a look at the different factors which determine how severe hail damage can be.

HAIL DAMAGE CHARACTERISTICS

Hail damage has certain characteristics, which will vary with both the different properties of hail, and with the properties of the various roofing materials that hail hits. First, let's examine the different properties of hail.

PROPERTIES of HAIL

The severity and appearance of the damage caused by hailstones depends on a number of variables. The size, density, free-fall velocity, the shape the hail, its directionality and angle of impact can all affect the damage you see during an inspection.

IMPACT ENERGY

Three of these properties - size, density and free-fall velocity - affect what's referred to as the "impact energy" of hail. Impact energy is the amount of energy transferred to the roof-covering material when the hailstone strikes. Impact energy is the most important factor influencing the severity of damage caused by a hailstone. A hailstone carrying a lot of impact energy will do more damage than one carrying less impact energy.

Size

Size is an important factor because larger hailstones are heavier and fall faster than smaller hailstones and so they carry more impact energy.

Hail size is described by comparing it to a common object. Here are commonly used descriptions:

Pea = 1/4 inch diameter
Marble/mothball = 1/2 inch diameter
Dime/Penny = 3/4 inch diameter - hail penny size or larger is considered severe
Nickel = 7/8 inch
Quarter = 1 inch
Ping-Pong Ball = 1 1/2 inch
Golf Ball = 1 3/4 inches
Tennis Ball = 2 1/2 inches
Baseball = 2 3/4 inches
Tea cup = 3 inches
Grapefruit = 4 inches
Softball = 4 1/2 inches

TABLE 1

Material	Hail size to Damage	
3-tab organic shingles	1 inch	25mm
3-tab fiberglass shingles	1.25 inch	32mm
Cedar shingles	1.25 inch	
Fiber-cement tiles	1.25 inch	
Flat concrete tiles	1.25 inch	
Heavy cedar shakes	1.5 inch	38mm
30-year laminated shingles	1.5 inch	
Built-up gravel roofing	2 inch	50mm
S-shaped concrete tiles	2 inch	

Table 1 shows the size of hailstone typically required to damage various types of roof-covering materials. This is a general guide only, since the severity, appearance and likelihood of hail damage can be affected by a number of factors, as you will soon discover.

You can see that organic 3-tab shingles are the most fragile, since they can sometimes be damaged by hail as small as 1 inch in diameter.

Fiberglass 3-tab, cedar shingles, fiber cement and flat concrete tiles may begin to suffer damage when hail reaches about an inch-and-a-quarter.

Heavy wood shakes and thicker fiberglass shingles may start showing damage when hail reaches about an inch-and-a-half.

Concrete S-tiles can start showing damage when hail reaches about 2 inches.

The size of a hailstone is determined by the number of ice layers it accumulates before it falls to earth. Larger, more powerful storms with strong winds may keep hailstones aloft long enough for them to reach large sizes.

It can be difficult to tell the size of a hailstone by the damage it leaves.

Damage left by hailstones of the same size can vary, depending on hailstones' density, their angle of impact, and the properties of the material they hit.

It's also common for the size of hailstones to vary within a single storm. Hailstones at the leading and trailing edges of storms may be of a size different from those in the main body of the storm, so it's not unusual to see damage to a property with characteristics of different-size hailstones.

When discussing the importance of impact energy and the characteristics of hailstones, size is the easiest to estimate. You can't tell the density or free-fall velocity of a hailstone by looking at the damage it leaves behind. But as you become more experienced at inspecting hail damage, you'll become more skillful at judging the size of the hailstone by looking at the damage to a variety of materials.
Hard hailstones hitting soft, thin materials like aluminum vents will leave a better indication of their diameter than soft hailstones hitting hard materials.

You don't really need to determine the actual size of the hailstone. Your mission is to idedntify functional damage or the lack of damage. Size is just one more clue.

As long as we're talking about size, let's take a look at a really big hailstone.

Here you see Dr. Charles knight opening a plastic bag containing the largest hailstone ever recorded in the US.

Hailstones have been known to smash completely through roof and attic materials and land inside homes.

A hailstone like this one punched right through the garage roof sheathing.

Although recognizing damage from huge hailstones is easy, recognizing what is and isn't damage from smaller, softer hail can be much more difficult.

Density

Studies have shown that hailstones vary in density. The density of a hailstone is an indication of how hard it is. The layers of ice, which accumulate as a hailstone grows, often contain air bubbles which make the hailstone softer, lighter and less likely to cause damage.

A low-density hailstone can have more in common with a snow cone than it does with a hailstone. Softer hailstones leave distinctive marks called “spatter”, which can be a good indicator of the size, density and quantity of hail fall.

Larger hailstones are not necessarily harder than smaller stones. Hailstones consist of layers, and each layer can vary in density. Many different degrees and combinations of density are possible.

Although softer stones may not damage roof-covering materials, they may leave noticeable temporary marks on whatever they hit. Instead of indentations, spatter often leaves marks resulting from the removal of surface oxidation, particulates such as dust and dirt, or microbial growth.

Velocity

Another word for the speed at which a hailstone falls out of the sky is its “velocity”. The velocity at which a hailstone falls is limited by its aerodynamic shape, its size, and the quality of its surface.

The fastest speed at which an object of a specific shape can possibly fall is called its “terminal velocity” or “free-fall speed.” The terminal velocity of hailstones is important because the faster a hailstone falls, the more impact energy it carries. A hailstone falling fast is more likely to cause damage when it hits than a similar hailstone falling more slowly.

