InterNACHI
"General Roof Inspection" online video course
http://www.nachi.org/roof-inspection-online-training-video-course.htm
86,000-word student book
67 minutes of video
one 15-question quiz
50-question final exam

Welcome to the InterNACHI General Roof Inspection course.

The purpose of the general roof inspection course is to teach students to recognize proper and improper conditions when inspecting steep-slope residential roofs. This course covers roof framing, roofing materials and attic conditions that affect the roofing materials.

Although we'll be using common terms, the same things can have different names in different parts of North America. The term "roof-covering materials" refers only to the visible roof-covering material… the shingles, tile, metal or slate, which form the primary roof covering. It doesn't include other roofing materials like underlayment or flashing. The term "roofing materials" includes everything attached to the roof deck

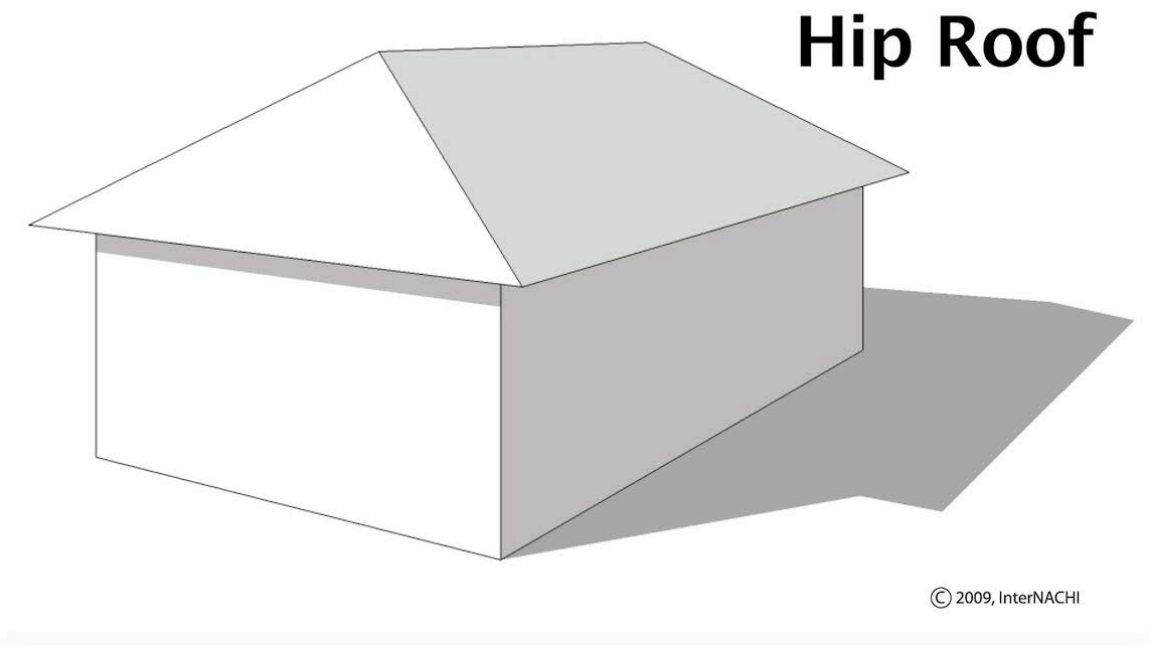
We're going to start by identifying some basic roof styles and features.

Gable

Gable roofs are one of the most common styles. They’re easily identified… they have two slopes and the ridge extends the length of the home.

The lower, level edges of the roof are called the eaves and the sloped edges are called the gables or rakes. You’ll hear both terms.

Hip



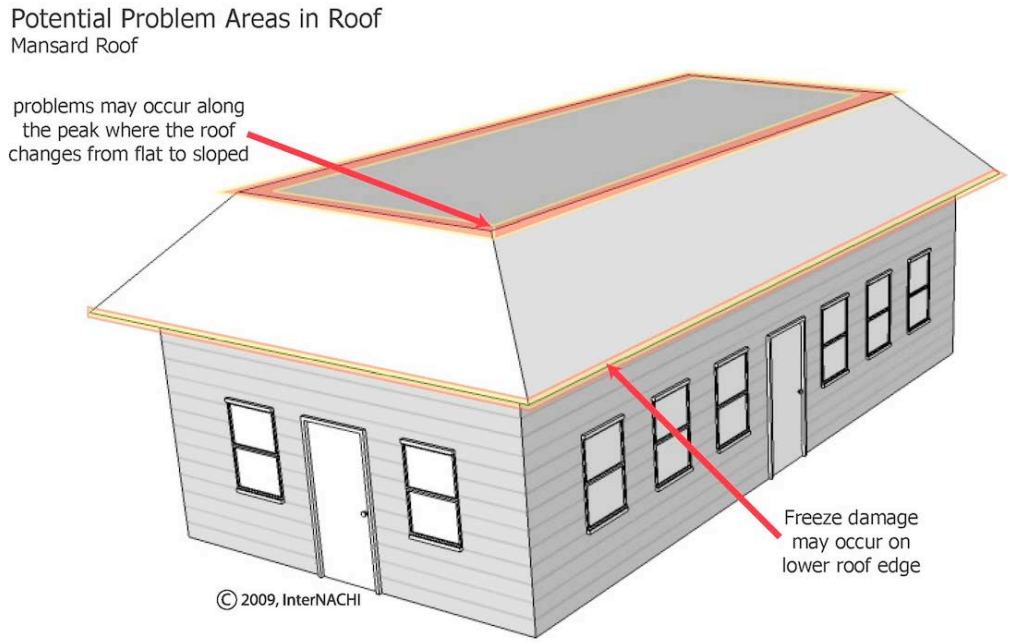
There are two types of hip roofs, and both have four slopes. The basic hip roof has a level ridge, but the ridge doesn’t extend all the way to the exterior walls. Instead, hip rafters slope diagonally down to each corner.

The photo on the right shows a “full hip” roof. Full hip roofs have no real ridge. The hip rafters all meet to form a point at the peak of the roof.

Mansard

Mansard roofs were invented by the French when owners were taxed by the height of the building as measured to the roof eve.

They’re short, steep roofs installed around the perimeter of what’s usually, but not always, a flat-roofed building.



Some of these roofs are near vertical, and this can cause installation problems, which will vary with the different types of roof-covering materials.

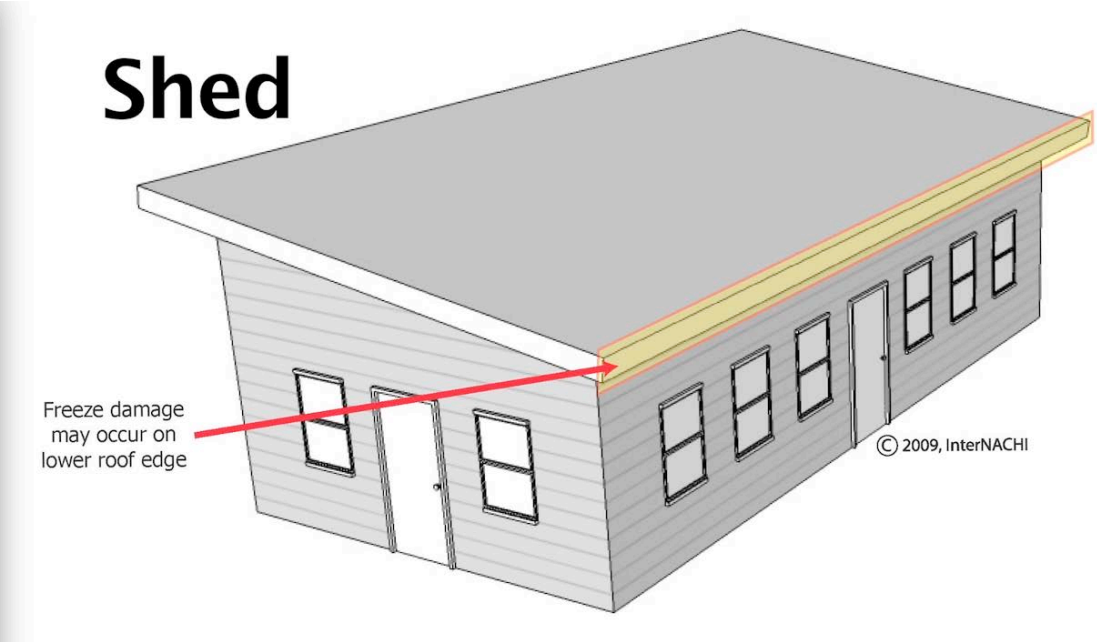
Flat

“Pitch“ is the term used to describe the degree of roof slope. Flat roofs have one slope but very little pitch. A typical pitch would be ¼-inch per foot.

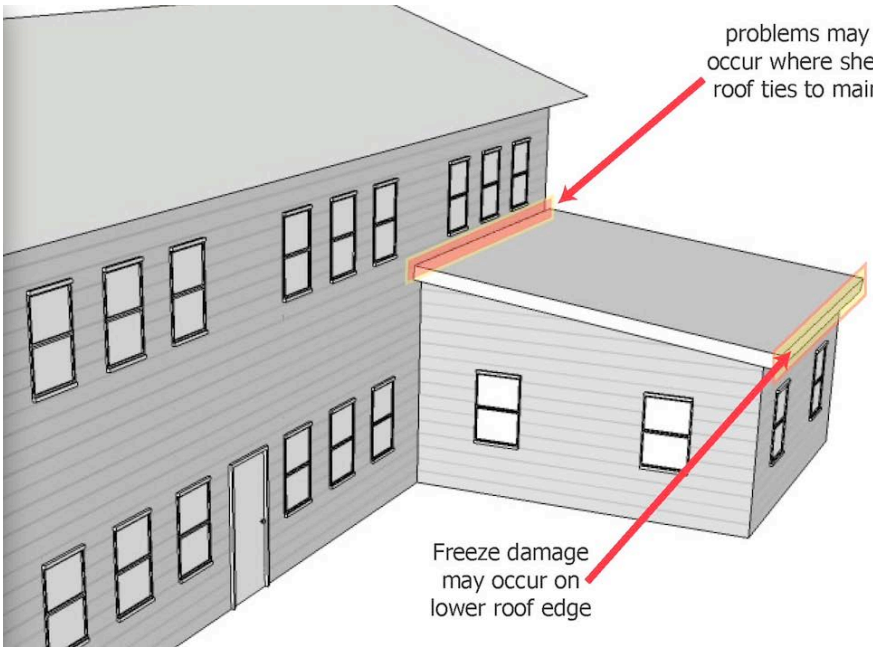
Flat roofs may drain over the roof edges, or through scuppers installed in a parapet wall built around the perimeter.

Flat roofs are low-slope roofs and since this course focuses on steep-slope roofs, we won’t be talking much about flat roofs. Low-slope and steep-slope roofs have different requirements.

Shed

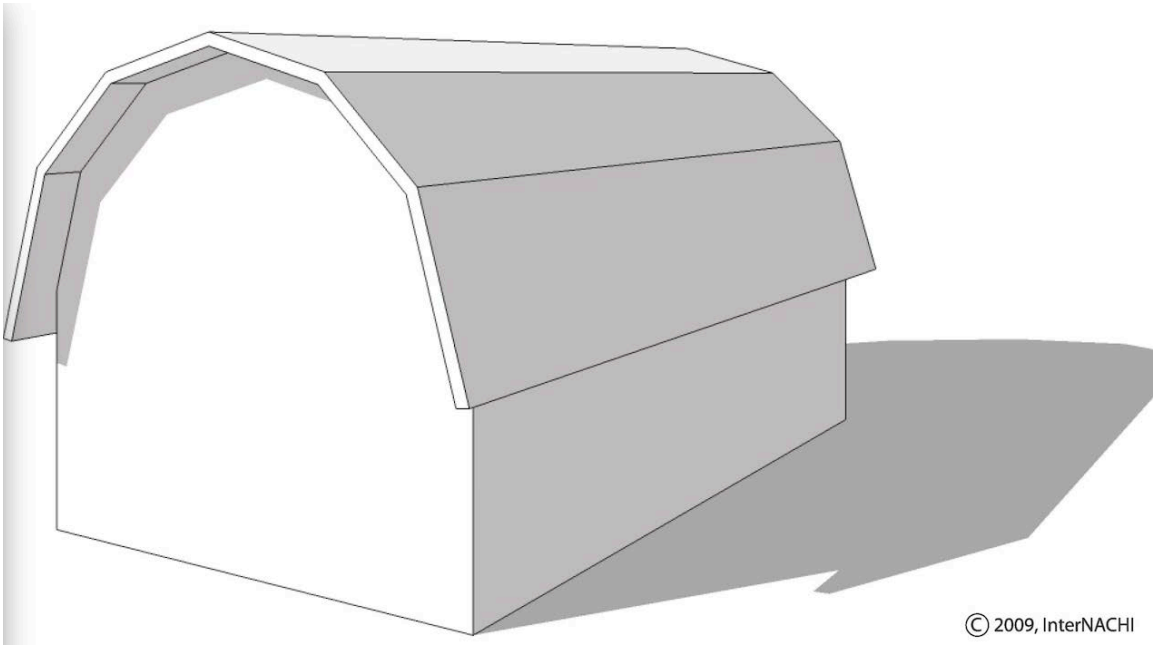


Shed roofs have one slope but more pitch then a flat roof.



Since shed roofs are often used for additions, one potential problem area is along the upper edge of the shed roof where it ties into the wall of the original home.

Gambrel



Gambrel roofs are usually associated with barns but are not uncommon on homes. They have two slopes, each of which changes pitch. The point at which the roof changes pitch should have metal flashing.

This barn was located in an area so windy that whenever the wind stopped blowing, all the chickens fell over.

Clerestory

These photos show roofs with clerestory windows. Although the term “clerestory” refers to the position of the windows it also generally describes their position as incorporated into a shed roof. In other words, “clerestory” is commonly used to refer to the combination of roof and windows.

Clerestory windows should have adequate clearance between the sills and the roof below in areas with heavy snowfall and should also have proper sidewall flashing.

Cupola

Cupolas are small structures built into the peak of a roof, often to provide light to the area below.

The inspection concerns are the roof framing supporting the cupola along with headwall and sidewall flashing.

Conical roofs

Conical roofs are often used to cover towers, as you see here, and are often steep. This first photograph shows a conical roof that is actually a series of tapered flat roofs, creating a series of hips.

Round conical roofs will require special roofing techniques to get shingles to lie flat, especially near the peak. In this second photograph you can see that 4 tiny dormers have been installed near the peak. Inspecting these steep roofs closely is difficult or impossible without special equipment, so you’ll get as close as you can, use binoculars and look for signs of leakage beneath these roofs.

Inspection concerns include flashing at the round sidewalls and areas at which conical roofs intersect with roofs of other shapes. Specially-shaped crickets or flashing may be needed to provide long-term protection against leakage. Crickets are shown here outlined in red.

These areas of intersection, which are difficult to see because they’re on the back side of the roof often collect debris like leaves and sediment. This debris holds moisture against the roof and flashing often corrodes more quickly than on the rest of the roof. So the areas of intersection are difficult to see and they’re a weak point.

If you can’t confirm the condition of the roofing on the back side of a conical roof, you need to disclaim it and recommend inspection by a qualified roofing contractor. A contractor may need to hook a ladder over the ridge in order to get high enough on the roof to see the back-side of a conical roof clearly. This is especially true when the roof is covered with fragile materials like slate or tile.

You may need to hook a ladder over the ridge in order to get high enough on the roof to see the back-side of a conical roof clearly. You’ll find that you need to do this in a variety of situations too, especially when you inspect fragile roof-covering materials like slate or tile.

Dormers

Dormers are projections built into the slope of a roof. Here you see photographs of dormers with gable, hip and shed roofs. Inspection concerns are valley, headwall and sidewall flashing.

You may occasionally run into roof designs that are more unusual.

Look at these two butterfly roofs and this bonnet roof.

You’ll often see several roof styles combined on one home. You’ll see roof styles for which there really is no name.

The structure on the left is a dormer. The one on the right is a second story, since the exterior wall is continuous from foundation to roof.