Material	Hail size to Damage	
3-tab organic shingles	1 inch	25mm
3-tab fiberglass shingles	1.25 inch	32mm
Cedar shingles	1.25 inch	
Fiber-cement tiles	1.25 inch	
Flat concrete tiles	1.25 inch	
Heavy cedar shakes	1.5 inch	38mm
30-year laminated shingles	1.5 inch	
Built-up gravel roofing	2 inch	50mm
S-shaped concrete tiles	2 inch	

This Hail Fall-Speed Table shows the terminal velocities for hailstones of different sizes, and the impact energy each size carries. It assumes that hail is smooth and spherical.

If you compare the speed and impact energy of a 1-inch hailstone to that of a 3-inch hailstone of equal density, it's easy to see why larger hailstones do more damage. The 1-inch hailstone falls at about 50 miles per hour and carries less than 1 foot-pound of impact energy. The 3-inch hailstone falls at almost 90 miles per hour and carries 120 foot-pounds of impact energy.

Impact energy increases exponentially as hailstone size increases.

Hailstone variation

It's not unusual for hail within a single storm to carry different amounts of impact energy. Hail at the leading and trailing edges of the storm may have characteristics different from hailstones falling from the main body of the storm since the conditions at the edges of the storm will be different from those in the middle.

Shape

Hailstone shape is important because it affects the manner in which the impact energy from a falling hailstone is transferred to the material it strikes.

A conical hailstone hitting at the wide end will spread the energy of its impact over a larger area than a hailstone hitting at the narrow end. The smaller surface area of the narrow end will concentrate the force of the hailstone strike, which increases the chance of hail damage.

About 75% of hailstones are spherical, conical, or ellipsoidal in shape, ellipsoidal being like a slightly squashed sphere.

Spherical is by far the most common shape, especially with small or medium-sized hail. Hail can form geometrical or irregular shapes. Larger hail is more likely to have lobes.

Directionality

"Directionality" is a term used to describe the fact that hail usually blows in from a certain direction. Since hail is associated with storms, the roof slope and elevation facing the direction of the oncoming hailstorm will suffer the most severe damage. Although supercells in the west generally move from the southwest toward the northeast, this can vary.

The concentration of damage should vary according to which direction each home elevation faces. This photo shows a home that had 10 hits in the siding at the back of the home, but no hits at the front or sides. The hail was not orange and did not do in the dog, although it may have clipped him. This area was hit by tennis ball-size hail. No wonder this poor dog is tired.

Hail can hit all exposed surfaces, so evidence of the direction from which hail came should be apparent on a number of different types of surfaces, and not just on the roof. Evidence of hail damage may be visible on a number of items around the home. This is called "collateral damage". Examining collateral damage may give you useful information.

Occasionally hail will fall almost straight down and in these situations damage on different slopes may be similar and collateral damage may be limited.

When you perform onsite inspections, you should see evidence of hail, which is consistent in its directionality. If hail blew in from the Southwest, you would expect to see the most severe hail damage on surfaces facing that direction.

If you see hail damage of similar severity on both the north and south sides that is not consistent with damage from a single hailstorm, but is more likely to be damage from two separate hailstorms. You should compare the damage from each side, and look for signs that indicate damage of different ages. We'll talk more about how to do that later.

Angle of impact

Hail falling in storms with higher wind speeds will impact at a steeper angle than hail falling through calmer air.

The severity of damage from the angle of impact should be consistent with other evidence of directionality that you see on various surfaces around the property.

Blown hail will also produce more collateral damage than hail falling closer to straight down.

PROPERTIES of ROOFING MATERIALS

Let's examine the properties that affect the impact resistance of some of the common steep-slope roof-covering materials.

Resistance to hail damage depends upon a number of factors:

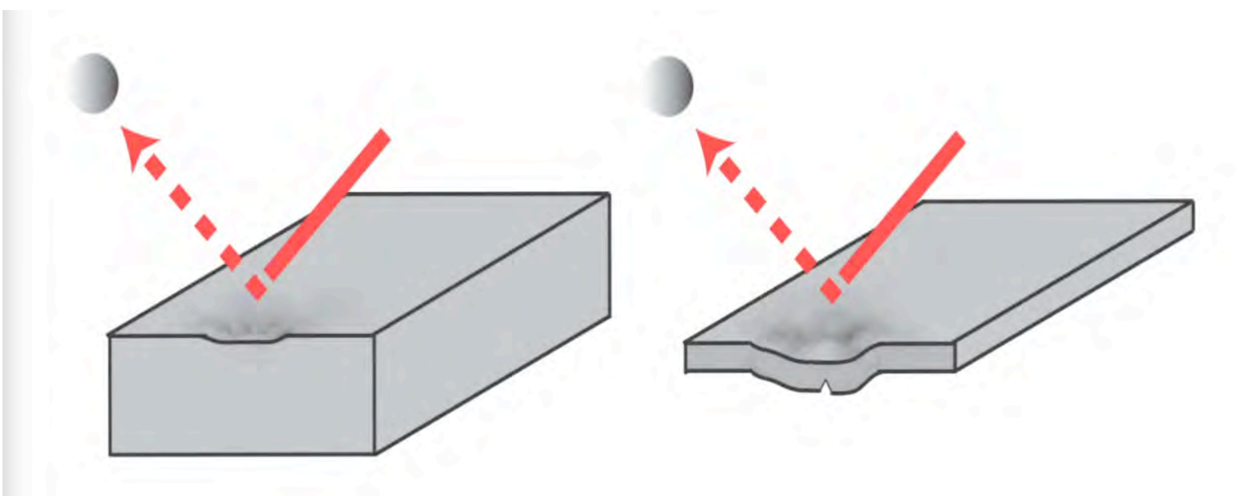
Type of roof-covering material

The type of roof-covering material is one factor. Some types of materials and profiles are more resistant to damage than others. Metal roofs seldom suffer functional damage from hail. Many thousands of asphalt shingle roofs are damaged by hail every year.

Roofing material condition

The condition of the roofing material is another factor. These photos show a 20-year old asphalt shingle roof that has suffered general granule loss. You can see it accumulated in the gutters.

This condition was probably contributed to by widespread blistering, an example of which is shown in the third photograph. General granule loss is not considered functional damage.



The thickness of the roofing material will also affect the severity of damage. Assuming that we're comparing similar materials like thick and thin asphalt shingles, thicker materials will typically resist damage better than thinner ones.

The characteristics of the substrate will also affect the severity of damage. Thick, solid, smooth, single-layer substrates will improve the ability of the roof-covering material to absorb impact, and this reduces the chances of functional damage. Solid wood decks supply good solid substrates. Layers of old roof-covering materials offer poor support against hail impact.

Part of the roofing material hit

The amount of damage will also be affected by the part of the roofing material that’s hit. The edges of roof components, like wood and asphalt shingles, are more fragile and subject to damage than material in the middle of the components, since the edges have less surrounding material for support. Ridge and hip cap shingles are more poorly supported and so are more likely to suffer hail damage.

Temperature of the roofing material

The temperature of the roofing material can also have an effect. Roof-covering materials like asphalt shingles become increasingly brittle at lower temperatures. Brittle materials are less able to absorb impact without damage, so cold materrials more likely to be damaged by hail.

FORENSICS OF HAIL DAMAGE

Next, we’re going to spend some time on the forensics involved in identifying hail damage. “Forensics” means looking at damage from a variety of perspectives, including close up – in fact, so close that you might need a magnifying glass to see tiny clues like scratches – and also from farther away, so that you can see the overall pattern of hail strikes. You’ll also look at places other then the roof.

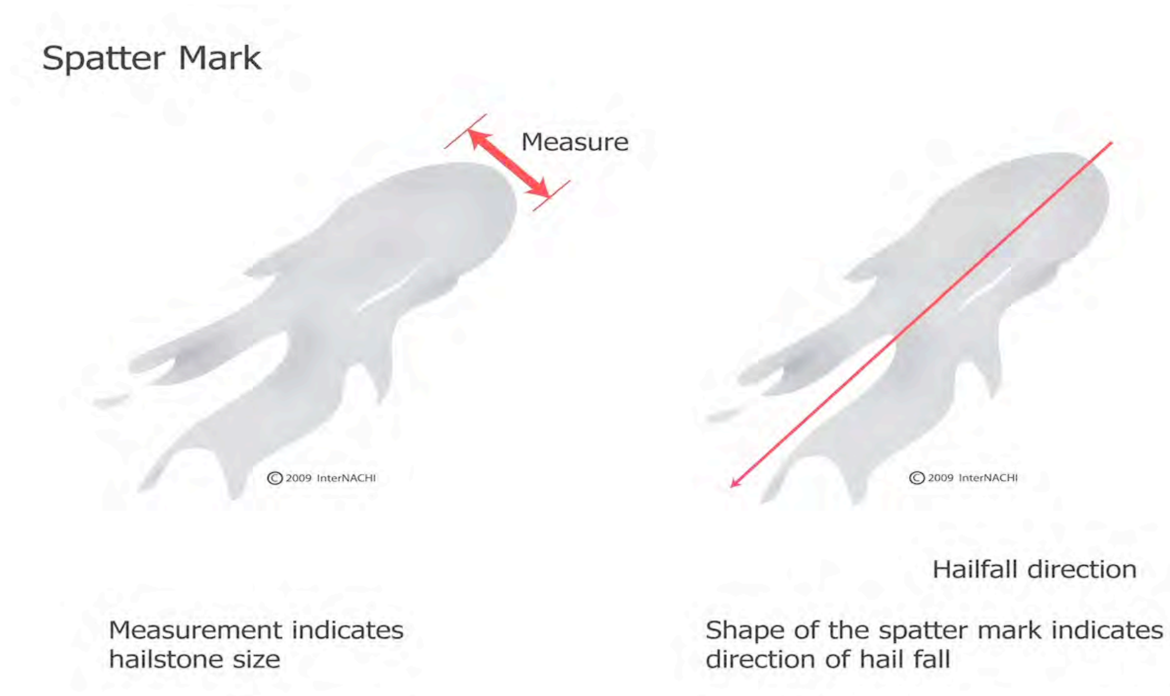
Collateral damage

Before you go up on the roof it’s a good idea to walk the perimeter of the home to look at collateral damage. We’ll talk more about collateral damage in more detail in a couple of minutes.

Spatter

Strikes from hailstones will usually leave one of two types of marks: spatter or indentations. Hailstones that leave spatter marks are more like sloshballs than hailstones. When these sloshballs strike they remove oxidation, dust and dirt, and microbial growth from whatever they hit.

Over time, spatter marks will re-oxidize, become re-covered by particulates and will blend in with the surrounding surface, so spatter is really temporary discoloration rather than damage.



The shape of a spatter mark can offer information about hail size and the direction of fall.

The long axis of the spatter mark will align with the direction from which the hail came.