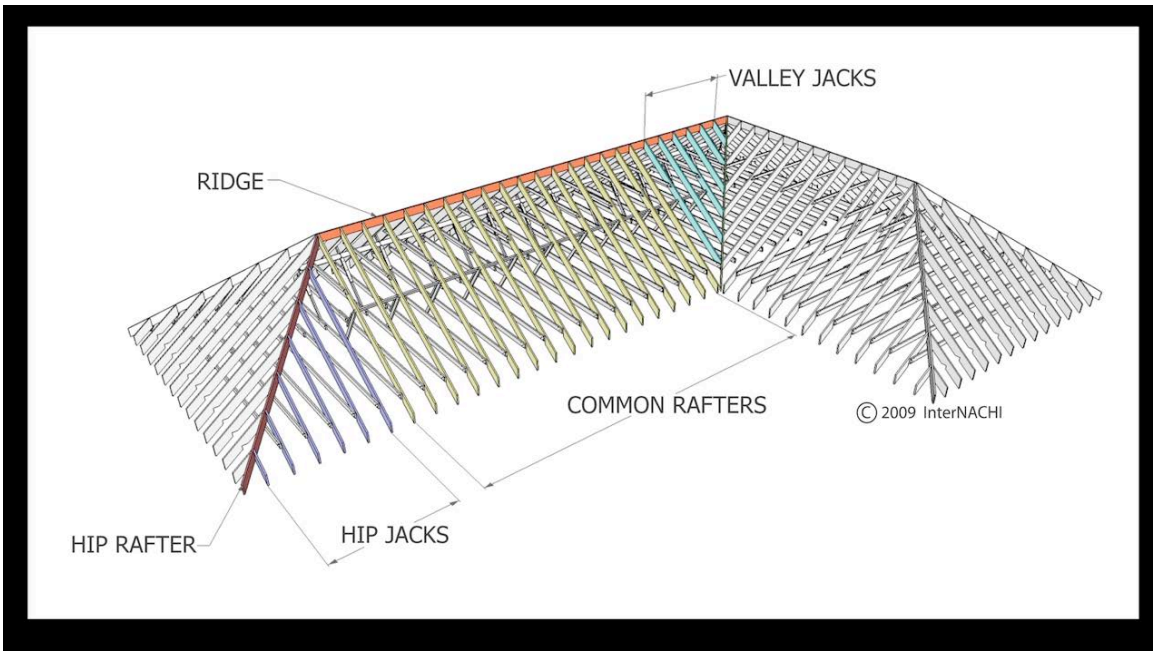
The only limitations to the number of styles possible are the human imagination, the laws of physics and the depth of the homeowner’s pockets.

We won’t go into attic inspection too deeply since this course is primarily roofing defect recognition, but you should have an understanding of the two main, basic, roof structure systems: conventional roof framing and roof trusses.

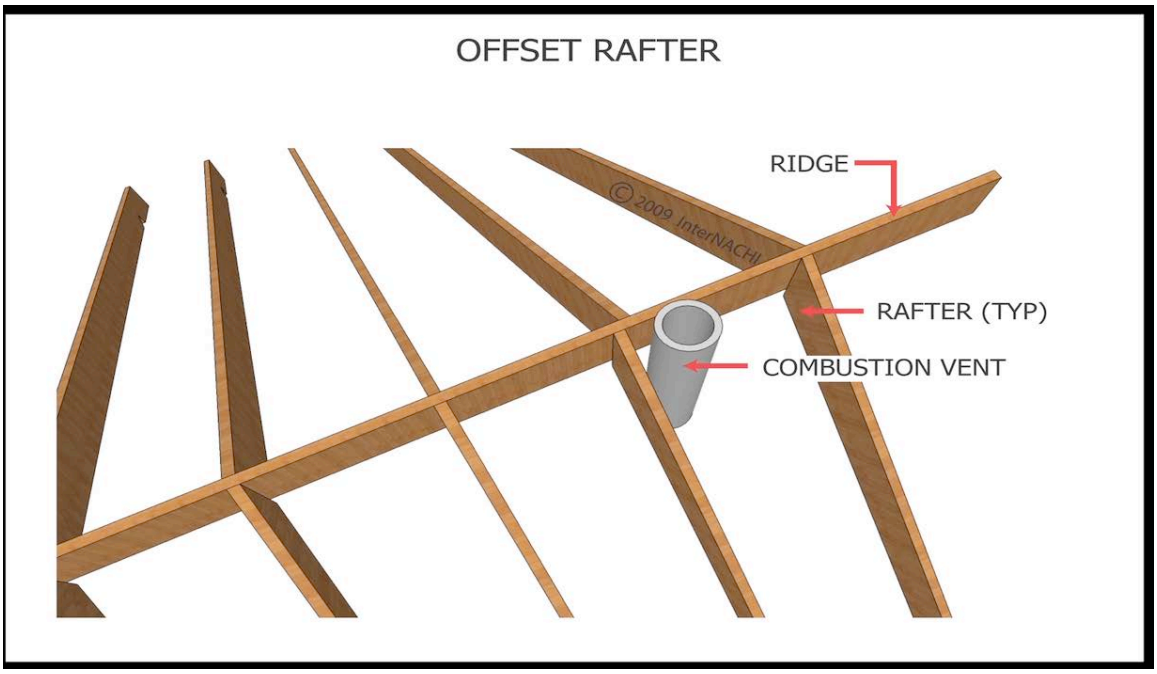
You’ll be evaluating the roof framing from inside the attic space, but we have an advantage in technology. Let’s strip away the roof and wall coverings of a home and identify some of the more common roof framing members. We’ll start with a conventionally-framed roof in which individual roof-framing members are cut and assembled onsite.

CONVENTIONAL ROOFS

Common rafters

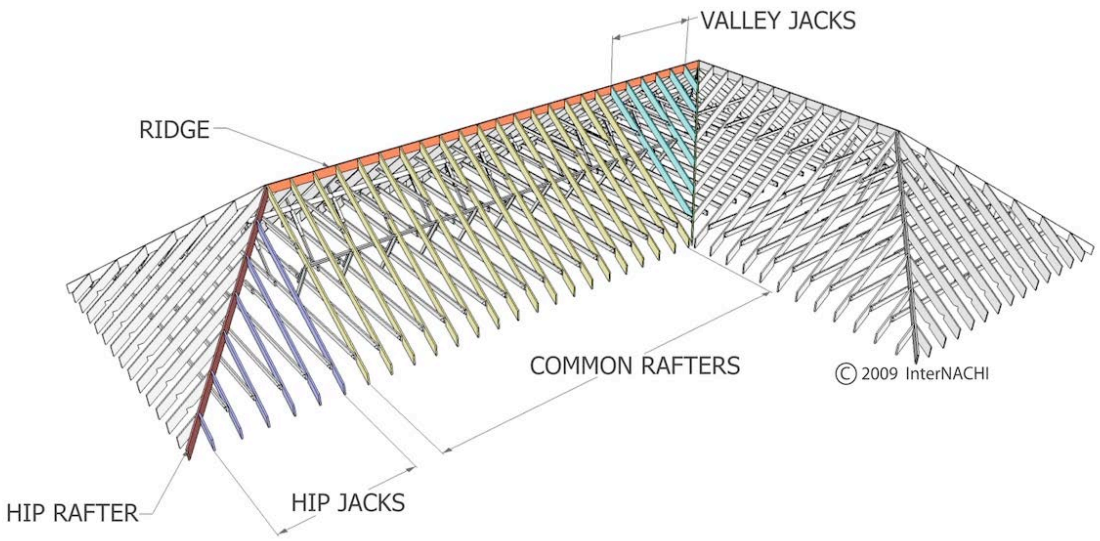


Rafters which rest on the outside walls at the bottom and connect to the ridge at the top are called “common rafters”. They’re shown here highlighted in yellow.



Rafters on opposite sides of the ridge should be installed directly opposite each other in pairs, although if you see a few that don’t align, it’s really not a defect. Rafters sometimes have to be moved a little to accommodate components of other home systems. This illustration shows a rafter moved to accommodate a combustion vent.

If you see many rafters that don’t align, you may comment on this, but in existing homes, refrain from calling it a defect unless you see failure. In newer homes, many rafters which don’t oppose usually indicates poor quality framing. It’s an indication that you should look carefully for other problems in the roof framing.



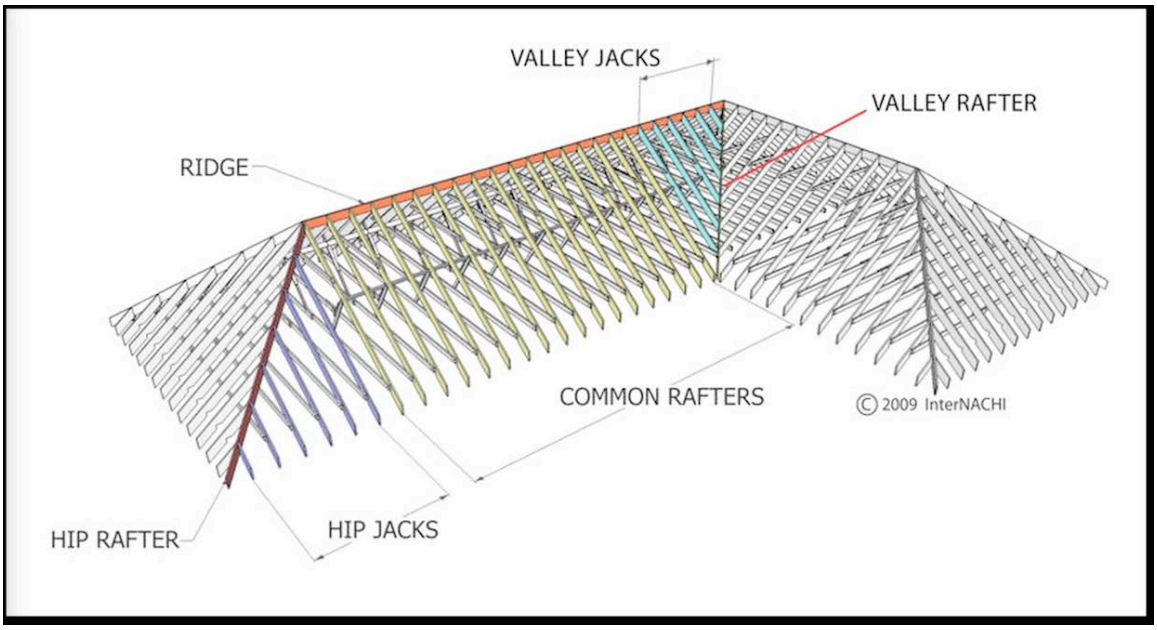
Rafters are typically installed on 24-inch centers. If you see rafters installed on centers greater than 24 inches, look for signs of failure such as sagging of the rafters. If you see sagging rafters, recommend stabilization by a qualified contractor. Stabilization typically involves installation of a purlin system, which we’ll go over in just a minute.

Hips

Hip roofs have hip rafters, which are oriented diagonally to the ridge and outside walls. Hip rafters are simply called hips, and are shown here as brown. Hips rest on an outside corner at the bottom and connect to the ridge at the peak.

Rafters which rest on the exterior walls at the bottom and connect to a hip at the top are called “hip jacks” shown here as purple.

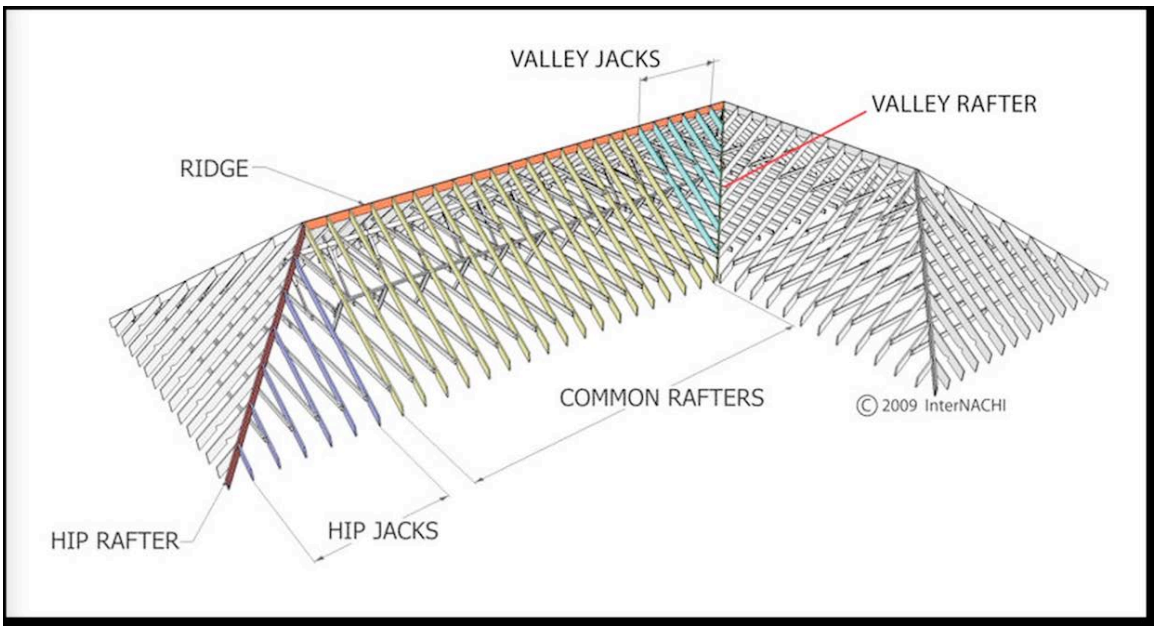
Valleys



Where ridges change direction, an inside corner is created which is spanned by a “valley rafter” or simply “valley”, shown here as green. Valleys are also oriented diagonally to the ridge and exterior walls. Valleys rest on top of the walls at the inside corner at the bottom and connect to the ridge at the top.

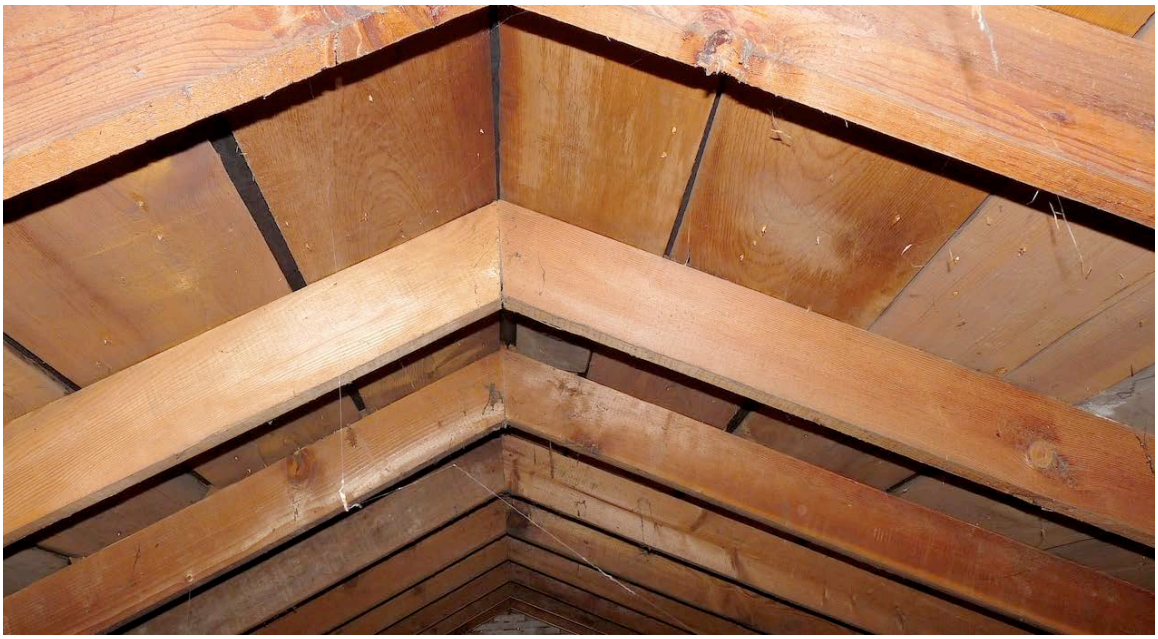
Rafters which connect to the valley at their bottoms and connect to the ridge at the top are called “valley jacks”, shown here as light blue.

Conventional ridge



This illustration shows a conventional ridge colored orange In homes with conventional ridges, the rafters support the weight of the roof and transmit the roof load down through the walls to the foundation, and finally to the soil. The route taken by the weight of the roof through the framing members to the soil is called the “load path”.

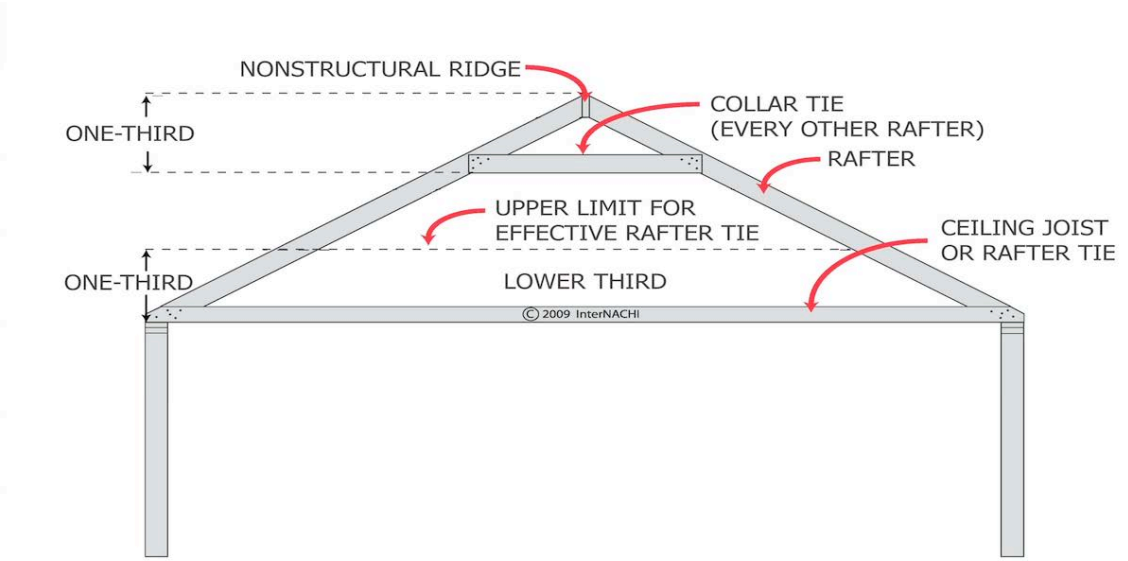
The purpose of the ridge is to provide an easy method for connecting rafters at the peak of the roof and to provide better nailing at the peak.