The width of the spatter mark will give a rough indication of the hailstone’s size for hail less than 2 inches. With hail larger than 2 inches, the width of the spatter mark will increase significantly in relation to the actual size of the hailstone that made it.

SOURCE OF DAMAGE

Indentations can have many causes other than hail. The downspout material can be aluminum, galvanized steel or copper. Hail does not scratch or crease metal.

These photographs show actual hail damage to gutters.

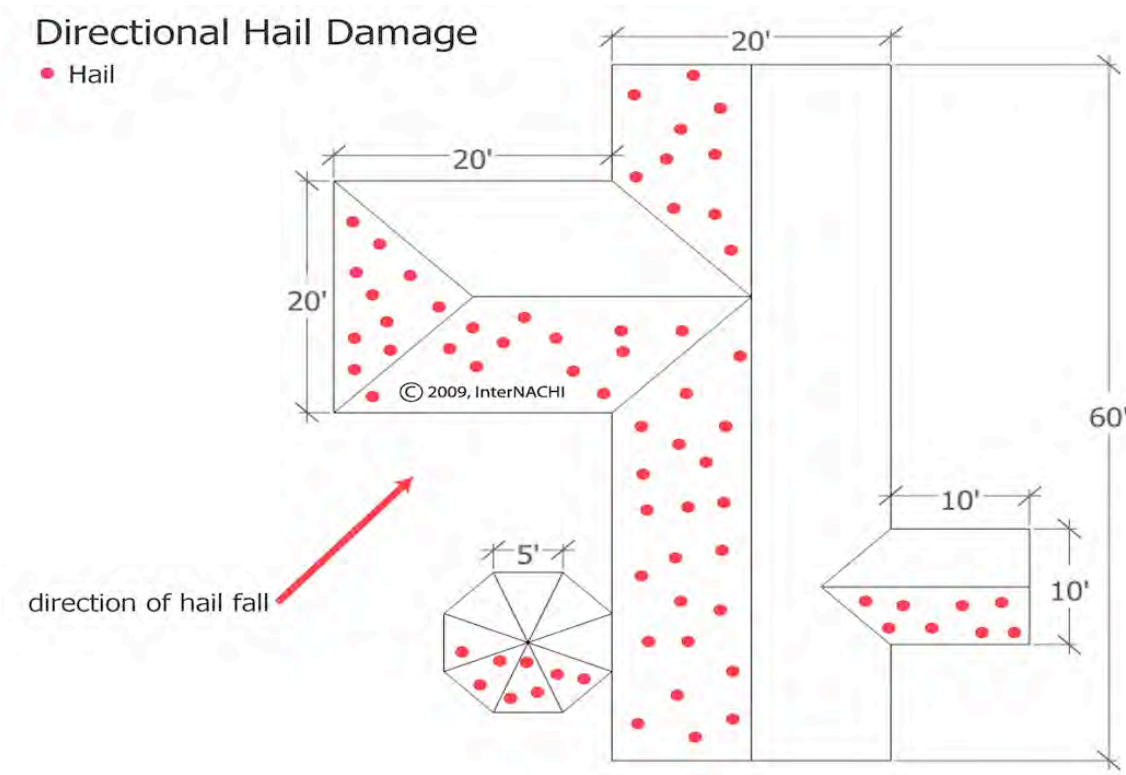
You can see that the force that created the indentations came from above.

Damage can come from a variety of sources.

Here you see damage that's not consistent with hail damage. The force that created this damage did not come from above.

DAMAGE DISTRIBUTION

Directionality



We've talked about viewing evidence of storm direction by examining collateral damage. The same is true with the roof. You'll usually see that damage is more serious on slopes facing the same direction. This is the direction from which the hail came. If opposite-facing slopes both have damage, you may be looking at damage from different storms. It's possible that hail from one storm carried more impact energy than hail from another. Look for differences in the age of damage. It's also possible that there was little wind and that hail fell nearly straight down.

Random fall pattern

The fall pattern should be random. Hail falls from thousands of feet in the air, so the pattern of damage across the roof should be random. If you see geometrical patterns of damage, examine the damage closely for evidence of causes other than hail.

Intentional damage

Roofs are sometimes intentionally damaged by those wanting to defraud insurance companies to get a new roof. If you see damage that is concentrated in areas away from the roof edge, areas in which damage appears as a series of short arcs, or damage which appears as separate groups, you should examine individual marks closely for signs of intentional damage. The details of intentional damage will vary with the type of roof-covering material.

Again, damage should be random across the roof. Hailstones may hit any part of a roof-covering material, including its edges, and you may see one indentation overlapping another. If you see damage, which appears only in the same part of different shingles, look closely for evidence of other types of damage.

AGE of DAMAGE

The appearance of older damage usually has to do with color. Hailstrikes often remove oxidation and particulates, leaving the area of the strike a different color from the surrounding material. Over time, the damaged materials will re-oxidize and become recxovered with particulates, so that although some evidence of damage may remain visible, older damage may look different from newer damage.

INSPECTION METHODS

Since hail is associated with storms, you may find wind and hail damage together as a result of a single storm. Let's go over some inspection methods you might use if you suspect that the home has hail damage.

IDENTIFYING COLLATERAL DAMAGE

Not all hail damage is on the roof. Many materials at ground level can also be damaged by hail. Damage to items other than the roof are called "collateral damage". The nature of collateral damage may give you information about hail size and density that will help you to better understand damage you see on the roof

The most imoprtant type of collateral damage is "elevation damage". "Elevation damage" is damage to those parts of the home on the exterior walls, like siding and trim, windows and doors, window well covers or any other building components that can be damaged by hail.

"Collateral damage" is more general and might include lawn furniture or decorations, or free-standing components like air-conditioning units. In performing the "elevation inspection" you'll be examining everything you see when you step back from the exterior walls and look at the side of the home. Depending upon the material, you could be looking for cracks, dents, punctures, broken glass, spatter marks or dislodged materials. Remember that hail does not leave scratches in the material it hits, so if you see scratches in indentations, the damage was not caused by hail.

Hailstones do not produce damage with creases, so if an indentation is creased, it's not hail damage.

All materials can be damaged by hail. Even concrete and steel can be damaged if hail is big, hard and wind-driven.

Let’s take a closer look at the components you’ll be examining when you inspect for elevation damage. We’ll start with the exterior wall components.

Gutters and downspouts

Gutters and downspouts are often fabricated from steel, which is highly resistant to hail damage. Aluminum gutters are damaged fairly easily and copper is harder than aluminum but softer than steel. In addition to the type of metal, damage to metal gutters and downspouts will depend on the thickness of the metal. Vinyl gutters and leafguards will show punctures or cracks.

Gutters

Downspouts

When you look at gutters you’ll be watching for dents made by hail falling from above or blown from a particular direction. Hail striking the bottom of the gutter will create downward indentations. Hail striking the front side of the gutter may create indentations either toward or away from the gutter channel, depending on the direction of hail fall. These are called innies and outies.

Hail-caused indentations in aluminum gutters and downspouts are typically smaller than the diameter of the hail that caused them.

Damage from ladders leaning against a gutter and other mechanical damage should be fairly localized and easy to identify. A ladder will leave two scrapes or dents about 16” apart. Damage is usually in a spot where it would be convenient to place a ladder.

Not all damage you’ll see will be hail damage. This photo is an example of non-hail damage. There are several clues:

The force that created the upper indentation was from the side. Hail might be wind-driven, but hail with enough impact energy to create a dent this severe would not be blown horizontal. This damage also includes creasing and has chipped paint. Hail does not crease metal.

The force which created the lower indentation was from below, which is inconsistent with hail damage.

Windows and doors

Window screens can show streaking or damage from even relatively small or less dense hail.

Wood windows, doors and trim are sometimes clad with aluminum on the exterior and this cladding, especially on horizontal surfaces, can show indentations or spatter marks from hail.

Fiberglass or vinyl windows may have cracked frames. Steel frame windows may have indentations or spatter marks. If hail carries enough impact energy, it may break window panes.

Garage doors are often made of aluminum and will show damage.

This garage door opening has aluminum trim, which can be easily damaged by hail. In looking for hail damage you’re not limited to using your eyes. You can also feel for it. If the surface you’re examining is in the shade, it may be easier to feel damage than see it. It’s often easier to see if you use the side of a piece of sidewalk chalk to color the area around the hit, although this will create the illusion of larger damage than actually exists.

Siding

Aluminum siding

Aluminum siding is the type most easily damaged by hail, with the damage appearing as indentations as you can see in this photograph. Soaking the siding with a hose will make the damage much more apparent, so if possible, you should spray it before you photograph it.

Also important to remember is that just because wetting the surface makes hail impressions easier to see doesn’t necessarily mean that the siding has suffered functional damage functional loss like fracturing, which would allow moisture intrusion.

This damage is not all hail. You can see spatter marks, but also more severe damage. Hail won’t leave damage that looks like a slice, and hail damage doesn’t appear as scratches.

Aluminum dryer vents will also show damage. Spatter marks, which are areas where hail impact has removed oxidation from the surface. These marks will re-oxidize and fade over time.

Hail fall is random. It’s not likely to leave marks of identical size, equal distances apart and appearing on the same part of different shingles.

Vinyl siding
Vinyl siding is easily cracked or broken and large hail can leave spectacular damage.

This neighborhood was hit by a storm dropping hail in the 1 ½” to 2 ½ inch range. Homes in surrounding neighborhoods had hardboard siding that showed only minor damage like paint chips. This storm left damage on downspouts, vinyl, wood and aluminum trim. The entire neighborhood looked like it had been attacked by a battalion of teenagers with potato cannons.

Wood siding can be cracked, dented or broken. Lapped wood siding is more easily damaged than wood panel siding. Lapped siding on older homes was often manufactured from redwood, which is a relatively soft wood that becomes brittle with age.

Hail not dense enough to damage wood siding may discolor it by removing oxidation, or organic growth like black algae and green mold. This “spatter-cleaning” is a temporary condition.
Paint may also be damaged if wood is indented.

Fencing

Wood fencing may be dented or discolored by hail. This photo shows a fence that has been hit by small, hard hail.

Minor dents will often disappear with time as wood fibers compressed by the hail impact swell as they absorb moisture from precipitation or humidity.

Discoloration from the removal of oxidation by the impact will typically blend with the rest of the fence after a few months as the newly-exposed wood re-oxidizes.

Metal fences may also have oxidation removed, which will soon blend with the rest of the fence.

Fences which have been painted may have damage to the paint which will require re-painting the fence. Vinyl fencing may be cracked or punctured depending on its profile and the impact energy of the hail that hits it.

Painted surfaces

Painted surfaces can be chipped or cracked by hail. Horizontal surfaces are more likely to show damage and so are surfaces with older paint, lower quality paint or surfaces that were not primed before they were painted.