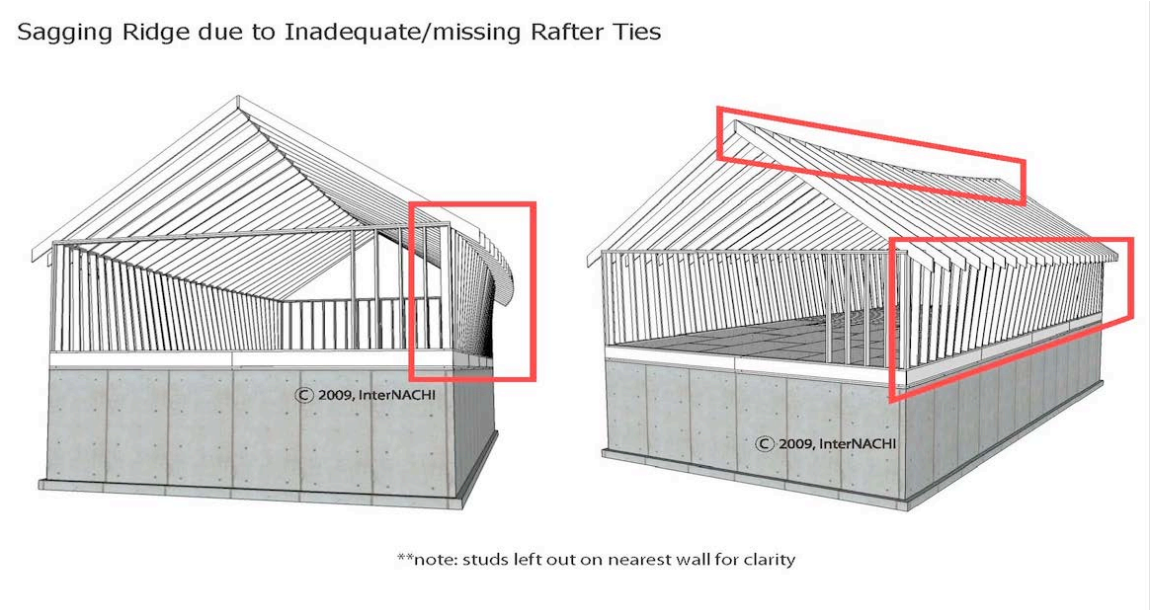
Older homes may have no ridge at all. Lack of a ridge was not unusual in various parts of North America and it’s not a defect as long as the rafters oppose each other.

Engineered lumber used for roof framing has very specific requirements for connections and talking about them here exceeds the scope of this course. The manufacturers of metal connectors for engineered lumber publish connection specifications in their catalogues and on their websites.

Rafter ties

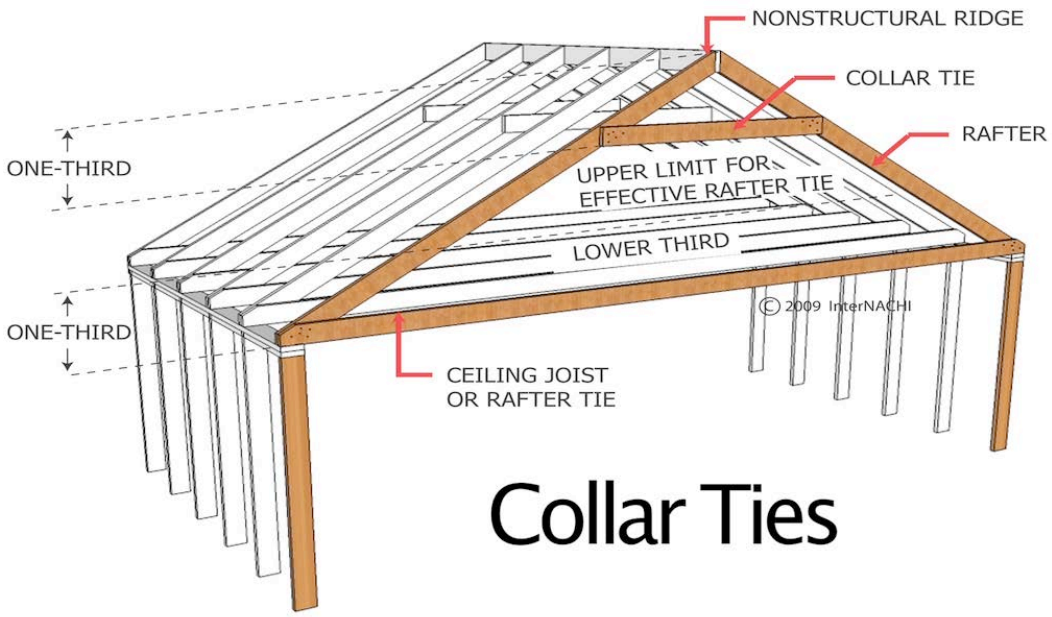


In homes with flat ceilings and an attic space, the bottoms of opposing rafters should be fastened together with ceiling joists, which form “rafter ties”. When rafters have been installed perpendicular to the ceiling joists, rafter ties typically rest on top of the ceiling joists.



Rafter ties prevent the weight of the roof from spreading the tops of the walls and causing the ridge to sag.

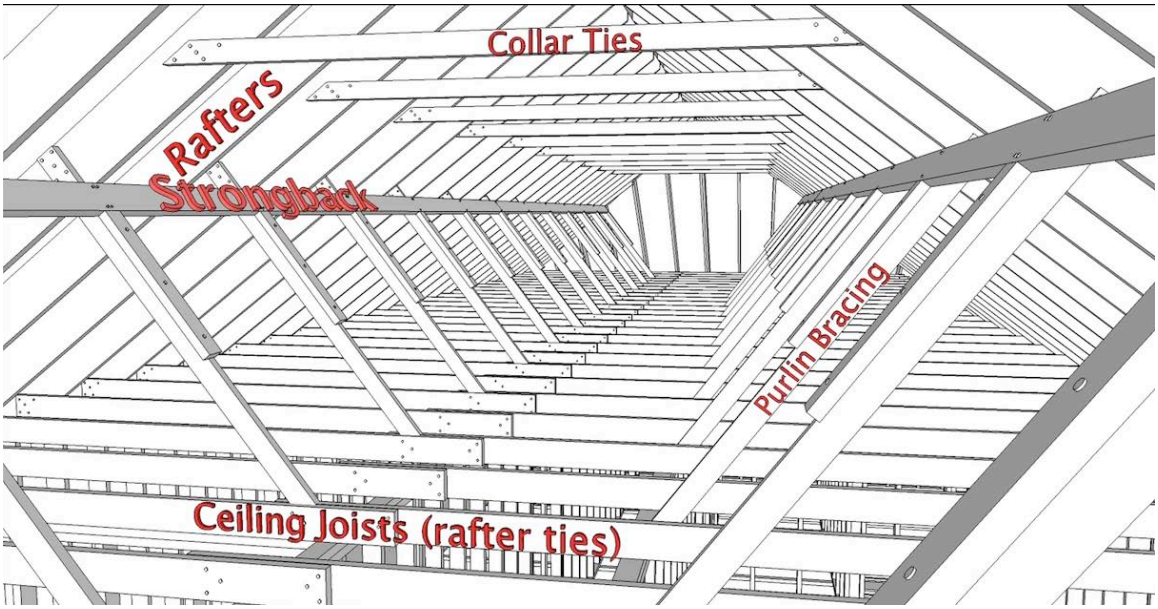
Collar ties



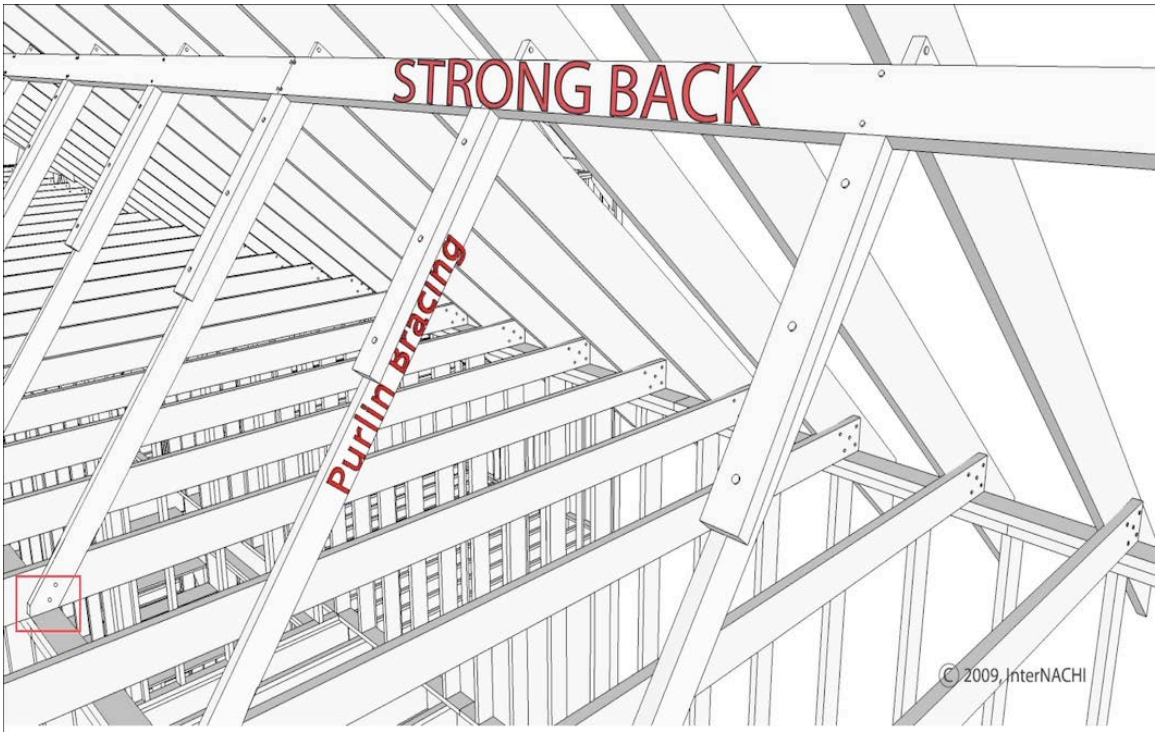
Collar ties connect the upper ends of opposing rafters and should be installed on every other rafter in the upper third of the roof. Their purpose is to prevent uplift. Whether to install them is an engineering call. They aren’t always required, lack of them is not a defect, but when you see them, they should be installed correctly.

Here you can see collar ties installed in the upper third of the roof, rafter ties installed down low and spliced over a wall.

Purlin systems



You can also see the purlin system. Purlin systems are designed to reduce the distance that rafters have to span. They consist of strongbacks nailed to the undersides of the rafters and supported by diagonal braces.



Braces are typically installed every other rafter and should be at an angle no steeper than 45°. The bottoms of purlin braces should rest on top of a bearing wall. Braces that rest on ceiling joists or which somehow pass the roof load to the ceiling below are not good installations.

If you see braces that rest on ceiling joists, look for a sag in the ceiling. Here you see a condition in which there was no bearing wall close enough to support the braces and so a strongback was installed to distribute the roof load more evenly and help prevent sagging of the ceiling.

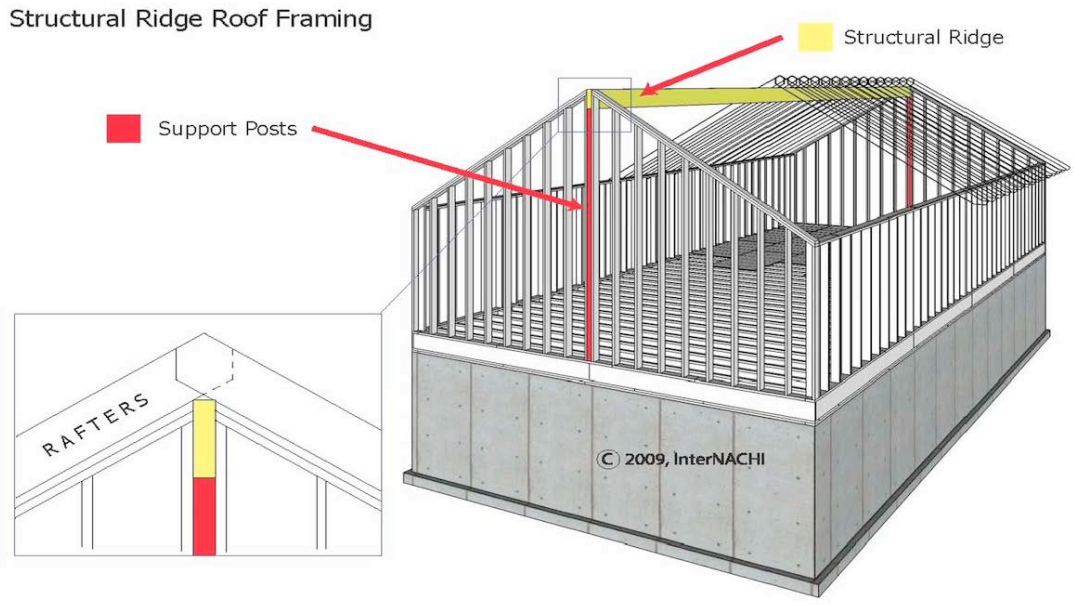
Here’s a purlin system installed in the garage of an older home. With no central wall to carry the braces, they bear on a strongback that rests on the ceiling joists. There was no sagging, so there was no comment in the inspection report.

Purlin systems have been built in many ways, some better than others. Modern building codes call for strongbacks to be of equal or greater dimension than the rafter dimension, but most purlin strongbacks you’ll see will not meet this requirement. If you know that the home was required to meet this code when it was built, call it a defect, otherwise, limit your inspection to looking for signs of failure like:
sagging or broken rafters or
broken components, or look for improper installation like
braces resting on ceiling joists
braces but no strongback, or
too few braces

In older homes in some areas, it’s common to find no strongbacks. It’s a quality issue unless the roof is sagging, then it’s a structural issue and you should recommend stabilization by a qualified contractor.

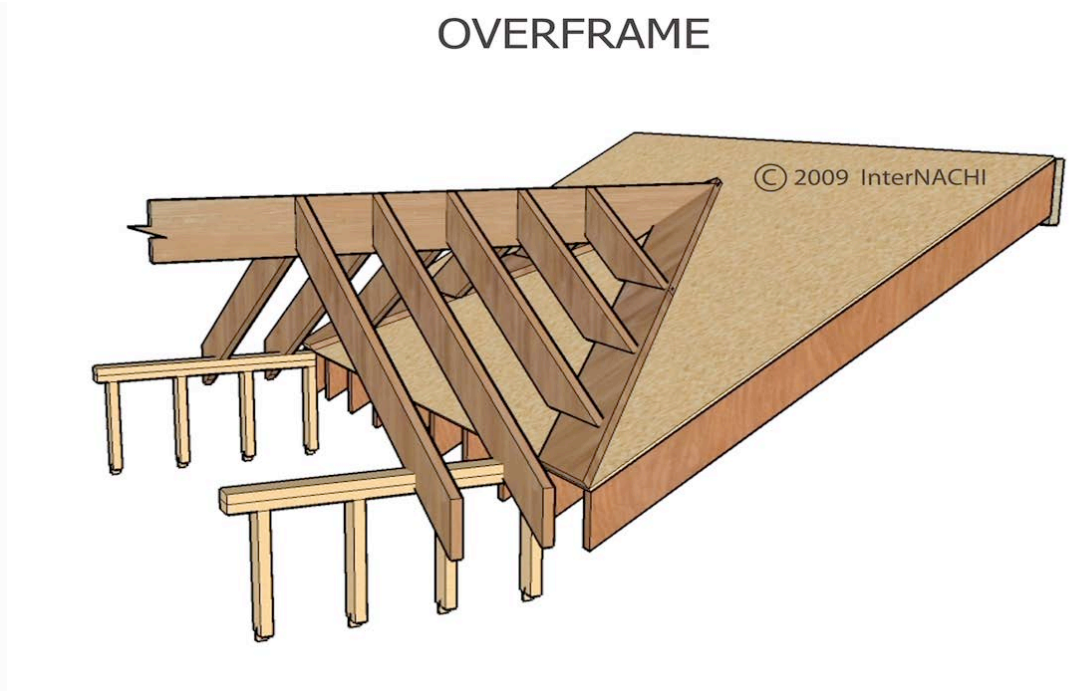
The term “purlin” has several different meanings depending on what part of North America you’re in, what part of the roof you’re talking about and the background of the person you’re discussing it with, so don’t be surprised if someone tries to correct you.