Air-conditioning units

The heat-radiating fins of air conditioning units are easily damaged by hail and the metal jacket of the unit may show damage from larger hail. Indentations on the thin aluminum fins can reflect pretty accurately the diameter of hailstones that caused them.

Aluminum AC fins usually reflect closely the actual size of the hailstones unless you see spatter marks, indicating that the hail was soft.

Hail indentations of the fins may be a covered loss requiring fin combing or even replacement and so should be included in the report. Photograph AC units from opposite corners so that all four sides are visible in two photographs

Metal electrical panels are one more ground-level item that may show indentations but more typically show spatter from hail. Spatter marks on panels can help you determine the direction from which the hail came.

Window well covers may also take a beating and can sometimes give you a good idea of hail diameter, density, direction and quantity.

Directional clues

If you see hail damage on different sides of the home, indicating that hail came from different directions, you may be seeing damage from two different hailstorms. You should examine the evidence closely for clues to differences in age of damage, like color variations in similar materials due to differing amounts of UV exposure or oxidation.

HAIL DAMAGE on the ROOF

When inspecting for hail damage, it’s important to understand the methods used by insurance claims adjusters, since, if damage for which an insurance company will pay exists, it should be identified and documented using insurance company criteria.

Test squares

Claims adjusters mark off test squares on a roof to document the extent of damage. The size and locations of test squares are the same no matter what roof-covering material is installed. Here are some test square details:

Test squares are 10 feet by 10 feet. A square shape is used whenever possible, but if it's not possible to use a square because of the roof shape, other shapes can be used. The test area size should always be 100 square feet no matter what the shape.

Test squares should be placed on each roof slope.
They should be located in areas of the most damage. They should not be located in areas of a roof which are protected by things like overhanging tree branches.

Number of hits
Once the test square has been created, the adjuster counts the number of hailstrikes within the square. These hailstrikes have to meet the definition of functional damage. The number of hits required to replace that slope of roof will vary. Different insurance companies have different policies. 8 hits is a common number.

Slope/roof replacement

The decision of whether to replace individual slopes or to replace the entire roof requires weighing a number of factors. The age of the roof will be one factor. Older roofs are more likely to be replaced. Some insurance companies use a formula in making the decision.

Disagreements
Occasionally disagreement will arise among insurance companies, roofers, home inspectors and policyholders about whether damage meets the criteria for roof replacement.

One area with a lot of potential for disagreement is whether the damage meets the description of "functional damage".

The characteristics of hail-caused functional damage will vary with the different types of roof-covering materials. It will be easier to identify functional damage with some materials than others.
There's more potential for disagreement with a material like asphalt composition shingles which may be damaged to some degree. It may be light damage, which does not meet the criteria for functional damage,

or it may be serious damage that does. These issues are discussed in detail in the courses on the individual roof-covering materials.

Resolving disagreements

The mechanisms for resolving disagreements can vary. The insurance policy is a contract, and in it there are certain provisions for settling disputes. One involves an arbitration process where the policy holder and insurance company each appoint someone and those two agree on a third person. These three act as referees in the process and reports from roofers and home inspectors are considered in reaching a determination.

This process doesn’t get used very much. Instead, policy holders usually complain to the state department of insurance, whose job it is to make sure the insurance company complied with the contract terms. They usually can’t force a company to pay for a roof if there is a lack of sufficient evidence showing roof damage, but they can encourage the company to pay if the damage criteria are met. They can sanction an insurance company if the company fails to follow the contract.

The other thing a policyholder can do is hire an attorney and file a lawsuit if they thing the insurance company has not acted according to their contract.

WIND DAMAGE

We know that hail is associated with storms. Usually, storms that drop hail also bring wind as low-pressure fronts move in an out of the area. You may see damage from either one during an inspection. This next section will concentrate on recognizing damage caused by wind.

SCOPE of the WIND SECTION

The wind section of this course is general in scope; it’s not meant to cover hurricane damage. Hurricane damage often includes damage from heavy rain, flooding, and for coastal areas, storm surge. Inspection of hurricane damage requires expertise, which exceeds the scope of this section on wind damage.

WHAT CAUSES WIND?

Differences in atmospheric pressure

In talking about wind damage we should cover some basics first.

"Wind" is air moving from areas of high air pressure to areas of low air pressure. The greater the difference in air pressure between two points on earth, the faster the air will move between them.

These differences in atmospheric pressure are created by uneven heating of the earth's surface. Because of the earth's shape and orientation to the sun, more warming takes place along the equator than at the poles. The different rates at which heat is absorbed and released by land, water and the atmosphere itself also contribute to thermal differences.

As air in warmer areas rises, cooler air moves in to replace it. It's this replacement air that we experience as wind and the force that pulls the replacement air is called "convection". Convection can cause both updrafts and downdrafts, which create wind with different characteristics, including varying:

- Direction
- Strength
- Duration
- Speed

Hurricanes
Category One -- Winds 74-95 miles per hour
Category Two -- Winds 96-110 miles per hour
Category Three -- Winds 111-130 miles per hour
Category Four -- Winds 131-155 miles per hour
Category Five -- Winds greater than 155 miles per hour

Hardcopy only

This process happens on both large and small scales.

At the large end of the scale are hurricanes in which the area of strong winds might be between 25 miles and 150 miles wide. Hurricanes are classified according to wind speed. These images show some of the damage left behind by Hurricane Katrina.