Structural ridge



Homes with vaulted ceilings usually don’t have rafter ties to keep the walls from spreading and the ridge from sagging, so they use a structural ridge. In a home with a structural ridge, the ridge consists of a beam strong enough to support the roof load without sagging.

Overframe



When you’re inside an attic, you may see a condition in which the ridge and a few jack rafters from one roof section are framed on top of an existing roof.

This is called an “overframe” and it’s quite common in certain areas. Built correctly, it’s structurally sound.

You’ll often see a section of roof sheathing removed to provide a passageway between attic spaces. If you can’t enter a portion of the attic, recommend that it be inspected by a qualified inspector after access is provided. This is especially important if it contains plumbing or electrical components.

IMPROPER CONNECTIONS/FASTENERS

Rafters may be connected with metal hardware or just nailed to the ridge. Rafters on one side of the ridge will be nailed through the ridge and those nails will be hidden behind the opposing rafters. The opposing rafters will be toe-nailed. The proper nailing pattern for toe-nailing rafters is 3 nails in one side and two in the other.

In roof framing there are a lot of places where framing members connect. Requirements for these connections have changed over the years, but you can still identify basic defects.

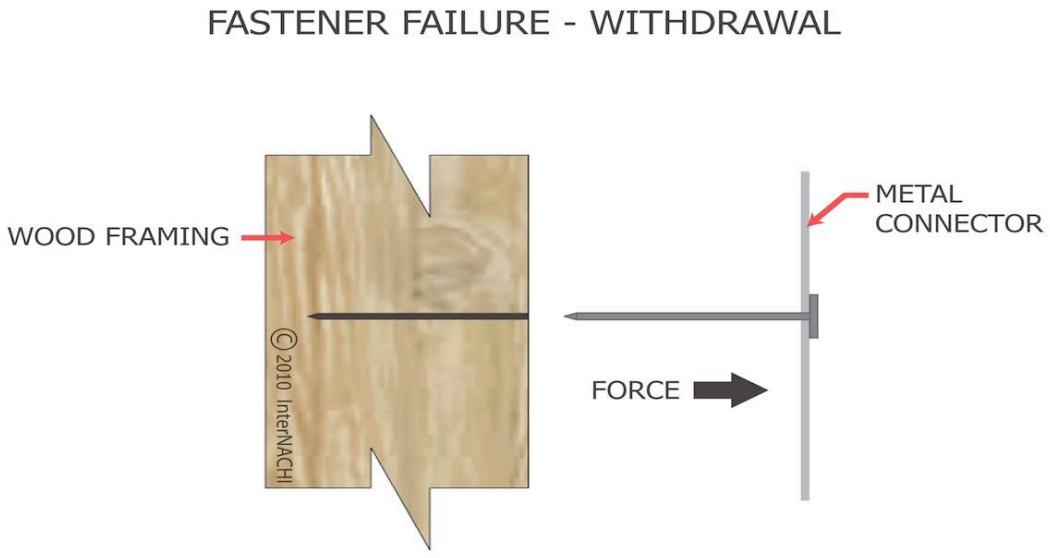
Engineers have to calculate the loads on connections between framing members and specify hardware that will support those loads. Fasteners are what attach metal connectors to wood framing members. In order to ensure safe connections, fasteners of the right metal alloy and of the correct minimum diameter and length have to be used.

When a workman uses a roofing nail instead of a hanger nail at a structural connection, that connection will be much weaker because roofing nails are weaker than hanger nails. Roofing nails are designed to anchor roofing materials against uplift, not to support a structural load.

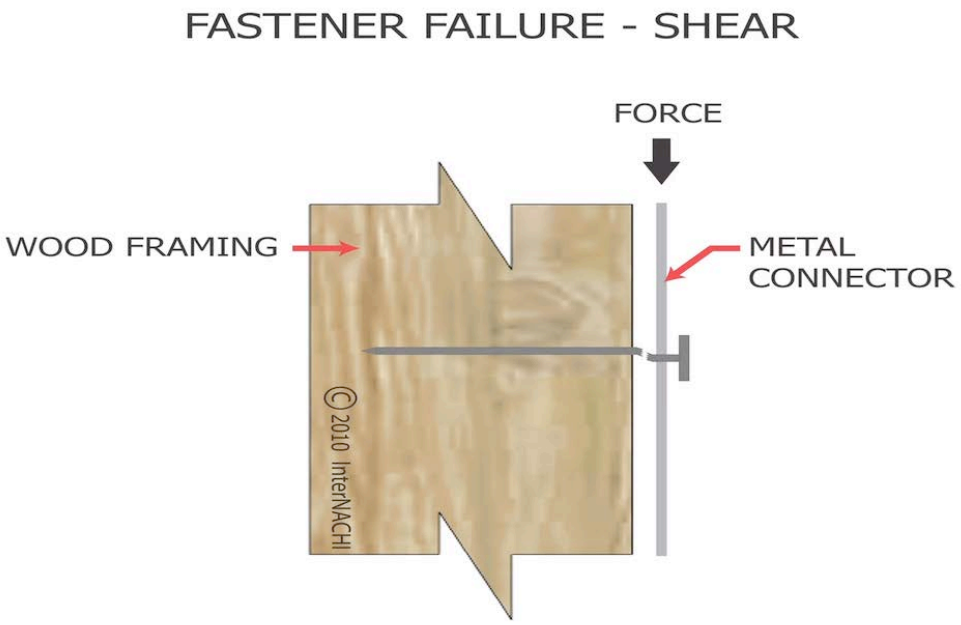
If fasteners are used that are inadequate in strength, the connection may fail.

Fastener failure

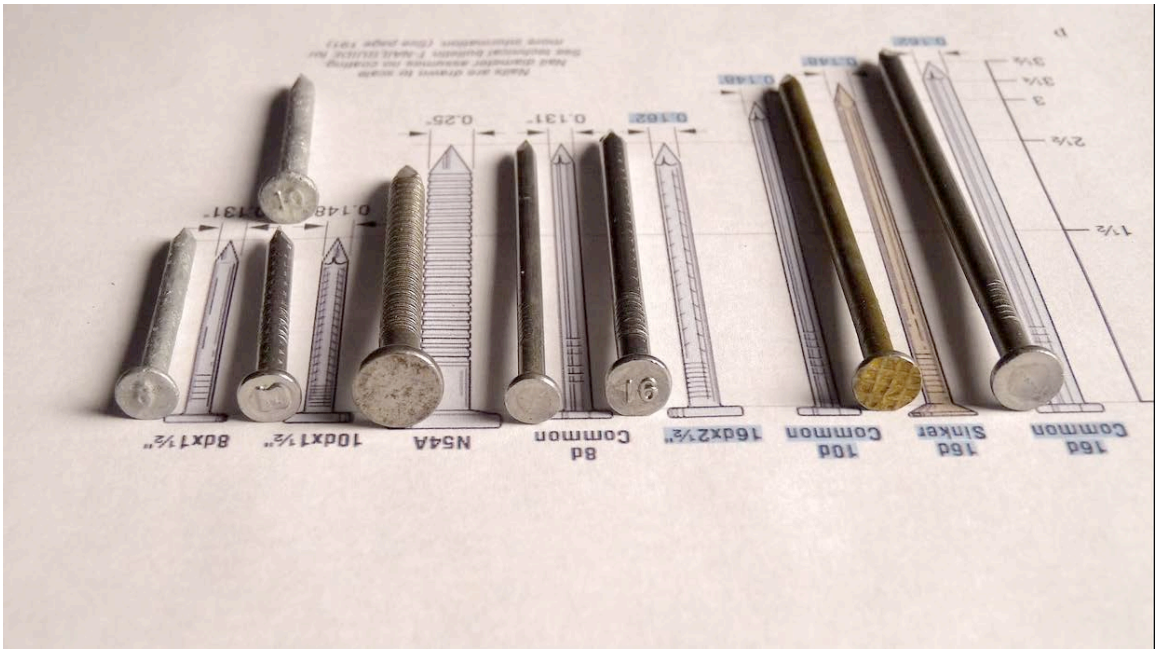
Fasteners can fail in one of two ways: withdrawal or shear.



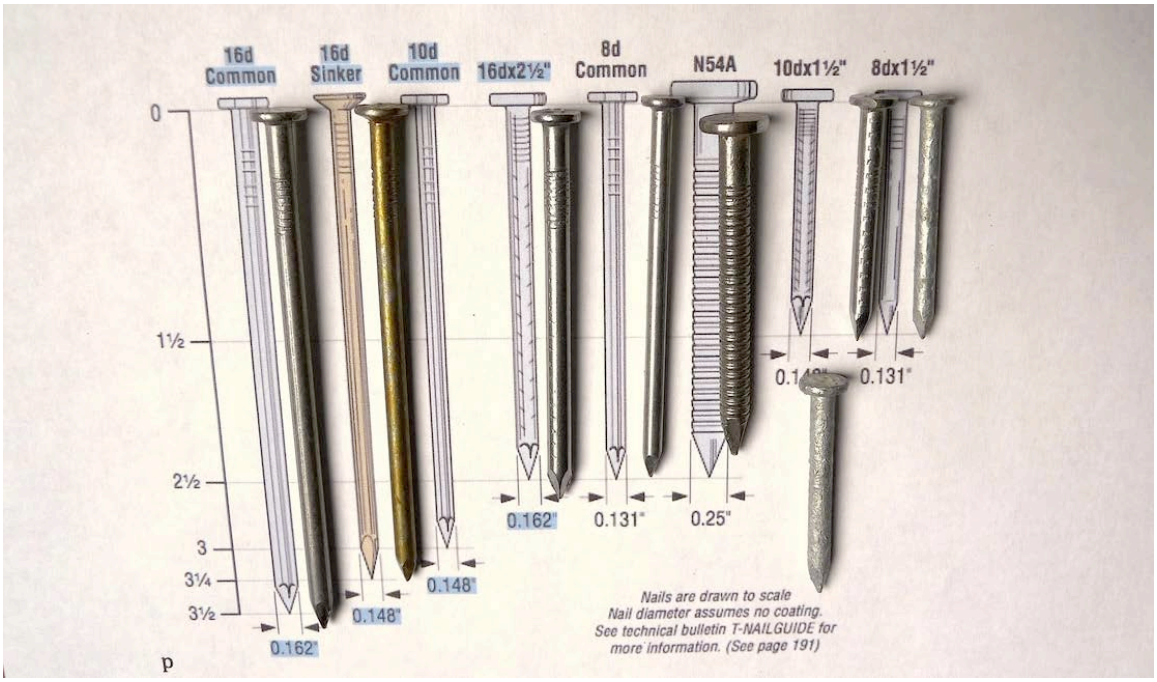
Withdrawal simply means that the fastener pulls out. When withdrawal causes failure, the force causing the failure is parallel to the shaft of the fastener.



Shear failure is caused by a force perpendicular to the shaft of the fastener. The fastener bends and breaks kind of like it had been sheared off by a guillotine.

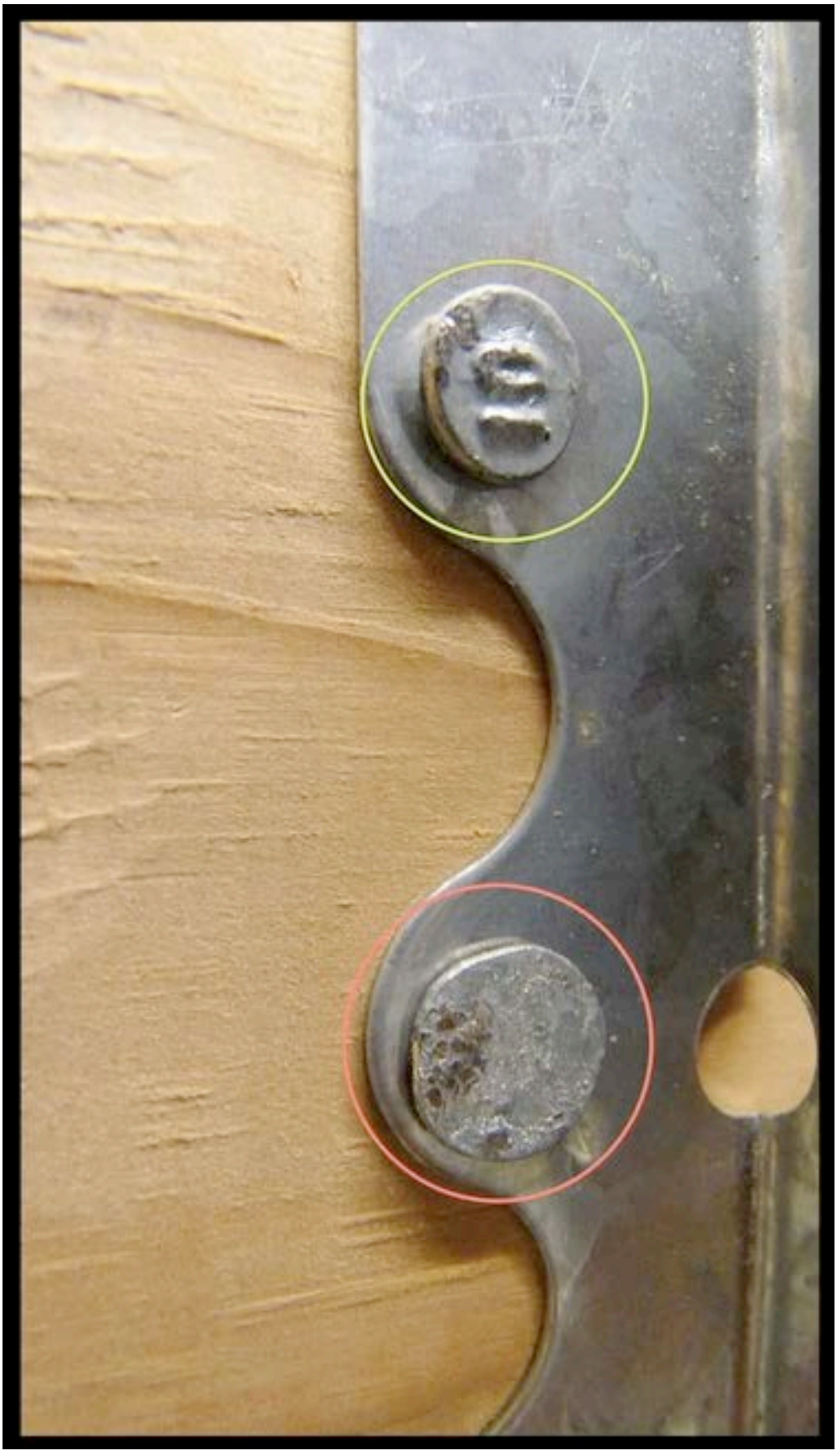


It’s important that you be able to identify proper fasteners.

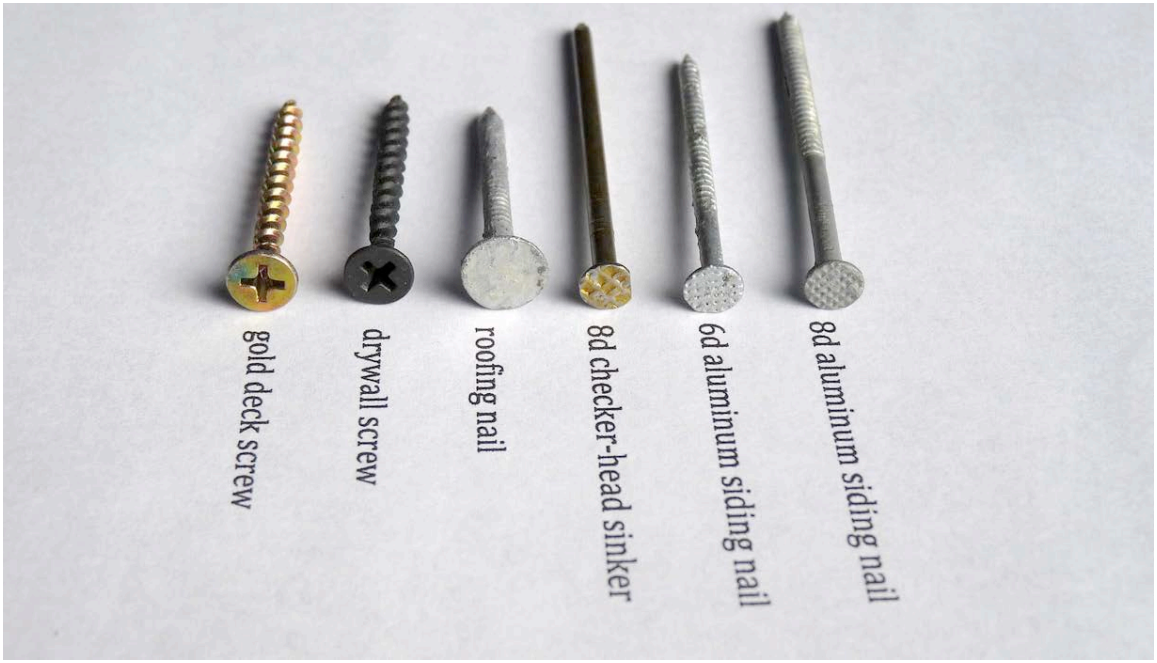


These are all acceptable, but the most commonly-used acceptable nails are 16-penny checker-head or numbers 8 and 10 hanger nails.

If you look at framing hardware fastener specifications almost all of them call for 10-penny hanger nails instead of 8-penny, so you want to see the number 10 on the heads of hanger nails when you inspect.



Although any nail with a number cast into the head is acceptable, not all acceptable nails are numbered, so look closely. Acceptable nails tend to have thicker heads.



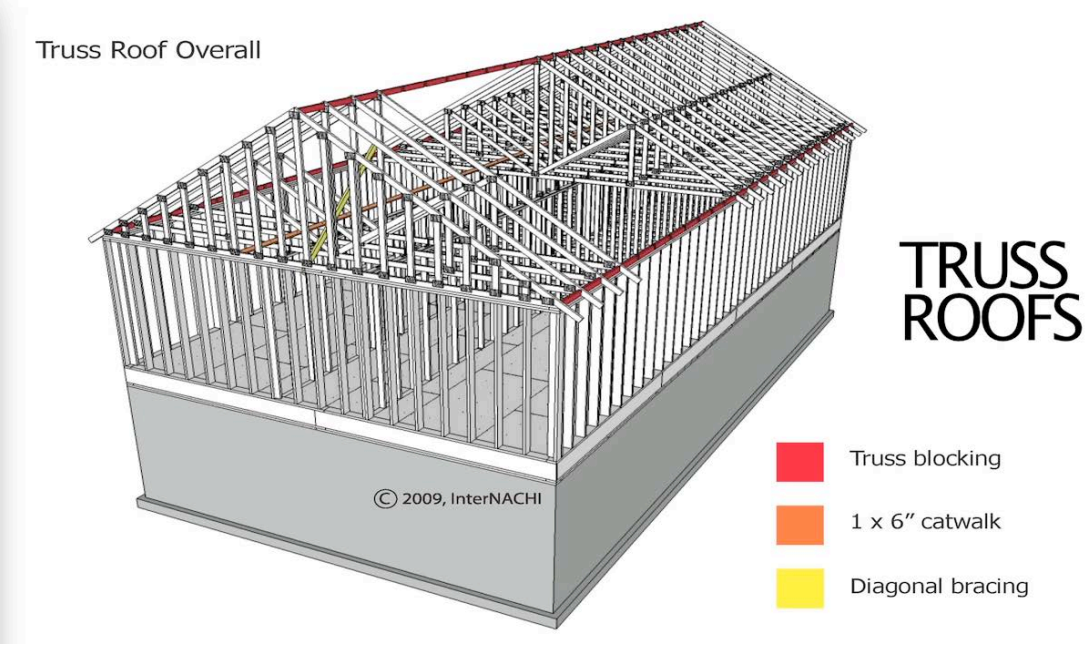
These are examples of nails NOT ACCEPTABLE for use with metal connectors. Finding the 8-penny checker-head sinker installed is an especially common defect

I’ve been on jobs and watched building department officials pass structures in which many connectors were fastened with eight penny vinyl-coated sinkers, but they shouldn’t have. 8-penny vinyl-coated sinkers used with metal connectors are a defective installation.

So many connectors have been installed with eight penny vinyl-coated sinkers without being called out as a violation by building department officials that you should not recommend replacement unless you find them on heavy steel connectors.

Instead, recommend evaluation by a structural engineer and let him be the one to jam the crowbar into the spokes of the transaction. He may also say it’s fine, but you should pass the liability on to the engineer.

TRUSS ROOFS



Roof trusses are engineered roof framing systems in which the main components- roof trusses- are designed by structural engineers, then assembled in a manufacturing facility before being delivered to the jobsite by truck.
Let’s take a look at how trusses are built.

Truss Manufacturing

Watch the video about manufacturing trusses.

The process starts in the picking yard where workmen pick through lumber to ensure that what’s chosen is of adequate quality. Lumber for trusses is stacked on racks outside the entrance to the area where the programmable saw is located.

Using a computer-generated cut list for reference, the operator programs the saw using a touch screen monitor. Information he enters will control the length of the truss members and angle of the cuts. All he has to do is roll the material onto the conveyor as often as it’s needed. The conveyor moves the material past a series of blades, then out the back of the saw gantry to where a workman is waiting to stack it on a mobile cart and mark it.
The saw moves back and forth along the gantry to adjust for different lengths. This saw will cut all pieces longer than 3’.

As the saw cuts material, scraps fall onto a conveyor belt which carries them through the exterior wall to a dumpster.

Web members shorter than 3’ are cut by hand using a radial arm saw and a cut list. While the shorter members are being cut and stacked, another employee assembles gangnails

Truss packages of individual truss members which have been pre-cut are rolled into the assembly area and spread to the areas where they’ll be needed.

The first truss is carefully assembled using a string to ensure that top and bottom chords are straight. Guides are moved into place which will help speed the assembly of subsequent trusses. Steel plates are moved into position beneath areas which will support gangnails at key connection points.

The truss is tacked together with a staple gun to keep it aligned while web members and gangnails are installed.

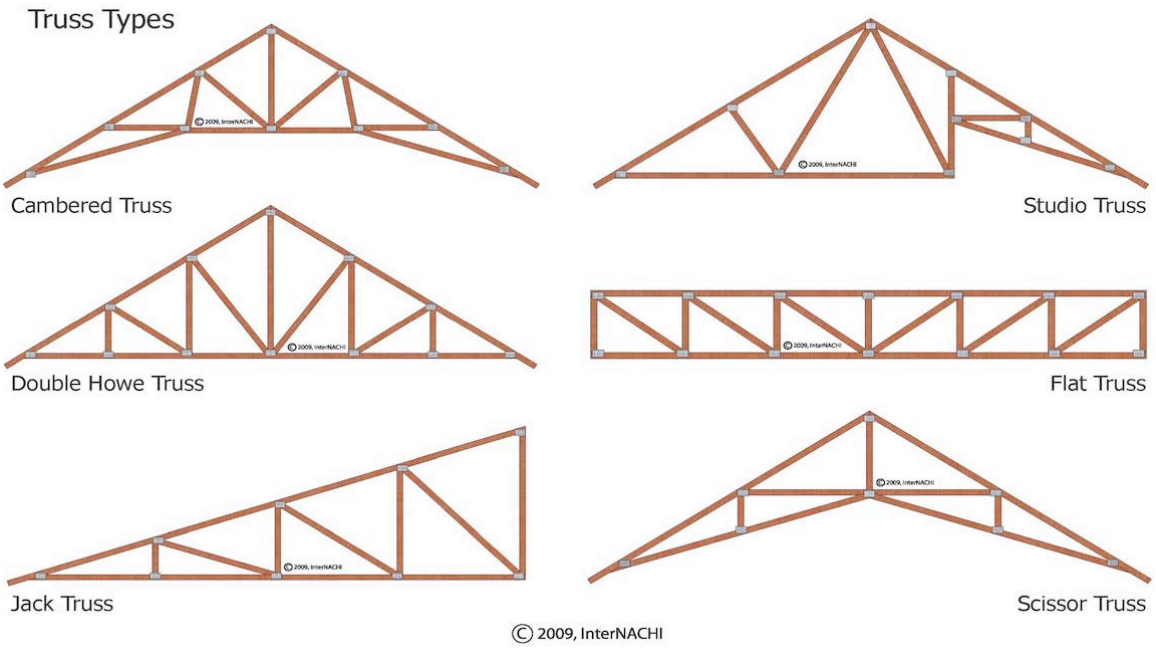
Gangnails are spread and placed both above and below the connection points. One or two blows with a hammer will hold them in place until the roller press makes a pass down the gantry. Once everything is in place, the operator climbs aboard the control station and the press glides down the gantry, the big roller pressing the gangnail spikes into the wood just far enough to hold the truss together while it’s moved. If the press applied enough pressure to sink the spikes completely, the truss might distort. For this reason, gangnails are pressed into place in two separate operations.

Once the press has made its first pass, hydraulic-powered supports lift the truss up to the level of an adjacent set of rollers. Workmen slide the truss over to the adjacent rollers and push the truss out through an opening in the wall.

Before moving through the opening, the truss passes through another roller press which presses the spikes in the gangnails all the way into the wood, creating extremely strong connections.

The truss exits the building onto another set of rollers before being removed and stacked. Trusses will be banded together with steel bands, before being loaded onto a truck for delivery to a jobsite.

INSPECTING TRUSSES

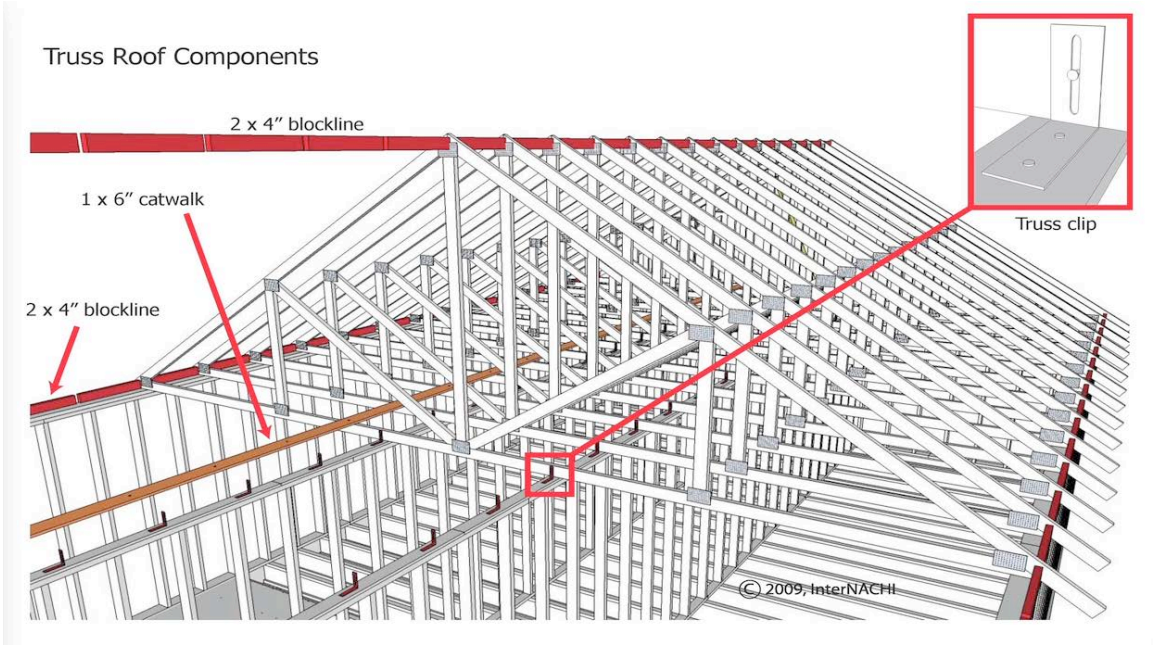


Trusses are manufactured in a wide variety of configurations and have been around since the early 1950’s.

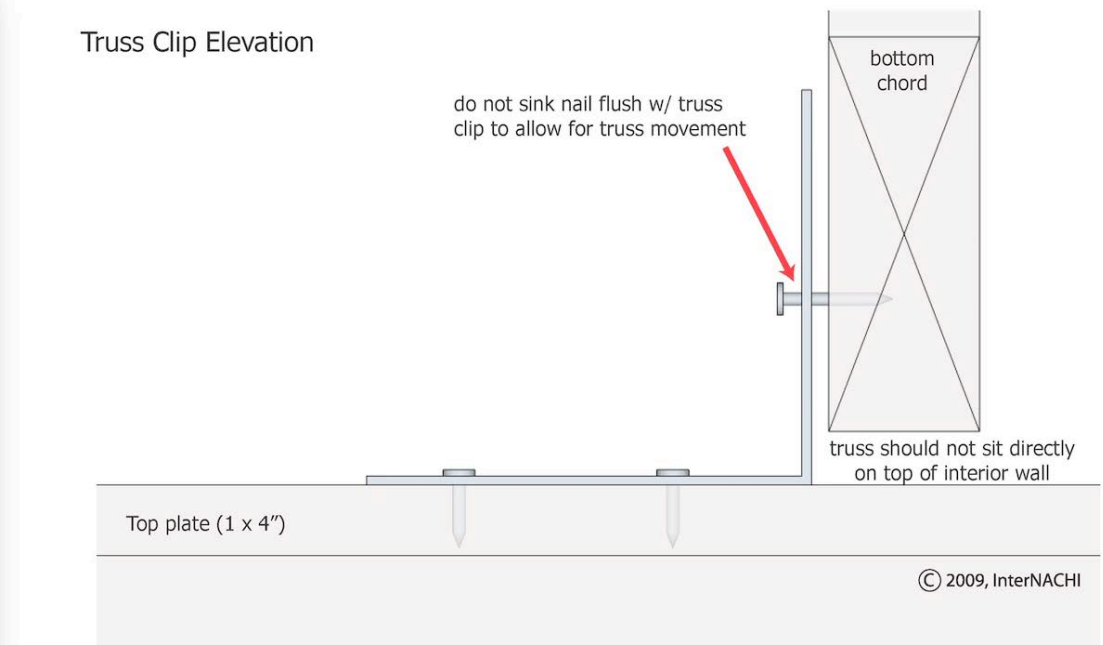
Trusses have to be engineered correctly, so if you see trusses fastened together with plywood gussets instead of

rings or gangnails, you’re looking at a non-professional design and you should recommend evaluation by a structural engineer.

In this photo from the same home, you can see that roof leakage has caused wood decay of the plywood gusset. By the time decay becomes visible, wood may have lost up to 50% of its strength, so decay is one more reason to recommend evaluation by a structural engineer.



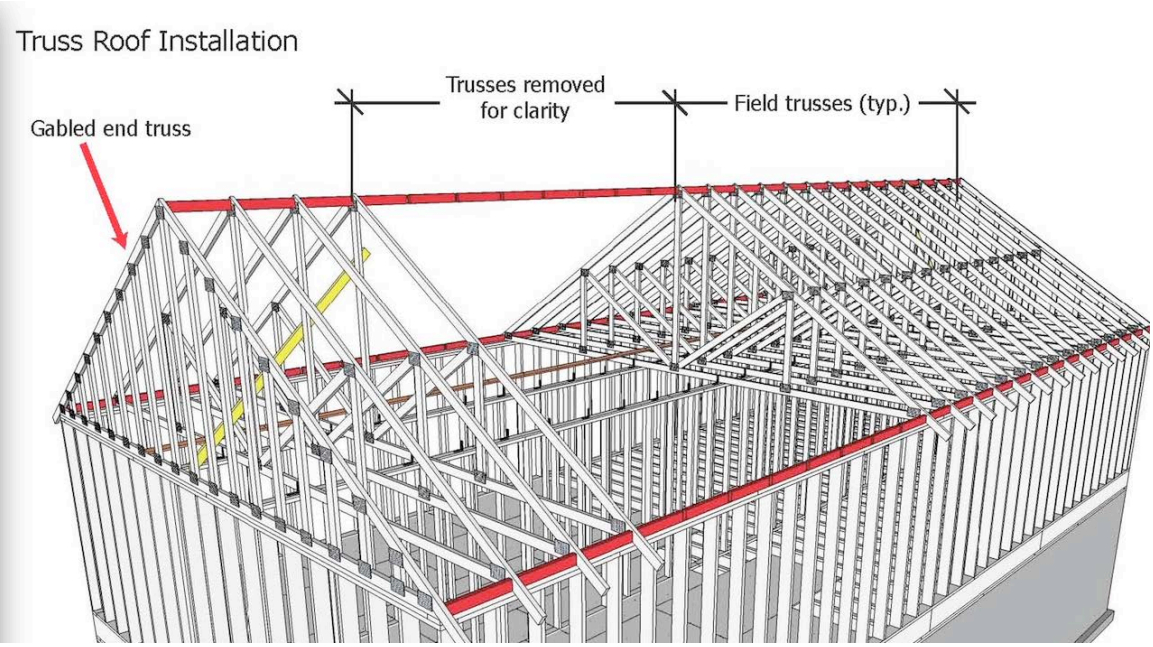
Most roof trusses are designed to bear on the exterior walls only. Trusses touching interior walls can transfer roof loads to walls not designed to carry a structural load.
Trusses touching interior walls can also create point loads on trusses at points not designed to support point loads. In rare cases this has resulted in “exploding trusses”.



As you see here, the bottom chords of trusses should be fastened to the tops of interior, non-bearing walls with slotted clips, which allow for some vertical movement of the trusses. Movement is usually related to changes in the moisture content of the wood trusses. This can be a response to changes in relative humidity or other conditions, which cause moisture level fluctuations in attic spaces.

Truss movement can also result when roof loads exceed the structural design loads of the tresses, as might happen with the accumulation of lots of wet, heavy snow in an area that seldom gets snow.

There are no simple guidelines. Truss engineers generally don’t recommend calling truss contact with interior walls a defect, even though contact is probably not correct.
The best option is to look for signs of failure. If trusses are in contact with the interior walls, keeps your eyes open for signs of foundation heaving which could transfer stress to the trusses. Recommend evaluation by a structural engineer if the potential for damage seems strong or if you have doubts about your ability to accurately evaluate conditions.