Tornados
F0 65–85 mph (53.5% of all tornados)
F1 86–110 mph (31.6% of all tornados)
F2 111–135 mph (10.7% of all tornados)
F3 136–165 mph (3.4% of all tornados)
F4 166–200 mph (0.7% of all tornados)

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F5 >200 mph (Less than 0.1% of all tornados)

An example of much smaller but equally intense storms are tornados, which can have wind speeds of over 200 MPH, although wind speeds of less than 90 MPH are much more common.

Many other convection-related wind events occur, both with and without storms. Another condition which creates winds, which can damage roofs is large-scale weather patterns that produce a strong, deep flow of air which passes over a mountain chain.

Forced up out of its natural path by the peaks, the wind seeks to return to its original level but before settling back into a horizontal flow across the plains, it oscillates through several up-and-down cycles. As you can see in this illustration, these winds will actually bounce several times, and they can cause damage in certain areas with some predictability. If you're inspecting in an area that fits this description, be looking for wind damage… these winds can slam into the ground at over 100 MPH.

You can sometimes spot these areas even when the wind is not blowing. Over many thousands of years, the area near the base of the foothills where the wind first bounces will develop a trough, with soil scooped out by the wind. This is often more pronounced below geological features which channel wind, like canyons.

FACTORS AFFECTING WIND SPEED

- Exposure Category
- Height above the ground
- Wind speed
- Wind speed VS wind load

Wind blows faster in open areas where there's nothing to slow it down. Building codes generally list four wind Exposure Categories, labeled A, B, C and D according to the degree of obstruction offered by the topography.

An example of exposure A is an urban environment in which 50% or more of the buildings are taller than 70 feet.

The B exposure is an urban or suburban environment with closely-spaced homes or home-sized buildings. Exposure C is generally-open terrain with scattered obstructions less than 30 feet tall.

Exposure D is flat, unobstructed areas like shorelines.

Height above the ground

Wind slows due to friction with obstructions. Because air is a fluid, obstructions near the ground can affect wind speed at a much greater height. Aerodynamic drag created by buildings taller than 30 feet can actually slow down air which is flowing at an altitude of 1500 feet. This is because air moves by convection, so that flowing air will have an effect on the air surrounding it.

If wind above 1500 feet is blowing 100 MPH, at exposure C it will have slowed to 62 MPH. At exposure B, it will be blowing 44 MPH, and the exposure A wind speed will be 27 MPH.
Since wind speeds are higher farther above the ground, taller buildings will be exposed to higher wind speeds and will be more likely to suffer damage.

Wind speed

Wind speeds given by the National Weather Service are typically measured at a point 33 feet above the ground. This illustration shows how drastically wind speed can be reduced below 30 feet.
Wind speeds are usually given as a sustained speed which better reflects the average speed of the wind.
Wind may also be reported as a 3-second peak gust speed, which gives a better idea of the peak wind speed which is sustained for only a short time.
Hurricanes wind speed is measured as 1-minute sustained wind and may be measured at a much greater altitude by aircraft.

Wind speed and wind load

The wind load on a building is the force that the structure actually has to resist. Although wind speed will give some indication of the potential for damage, for a given speed, the wind load on the building can vary more than 30%. Many factors influence the wind load, including:

- the building shape
- its orientation to the wind
- air density
- and the wind exposure category in which the building is located.

HOW WIND CREATES DAMAGE

Uplift

One of the destructive forces created by wind is uplift, which is the tendency of materials to be lifted into a wind-created vacuum. Uplift can be created by either of two physical condition: loss of laminar flow or increased wind speed. Both of these processes reduce the air pressure immediately above the roof-covering material.

Air flowing close to a surface is in a state called "laminar flow". According to the laws of physics, flowing air will try to maintain contact with a surface. When that surface bends or curves sharply, the airflow can't turn quickly enough to maintain contact and it separates from the surface. We say that it "loses laminar flow". This creates a vacuum and anything that can move will be lifted up into that vacuum if the vacuum is strong enough.

The other process that creates uplift is related to the fact that increasing wind speed lowers air pressure. Wind speed on the roof can be up to 2 ½ times the approach speed, which is the speed of the wind as it blows toward the home. Reduced air pressure from fast-moving air just above the surface of the roof also increases the amount of uplift.

Damage location

Uplift can develop when wind blows across a roof.

The location of damage on a home will be affected by the orientation of the wind to the roof structure, and by the shape of the roof. In these illustrations, areas of uplift are shown in blue.

When wind blows perpendicular to the eves and ridge, uplift is created along the upwind side of the lower roof slope and along the downwind side of the ridge.

When wind blows parallel to the eves and ridge, uplift is created along the upwind rakes.

Wind blowing at the side of the building was deflected up and over the low-slope section, creating an area of strong uplift which sucked shingles and underlayment right off the roof.

If uplift can lift a portion of the roofing material, more of the surface of that material will be exposed for the wind to push against and it'll be more easily displaced or blown off the roof.

Uplift is strongest at areas of the home where the wind loses laminar flow. The areas most commonly affected include:

- Upwind eves edges

- Upwind rakes
- Upwind corners
- Downside of ridges

In addition to uplift, areas that lose laminar flow will also experience turbulence. This buffeting or fluttering effect can also loosen or displace roofing materials.

Positive pressure

Positive air pressure is really just the wind pushing against something that offers resistance, like a shingle tab that's been raised by uplift, or flashing which protrudes enough for wind to push against it. Eves and rakes are areas where roofing materials terminate and so are especially vulnerable to damage from wind pressure.