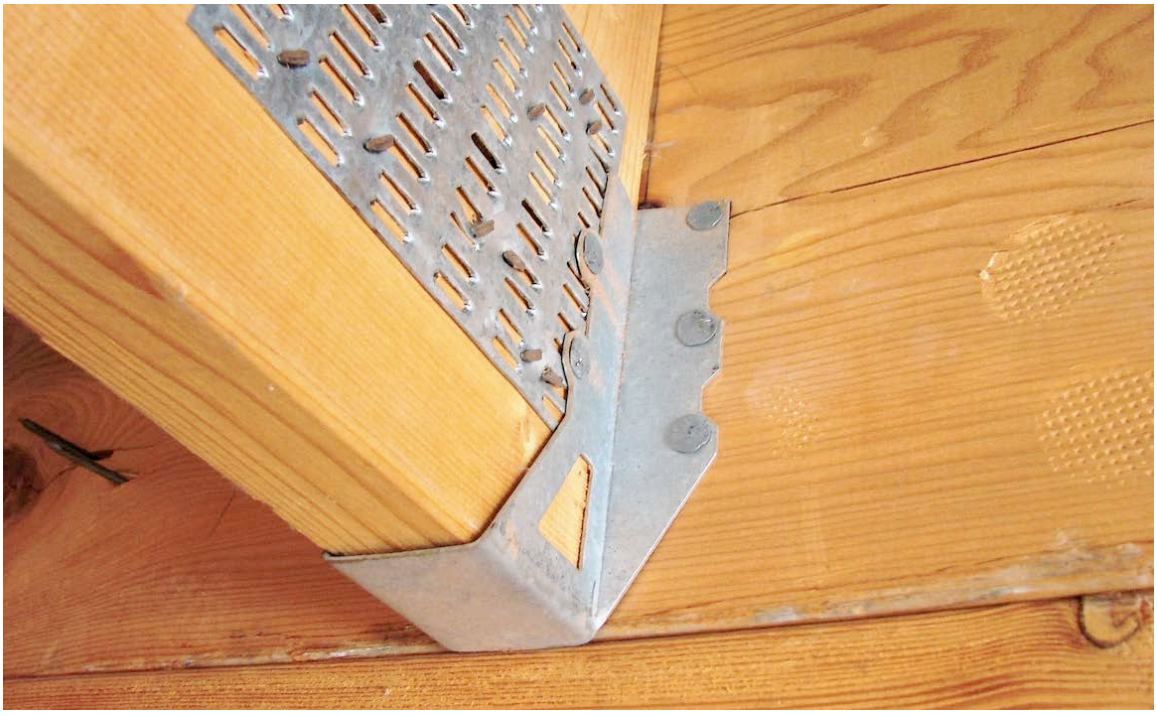


Trusses are usually braced with a system of 2 x 4’s and 1 x 6’s when they’re installed. The locations of bracing can be different for different truss designs and you’ll have no way of knowing what the requirements are. Trusses are often installed with blocks at the roof peak and above the outside walls, but these are not always required, so in your report, don’t call missing blocks or bracing a defective condition. Look for signs of failure.

Trusses out of plumb are poor quality construction but may be stable. If they’re badly out of plumb, mention that in your inspection report. Look for broken or damaged truss components and comment on them in your report.

Trusses should never be structurally altered in any way without approval from a structural engineer. If you see trusses, which have been cut or reinforced, recommend evaluation by a structural engineer.

Trusses sometimes rest in hangers instead of bearing on a wall. When this is the case, check the fasteners carefully.



These hangers were fastened with roofing nails, and that’s a defective installation.

Here’s the garage of a home I inspected. The neighbor told me that the roof of the garage next door had collapsed during a big snowstorm the previous year.

I noticed right away that the trusses had been altered. Plywood gussets had been added at a connection that would typically have had metal gangnails installed.

Looking over to the wall I noticed that the hangers seemed to be small for the load they were carrying.

The hangers turned out to be sized for 2x4s. That is too small for the roof load they were carrying, and they were fastened with a total of 4 gold deck screws each. The deck screws were a serious defect, rated far below acceptable hanger nail strength.

In addition to that, they were installed through drywall, which does not support the shaft of a fastener like wood does.

The problems didn’t end there. If you look closely at the gangnail, you can see that it’s been damaged and the spikes are no longer embedded in the wood. Instead, the gangnail is attached by a couple of nails, which have been bent over.

This roof was structurally inadequate and dangerous. It needed to have corrections designed by a structural engineer and bids from qualified contractors for making the corrections. Corrections needed to be done soon.

ATTIC AREA ROOF INSPECTION

Components from a number of different home systems may be present in the attic and the scope of this course is limited to roof defects, so we won’t be covering complete attic inspection in detail.

The attic is a great place to find evidence of roof leaks, especially if you’ve already seen potential problems on the roof.

Look for daylight. If you can see out, water may be able to find its way in. The exception is older shake roofs. You can sometimes see daylight through them without finding signs of leakage.

Penetrations

Check around roof penetrations. Long-term leakage often encourages mold growth, which usually appears as dark staining on the underside of roof sheathing and on roof framing members. Long-term leakage can cause severe decay, which is usually brown or white.

Use a moisture meter to check stains for elevated moisture content. Decay fungi become active at about 20% moisture in materials. They start to reproduce at about 27%. This truss web had a level of 43%.

The duct you see coming up from the lower right is from a bathroom exhaust fan which is supposed to terminate at the home exterior, not in the attic. The moisture meter read almost 70% moisture in the roof sheathing.

If you find elevated levels, the chances are good that it’s a recent leak instead of an old leak, which has already been repaired. You’ll want to report any stains you find… just don’t call it active leakage without a good reason. If you check a stain and it reads dry… maybe it hasn’t rained in a while. Report what you see. Don’t say anything that you don’t know is true. Recommend a qualified roofing contractor if you have doubts.

Poor connections

Look for poor connections and improper fasteners. Nails should be sunk to the head, not tacked. Metal connectors haven‘t always been required and lack of them is not necessarily a defect.

Here are some other conditions to watch for:
Look for broken, damaged or sagging framing components.
If the sheathing has been cut for ventilation purposes, check to see that underlayment has also been cut to allow air flow.
If the home has soffit vents, check to see that they aren’t blocked by insulation.

“H” clips are small metal clips designed to provide additional support to the roof sheathing panel edges. You may or may not see “H” clips installed between roof sheathing panels.

Whether or not to use them is an architect’s or engineer’s call. Lack of them is not a defect unless you know that they were required in the jurisdiction in which the home is located at the time the home was built.

EVALUATING ROOF FRAMING

Evaluating roof framing can be difficult because different methods have been used in different parts of North America, because standards and practices have changed over the years and because the quality of work varies a lot.

At one end of the spectrum are great design, great work, and great materials, and at the other end of the spectrum, all those things are poor and failing. Homes that are in either great shape or terrible shape are easy to inspect, because they require very little judgment.

In most of the homes you’ll inspect, one, two or all three of these things will lie somewhere in the middle. You’ll often have to decide whether something is a defect, or just poor quality work, and making that decision correctly is really the hard part.

When you’re faced with this decision, remember what you do. You perform a General Home Inspection designed to identify safety issues and system and component defects.
In older homes, look for failure. If it looks wrong but shows no signs of failure after 50 years, you need a pretty good reason to call for correction. If it’s new and looks wrong, it may fail and you should pass on the liability by making a proper recommendation.

For conventional roofs you can sometimes recommend a qualified contractor. For truss roofs you should recommend a structural engineer because most of the defects related to trusses require calculations.

If you are certain of the year the roof was built and know what codes were in effect at that time, then maybe you’ll want to identify an apparent code violation as a defect. From a legal perspective, you might be better off staying close to the Standards of Practice and limiting your comments to safety and system defects.

MOISTURE PROBLEMS

Before we really get into roofing materials, let’s talk a little about why they’re needed in the first place.

The primary purpose of the roof-covering material is to keep moisture out of the home. Too much moisture in the home can cause a number of problems.

Material damage

Moisture can damage a lot of different kinds of materials commonly found in homes. In a granular material like drywall, water is absorbed into the spaces between particles, reducing the material strength. This is why ceiling drywall sags when it becomes saturated.

In cellulose-based products like wood, wood rot, which is properly called wood “decay” can take place when material moisture levels reach about 20%. Since most houses are wood structures, decay can be a significant problem, especially if it continues undetected for a long time.

Corrosion is another concern. Most of the metal fasteners and connectors that hold roof framing together are made of metal and vulnerable to damage from corrosion.

Because roofs may leak into attics or the interiors of walls, evidence of leakage is not always visible.

Human health

Human health is another concern. Mold is caused by fungi which become active at about 20% moisture level. Mold fungi reproduce by releasing microscopic spores into the indoor air, which can cause health problems if they’re inhaled.

The immune systems of healthy people are usually able to handle elevated levels of mold spores. People with asthma, allergies, lung disease or compromised immune systems can develop serious or fatal fungal infections.

Comfort levels

Higher relative humidity inside a home is perceived by people as heat. This is why 85 degrees in Biloxi, Mississippi where the air is very humid will feel hotter than 85 degrees in Death Valley, where the air is very dry. In fact, in Death Valley, 85 degrees will feel cool.

The same is true inside your home. If air inside your home is humid because a roof leak allows moisture intrusion, during the cooling season comfort levels will be lower and cooling costs will be higher since the air conditioner will be running more often.
During the heating season dry is more comfortable than damp.

FORMS of MOISTURE

The types of moisture problems commonly found in homes can vary with the type of climate in which the home is located. Homes located in hot, humid climates like Key West, Florida and in cold, dry climates like Steamboat Springs, Colorado, will often experience moisture in different forms and different types of moisture problems.

Solid

Ice and snow are examples of moisture as a solid. As water turns to ice, it expands by about 10%, creating a powerful force that can crack materials that are too brittle to flex. As ice, moisture can form dams that cause melt-water to back up beneath roofing materials and cause leaks. Efforts to remove ice dams may damage roof-covering materials.

As snow, it adds weight to roofs and holds moisture against the roof.

Liquid

As a liquid, water falls down from the sky, bounces upward from the surfaces it hits, and moves in unexpected directions… like sideways, backwards and upwards… like when roof drainage is dammed by blockages or absorbed by materials.

Gas

Water in the form of a gas is called “moisture vapor”, and consists of microscopic droplets suspended in the air. These droplets can be carried through very small openings by air currents.

Cooking, bathing, washing clothes, even human respiration, all put moisture into indoor air. All the water used to water plants will eventually wind up in indoor air. If this water vapor has no good route to the home exterior, comfort levels and air quality can suffer.

Moisture vapor created in the home can be absorbed by the roof deck and cause it to expand, buckling shingles as the spaces between sheathing panels become smaller.

It can also enter the home from outside. Improper attic or roof venting practices can cause moisture from hot, humid, outdoor air to condense on roof framing. This condensation can then be moved into the home by gravity and the gradient forces we’re about to discuss.

MOISTURE MOVEMENT

A number of different forces can affect the ways that moisture moves from one place to another.

Gravity

The most obvious force is gravity. Water moves downhill. Gravity can create problems- like when it tries to move moisture past roofing materials protecting a home interior- or it can help prevent them- like when it moves water quickly off of a steep roof.

GRADIENTS

Other forces that move moisture include several gradients. A “gradient” is the movement of something across an area of difference. Gradients are named according to the force that causes the movement.

Thermal Gradient

According to the “thermal” gradient, moisture is moved by differences in temperature. Moisture moves from warm areas toward cold areas.
Moisture on a warm, wet roof will try to migrate toward a cool, air-conditioned home interior.

Pressure gradient

The “pressure” gradient describes the tendency of moisture, often in the form of vapor, to move from areas of high air pressure to areas of low air pressure.

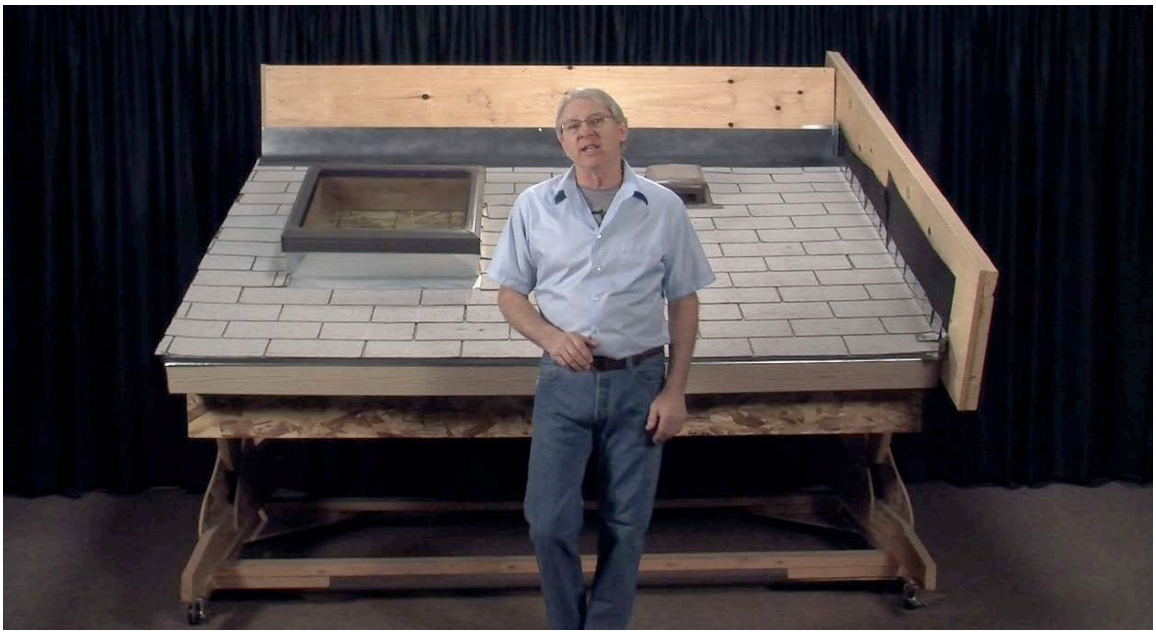
Air pressure inside a home can be lowered by whole-house fans, exhaust fans in dryers, bathrooms and kitchens or by the combustion exhaust systems of furnaces, boilers and hot water heaters.

All of these devices push indoor air to the outside. If it’s humid outside… this can draw moisture-laden air into the home.

Concentration Gradient

The “concentration gradient” describes the tendency of moisture to move from areas of high concentration to areas of low concentration. In other words, moisture moves from wet areas toward dry areas.

UNDERLAYMENT



In this section we’ll be looking at the various types of underlayment and their different properties.

When a roofer first walks onto a job, unless he’s tearing off an old roof-covering material, he’s faced with a bare roof deck. After the edge metal on the eves, the first component to be installed on the roof is underlayment.

Underlayments are manufactured with different properties designed to meet the needs of homes in different climate zones. An underlayment that works well under metal roofing in a hot, humid place like

New Orleans, Louisiana may not work well beneath wood shakes in a cold, dry climate like Jackson, Wyoming.

The different types of roof-covering materials may have specific underlayment requirements. We’ll be covering underlayment requirements in the video courses on each of those roof-covering materials.

You will not be responsible for confirming that the proper type of underlayment was used, but if you see problems with the roof, understanding the basic properties and general installation requirements of underlayment may give you a clue as to the source as to the source of the problem.

Although underlayment is typically required in new construction by building codes, in the past, roof-covering material manufacturers haven’t always required it.

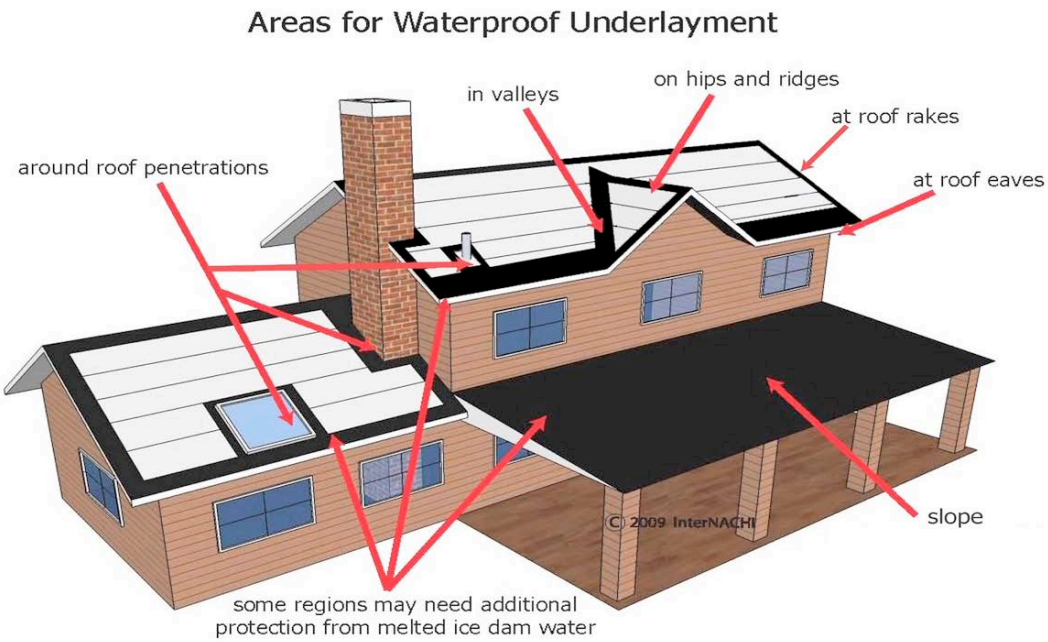
The PURPOSES OF UNDERLAYMENT

Moisture barrier

Underlayment serves several purposes. First, it protects the roof sheathing before the roof-covering material is installed. It also acts as a secondary barrier to moisture intrusion. The roof-covering material is the primary barrier.