In this photograph you can see the results of all three factors. The left side of the structure was the downwind side and you can see that roofing materials were lifted into the vacuum created by loss of laminar flow.

The left corner and right corners had roof sheathing removed from a combination of uplift due to loss of laminar flow and inflation.

WIND DAMAGE CHARACTERISTICS

Wind damage can be broken down into two basic types: direct and indirect.

An example of direct damage is conditions in which roofing materials have been blown off, damaged or displaced.

Indirect damage is sustained from objects blown by the wind– "missiles".

Missiles

Roof-covering materials- especially more brittle materials like tile- may be damaged by wind-blown debris, called "missiles". Missiles can include other roofing on the home which has been pulled loose by the wind and blown into roofing on adjacent roof slopes, or it may be tree limbs, gravel, yard apparatus or anything else capable of damaging roofing that can be carried aloft by the wind.

Missiles aren't always items lying around the yard. Anything that can be blown through the air and damage the roof or siding can be called a missile.

This particular missile was flying through the air under its own power before it was caught in a powerful gust and blown into the side of the home.

Material condition

Wind will damage materials in poor condition before it damages materials in good condition. In addition to deterioration of the roofing material itself, fastening systems deteriorate. In some systems- such as slate- the fasteners may be the weakest part of the system, corroding to a point at which wind will cause them to fail.

BUILDING CHARACTERISTICS

The nature of wind damage will also be affected by the characteristics of the buildings themselves.
The important building characteristics which affect the potential for wind damage are:

Home age

The year the home was built. Many new building materials and methods have been developed over the past 30 years. At the same time, our understanding of how buildings operate and react to conditions has improved and as a result, building codes have become more stringent.

Type of construction

Wind damage can vary with the type of construction. For example, mobile and modular homes are more likely to suffer damage than homes with a more substantial structure and higher quality materials.

Building quality

Some types of roofing materials are more vulnerable to wind damage than others. The type and quality of both the installation and the materials used in the roofing system will affect the chances for wind damage.

Roof shape and slope

Roof structures of different styles obviously have different shapes. Each shape will affect wind behavior differently and will affect the location and amount of damage. Wind blowing parallel to the ridge of a gable roof will be blowing along roof-covering materials, offering less chance for damage than wind blowing at a similar home but with a hip roof. The hip roof will have a section of roof lying perpendicular to the wind, offering more resistance and greater opportunity for damage to occur.

Orientation to prevailing winds

Even a single roof style can suffer different amounts of damage depending on how the roof is oriented to the wind. Wind blowing parallel to the ridges and eves of a gable roof is less likely to do damage than wind blowing at the ridges and eves.

MITIGATION FACTORS

Mitigation factors are variables which influence the amount and nature of roof damage. Damage isn’t always limited to one factor. Variables can combine in different ways to create unique conditions.
Some variables like air density and pattern of wind gusts are aspects of wind damage that you won’t know about before you arrive at the inspection and won’t be able to see once you’re there, but they can have a significant effect on the nature of the damage.

In this section, we’ll be examining the roles these variables play in creating wind damage. The bottom line is whether or not the damage is consistent with that caused by wind.
These include the following:

Wind speed

As previously mentioned, wind speed is related to the roof height above the ground, with speeds slowing closer to the ground. This image shows the wind blowing at 100 MPH at a height of 33 feet. At 5 feet above the ground, the wind speed is 66 MPH, a loss of almost half in only 25 feet. The speed of the wind as it passes over the roof can be more than 2 ½ times the approach speed. The “approach” speed is the speed of the wind as it approaches the building. Since higher wind speed can increase uplift, higher speeds increase the chances for damage.

Pattern of gusts

As a storm moves into an area, wind may increase in speed at a relatively constant rate, or this growth may include strong gusts. During wind gusts, wind speed may increase dramatically in just a few seconds. This has a physical effect similar to an impact. Strong, sudden gusts may do more damage than winds of higher speed which build and fade at a more gradual rate.

Air density

Air density is affected by temperature. Cool air is denser than warm air. This means that if cool air and warm air are blowing at the same speed, cool, denser air will place a greater wind load on the building. A greater wind load has the potential to do more damage.

Wind direction

Determining the direction from which damage-causing winds originated may help you recognize where to look for damage.

The orientation of damaged surfaces or displaced debris may provide clues. Look at the pattern of damage. Knowing how wind damage is created should help you determine the direction from which the wind was blowing. Look for distorted or displaced claddings such as siding or trim. Damage should be more severe on the side of the home exposed to the most intense wind. Look for debris at the downwind side of the yard. Many areas have predictable wind patterns. Strong coastal winds often blow from the ocean toward the shore. Homes located near features like the mouths of canyons can have wind directed at them.

PERFORMING a WIND DAMAGE INSPECTION

The same basic procedure is followed when inspecting for both wind and hail damage.
The inspection starts at the ground level. As you inspect the home exterior, you'll be looking for wind-caused damage

ELEVATION DAMAGE

In looking for wind damage, watch for the following:

- Roofing on the ground. If you find roofing on the ground there's a good chance that it came from the roof of the home you're inspecting.
- Pieces of shingle like this one may have pulled over the nail head and torn loose.

Look for damage to siding and trim. Siding can suffer both direct and indirect damage. Pay attention to the roof edges, especially near the corners. Loose drip edge may be more visible from the ground than from the roof. Try to determine the direction from which the wind has blown by looking at conditions visible from ground level. This will help in locating both wind and hail damage. Once you've made your way around the home documenting collateral damage, you'll need to get onto the roof.