And, if for some reason the roof covering material should be damaged or displaced, intact underlayment will help protect the home interior.

Water-resistant underlayment may allow the passage of moisture vapor, but prevent the passage of water in its liquid form.



Waterproof underlayment will prevent the passage of both liquid water and water vapor.

Waterproof underlayment is typically used on parts of the roof that are more likely to leak or suffer moisture intrusion. This includes penetrations, areas where roof-covering materials change or end, and low-slope sections of roof. It’s not unusual to use combinations of underlayment on a home roof.

The “permeability” of underlayment is the extent to which it allows the passage of water vapor. Although all underlayments are designed to prevent the passage of moisture in its liquid form, they can have different levels of resistance to the passage of water vapor.

Underlayment permeability ratings are provided by the manufacturers and are less important in roof underlayment than they are in housewrap. Underlayments with a perm rating of 1 or less are moisture barriers. Underlayments rated above 1 are moisture retarders.

Temporary protection

Underlayment provides temporary protection of the building interior and the roof deck before the roof-covering material is installed.

In a perfect world the roof-covering material would be installed as soon as possible, but in the real world, the roof may be protected by underlayment alone for days, weeks and sometimes months.

Protecting the building interior is especially important when an old roof-covering material is being replaced and the home interior is finished.

During that time the underlayment may be under attack from weather elements like high winds, UV radiation and precipitation.

It also needs to resist the wear and tear that occurs when the roof-covering material is being installed.

Preventing chemical degradation

Underlayment also provides a layer of separation between roof sheathing and the roof-covering material.

Newer homes use plywood or an engineered panel called “oriented strand board” or “OSB” for roof sheathing

For many years pine or fir boards were used as sheathing and lots of older homes still have these boards in place.

Resin pockets in these boards can react chemically with some roof-covering materials… like asphalt shingles. In these situations, missing underlayment can cause accelerated deterioration and premature failure of the roof-covering material.

Fire resistance

Underlayment materials are available for wood roofs which increase their resistance to fire, In fact, without special underlayment, wood shakes and shingles cannot achieve a class A fire rating, which is the highest available.

TYPES of UNDERLAYMENT

There are three basic types of underlayment:
Asphalt-saturated felt
Rubberized asphalt, and
Non-bitumen synthetic.

We’ll start by talking about felt.

ASPHALT-SATURATED FELT

One of the most common types of underlayment used in residential, steep-slope applications is a black, asphalt-saturated felt paper. Felt underlayment may be made from either an organic or fiberglass substrate, although the organic is much more common. It’s called “organic” underlayment because it has a cellulose base.

Felt underlayment is water resistant, not waterproof. It’s available in two thicknesses… 15-pound and 30-pound. 15 lb felt has a perm rating of about 5, although this number can rise in high-humidity conditions.

30 lb. felt will be more resistant to damage during installation of the roof-covering material and will protect the roof longer if it should somehow become exposed to weather. The difference is obvious once you see them together. 30-pound is much thicker and stiffer. It’s what you see being installed here

INSTALLATION of FELT UNDERLAYMENT

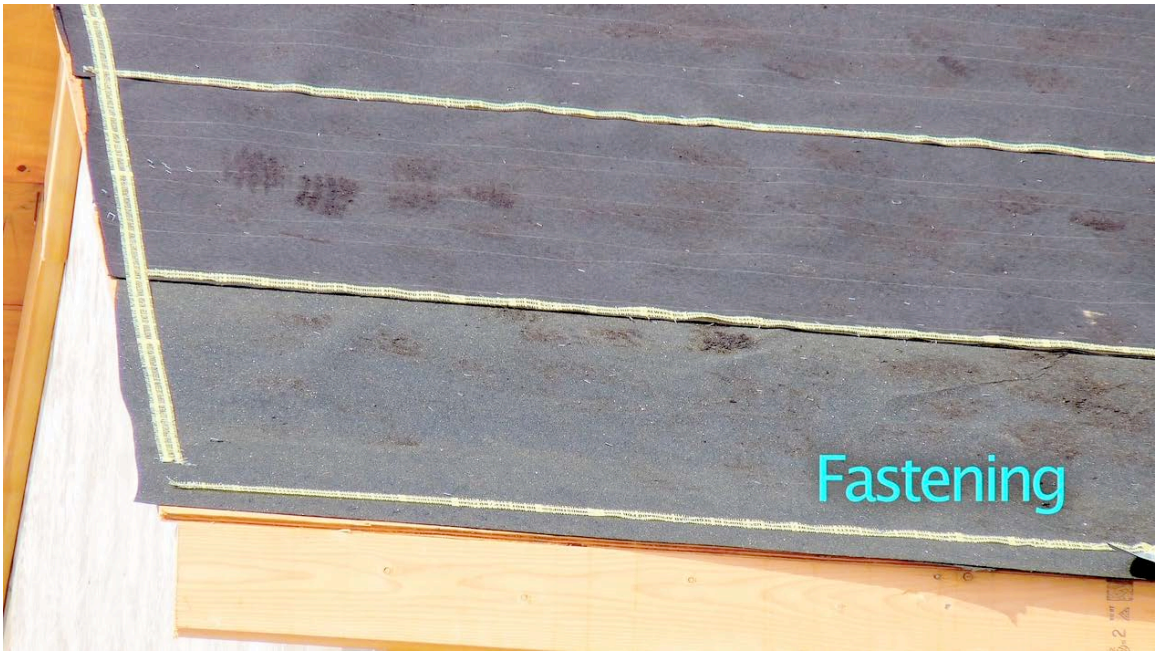
Slope limitations

In low-slope conditions, from 2:12 up to 4:12, felt courses should overlap a minimum of 19 inches. This will provide a double layer of underlayment across the entire roof.

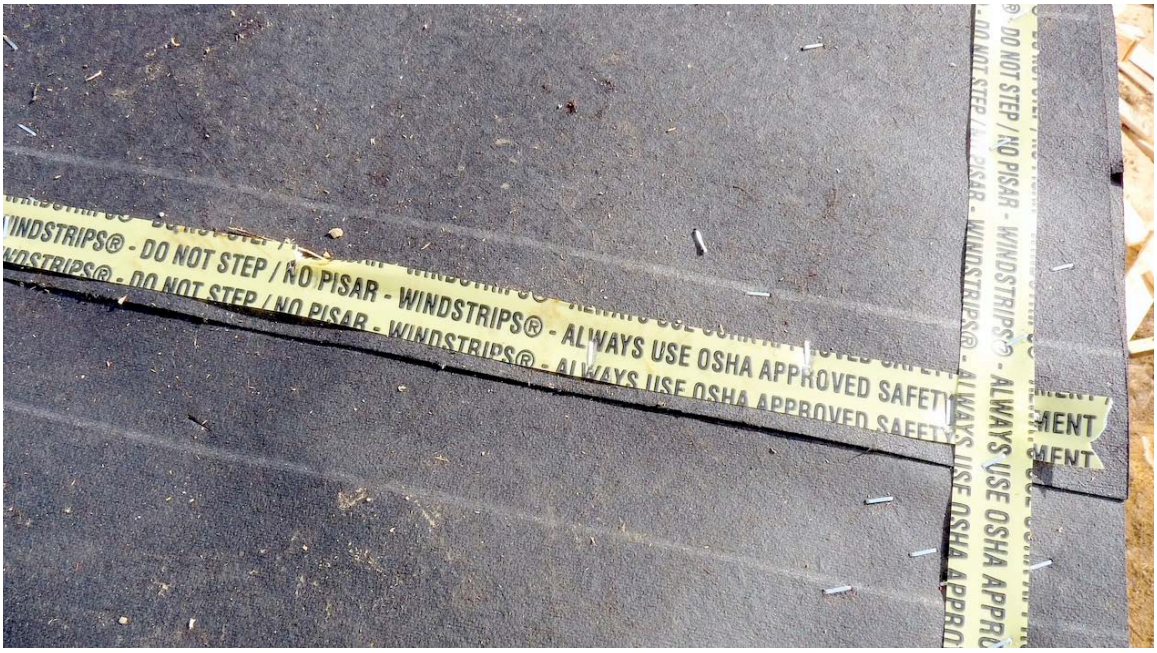
This is what a low-slope installation looks like.

In steep-slope conditions, 4:12 and steeper upper courses of felt underlayment should overlap lower courses by at least 2 inches. Here you can see the difference between the underlayment overlapped 19 inches on the roof to the right and overlapped 2 inches on the roof to the left.

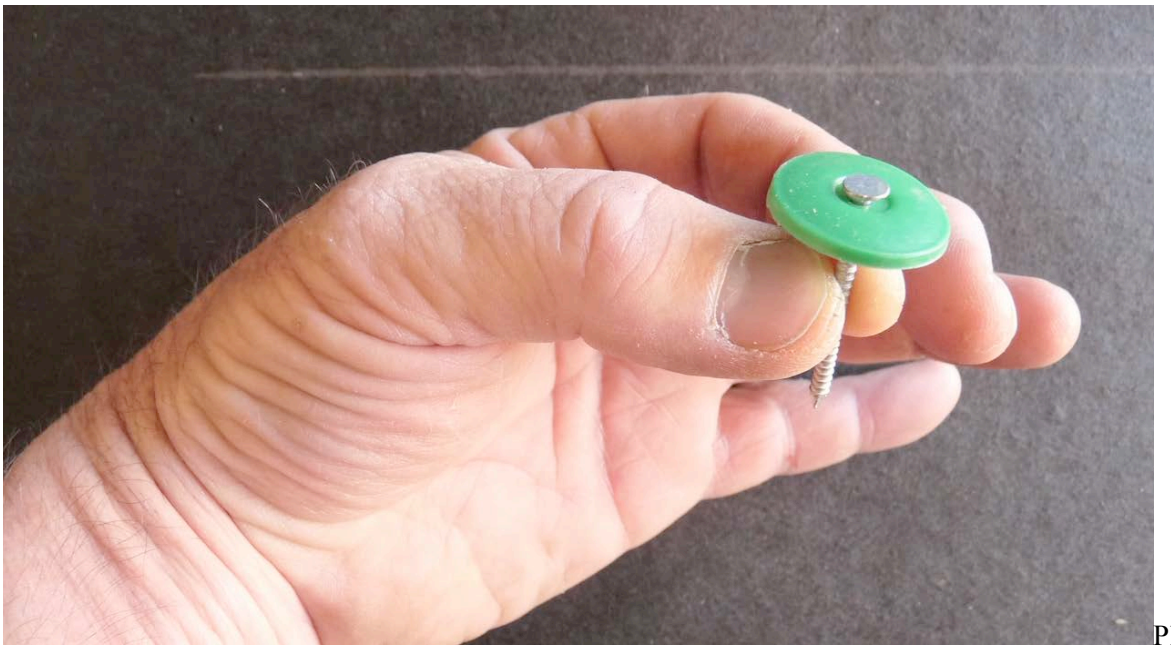
Fastening



Felt is usually fastened with staples, but in high wind areas, plastic windstrips may be used along the edges to prevent tearing.



Felt may also be attached in high-wind areas using plastic cap nails like these. Look at the picture below.



Plastic caps offer better wind resistance than staples and help prevent leakage through the hole made by the fastener.

Edge metal laps

Felt underlayment should overlap the edge metal at the eves and be overlapped by edge metal on the rakes. This is also true for rubberized asphalt underlayment, but no necessarily true for synthetics, and we’ll talk a little bit more about this later.

FELT UNDERLAYMENT FAILURE

Asphalt-saturated felt may fail for a number of reasons:

Poor quality

Poor-quality is one reason. A number of ASTM standards exist which offer specifications for asphalt-saturated felt.

Many manufacturers produce asphalt-saturated paper labeled “Underlayment”, “15-lb” or “30-lb” which do not comply with any standards and which are often saturated to a lower level than an ASTM-compliant underlayment. These underlayments typically absorb water more readily and fail sooner. Water absorption can cause wrinkling as the product expands. These wrinkles may telegraph through to roof-covering products like thinner asphalt shingles.

Water from the felt may be absorbed by the roof deck, which can cause problems with expansion and contraction of the deck.

You won’t be able to tell by looking whether a product complies with any standards, but if you see what looks like premature failure or distortion of underlayment, it may be caused by sub-standard underlayment.

Loss of volatiles

Over time, volatile compounds in the asphalt will dissipate and the underlayment will become more fragile and moisture absorbent. This will happen more quickly when felt is exposed to heat. The source of heat may be a warm climate, a particular type of roof-covering material or poor roof structure ventilation or a combination of all three.

UV exposure

Anywhere felt underlayment is exposed directly to sunlight, UV radiation will accelerate its deterioration.

These poorly-bonded shingles were attached with staples and the home was located in a high-wind area.

Asphalt felt production

Asphalt is basically the residue left over from the process of refining crude oil. As the price of oil has increased, refining techniques have been developed that are designed to extract the maximum amount of high-quality products from the crude.

These techniques… involving the use of “Coker units”… leaves as residue a powder instead of the sludge from which asphalt is produced. With less asphalt being produced, an allocation program has been established in which the asphalt produced each year is allocated in limited amounts to manufacturers of asphalt shingles and underlayment.

Since shingles produce a higher profit margin than underlayment for the amount of asphalt used, most manufacturers are phasing out of asphalt-saturated underlayments in favor of synthetic underlayments. Although they fluctuate with raw material prices, as of 2011, prices for felt and synthetic underlayments were similar.

RUBBERIZED ASPHALT

KENTON

Various types of rubber-like materials are also used as underlayment and are generally referred to as “rubberized asphalt”. These typically have adhesive on one side which is protected by a peel-off membrane, making them self-adhering. The rubber-like qualities of these underlayments also make them self-sealing, meaning that they seal well around fasteners like staples and nails.

Rubberized asphalt underlayments are manufactured to meet different requirements:

They may have polyethylene or polyester bonded to the upper surface to provide non-skid and weather-resistant qualities.

They may have a polymer film bonded to the weather surface to improve moisture resistance.

They may be fiberglass-reinforced.

They may have a mineral coating on the weather surface.

They may be formulated for use in high-temperature situations. Some underlayments are designed to resist heat up to 250 degrees without degradation of the adhesive. This allows them to be installed under metal roofs and in harsh environments.

The asphalt may be polymer-modified.

Polymer-modified bitumen

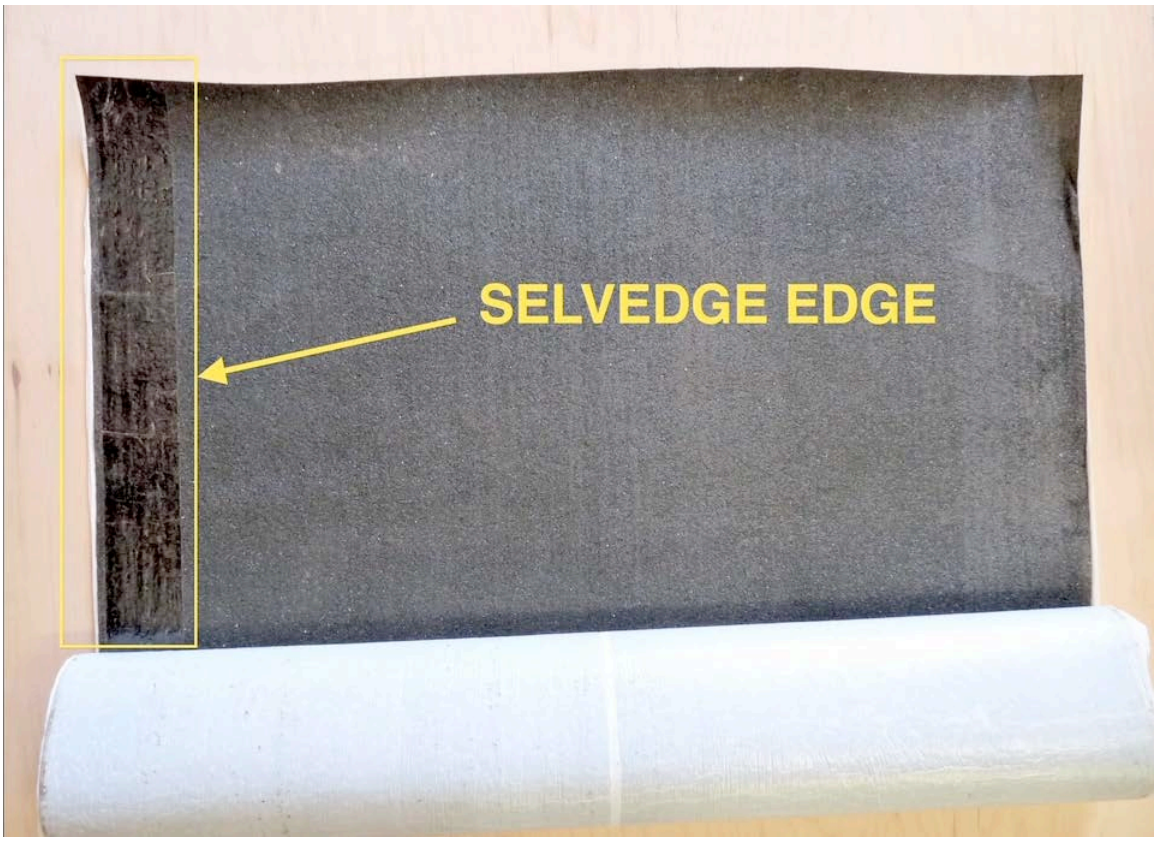
The term “modified bitumen” is often used when referring to asphaltic roofing materials. Sometimes it’s shortened to “mod-bit”. The term “bitumen” is a generic name applied to various mixtures of hydrocarbons. One of these mixtures is the asphalt used in underlayment, asphalt shingles and built-up roofing. It’s a common term in the roofing industry.

To improve various characteristics like strength and elasticity, bitumen is sometimes modified using polymers, which give it plastic-like or rubber-like properties, depending on which process is used.

Polymers are materials made of molecules, which are custom-designed to give the material specific properties. Polymers are used in lots of different types of roofing products to increase their resistance to damage and deterioration.

You may also hear the term “cross-linked polymer” used. Molecules in cross-linked polymers actually bond to each at the atomic level; they actually share atoms, which greatly increases the strength of the material.

Selvedge edge



Rolls of rubberized asphalt underlayment may come with a selvedge edge along one side of the roll. The selvedge edge is designed to create a strong, watertight seal along the edges where rolls overlap. The selvedge edge should always be along the top edge when the underlayment is installed in courses across a roof.

NON-BITUMEN SYNTHETICS

Non-bitumen synthetic underlayments are made from polypropylene or polyethylene. These synthetic polymers are also used to make a huge variety of other types of products, everything from food-storage containers and rope to long underwear.

Advantages

Like other underlayment materials, the use of synthetics has both advantages and disadvantages. The advantages are:
They are lightweight and high-strength.
The fact that they’re typically non-skid.
Synthetics are resistant to fungal growth and wrinkle-free, since they don’t absorb moisture. Although they can be designed as moisture permeable, they are typically moisture barriers.
They’re also very resistant to UV damage and can be left exposed to weather for periods from 6 months to a year, depending on the manufacturers recommendations.

Disadvantages

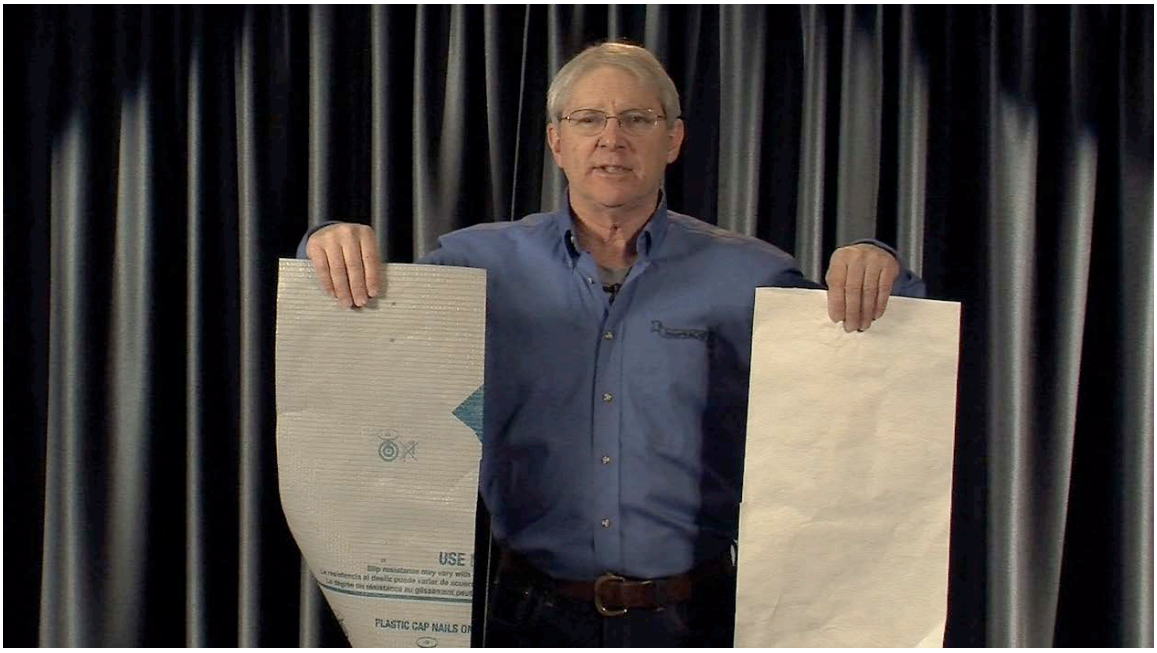
As of 2010 there are some concerns with synthetic underlayment. According to the National Roofing Contractor’s Association:
To date, there are no applicable ASTM standards for these products.
Many synthetic underlayments don’t meet current building code requirements
Use of these underlayments may void some manufacturers' material warranties for certain roof coverings (like asphalt shingles).
Wicking can be more of a problem than with felt underlayment. Installation along the roof eve is different with some types of synthetics.

If the installer fails to read and follow the manufactures’ installation instructions, but instead installs it like they would if they were using felt, they may create moisture problems.

Here you see synthetic underlayment installed on a home.

Again, as an inspector you are not responsible for identifying the type of underlayment, but it’s a good idea for you to know what types exist and some of their properties.

Although companies who manufacture synthetic underlayment may also manufacture similar-looking housewrap, housewrap does not meet roofing underlayment requirements. Housewrap installed as underlayment is a defective installation.



Underlayment is usually thicker than housewrap. Here you can see the difference between the two.

INSTALLING SYNTHETIC UNDERLAYMENT

Slope limitations

Slope limitations will vary by manufacturer. Some will specify a greater overlap for low-slope roofs and some won’t.

Roof edges

To avoid problems from wicking moisture, many synthetic underlayments are designed to wrap around the roof edge and protect the edges of the roof sheathing. The edge metal is installed over the underlayment at both the eves and rakes.

Fastening

Fastening is generally with plastic caps or roofing nails. The use of staples is discouraged because synthetics are not self-sealing.

FACTORS AFFECTING UNDERLAYMENT

A number of factors can affect the performance of underlayment and determine which types are appropriate.

Climate Types

Climate in North America can be roughly separated into four basic types:
Hot or cold dry climates, and
hot or cold humid climates.

Hot and dry climates will affect bituminous underlayment by accelerating the loss of volatiles.
In humid climates, older felt underlayment will absorb more moisture, which in turn can be absorbed by the substrate, causing it to expand.

In cold climates, underlayment will become brittle and more easily damaged by footfall and impact.

Each of these climate types should have underlayment installed, which has performance characteristics compatible with that particular climate.

Roof design

Some designs shed run-off quickly and some have design features, which may actually trap run-off and expose the underlayment to more moisture.

Roof-covering material

Manufacturers produce underlayment of different types for use with the different types of roof-covering materials. The use of underlayments that are not compatible with the roof-covering material with which they’re installed can cause problems. You’ll learn more about this in the sections on the individual roof-covering materials.

Roof-covering materials in poor condition which expose underlayment to weather and especially to UV radiation from sunlight can accelerate deterioration.

Builder’s budget

Poor quality roof-covering materials or installation can affect the long-term service life of underlayment.

Missing underlayment

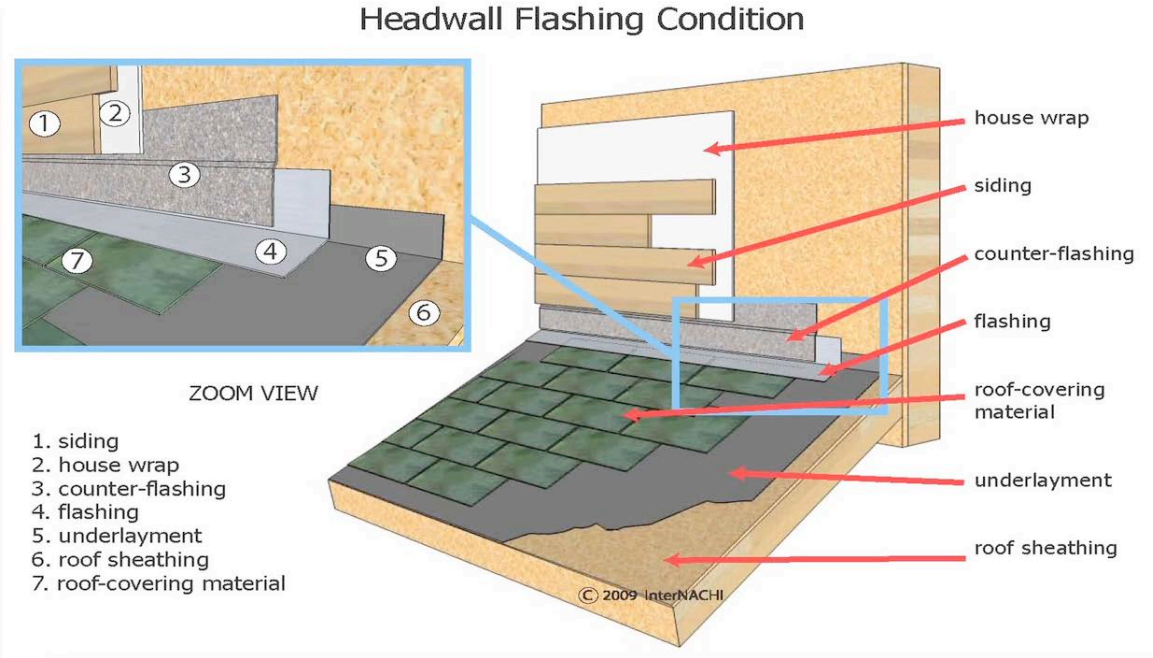
Although underlayment is typically required in new construction by building codes, in the past, some manufacturers have not required it on roofs of 4&12 and steeper. Unless you know for certain that the roof-covering material on the home you’re inspecting required underlayment, you should refrain from calling missing underlayment a defective installation.

Determining whether underlayment was required means finding the manufacturer’s installation instructions for that particular roof-covering material and also finding out what jurisdictional requirements were in place at the time the home was built.

Since this research falls well beyond the Standards of Practice, you might better serve your client by making them aware of the steps needed to confirm proper installation and recommending a qualified roofing contractor.

UNDERLAYMENT INSTALLATION METHODS

Installation methods vary with the pitch of the roof, with the requirements of both underlayment and roof-covering material manufacturers and with jurisdictional requirements.



At headwalls and sidewalls, all underlayments should extend up the wall for at least several inches.

Fastening methods

Unless the underlayment is self-adhering, it’s attached to the roof with fasteners, which are a disadvantage because they make holes in the underlayment.

One of two fasteners is usually used.

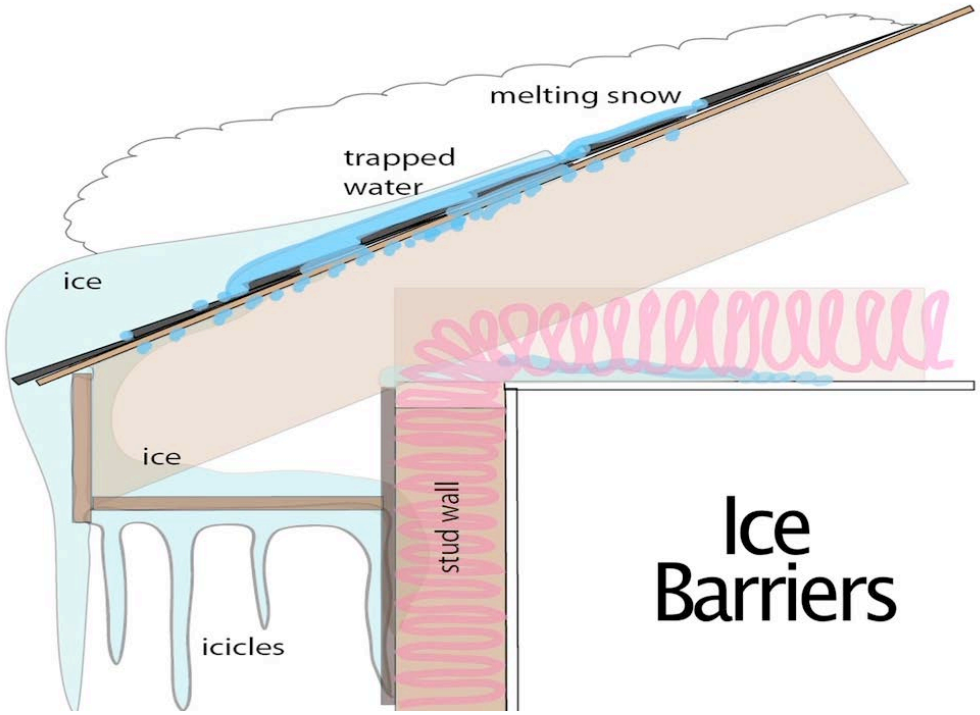
Staples are the most common, but in high wind areas and with synthetics, underlayment is often fastened with plastic caps.

“Plastic caps” are the industry term for nails that come with a plastic gasket attached. Here’s an example. Plastic caps are typically used in situation in which wind damage to underlayment is a possibility, but they also help seal against moisture intrusion.

It’s not unusual in areas subject to high winds for roof-covering materials to be blown off but for underlayment to remain in place.

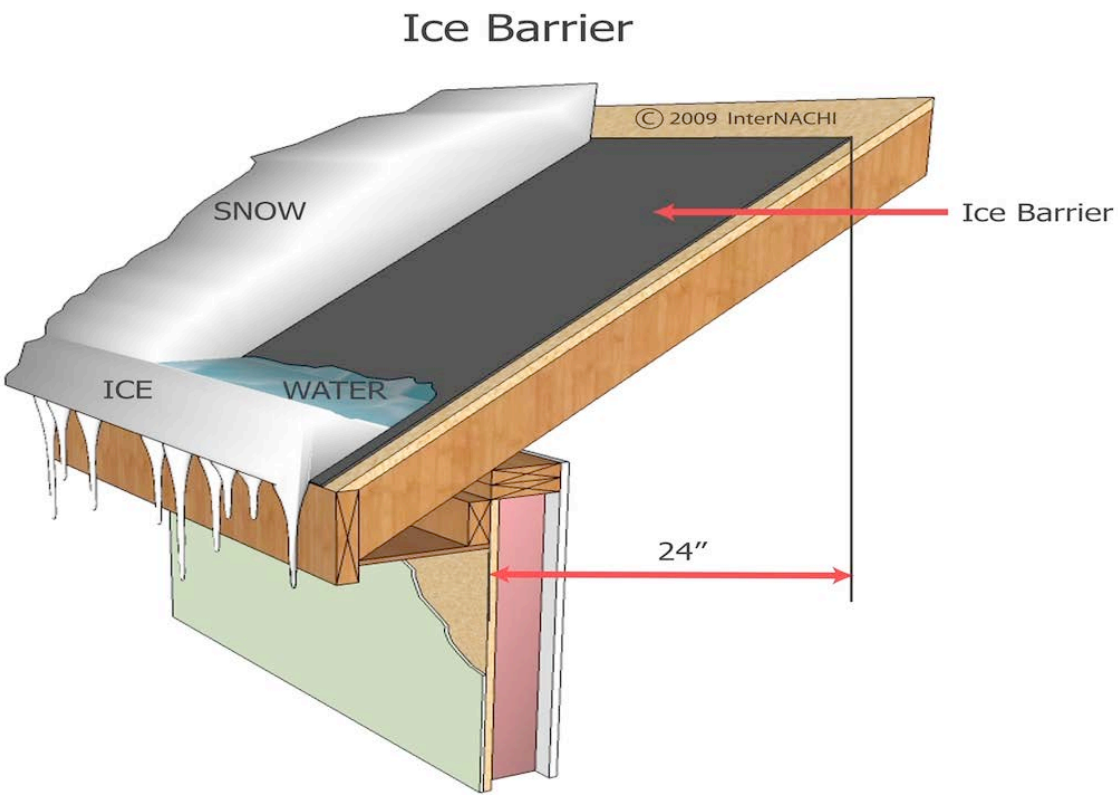
In these situations, the remaining underlayment can make a big difference in limiting interior water damage. Underlayment fastened with plastic caps instead of staples is a lot more likely to remain in place.

Ice Barriers



In areas where there has been a history of ice forming along the eves causing melt-water to back up under the shingles, in other words, ice dams, ice barrier underlayment should be installed at the roof edge.

An ice barrier is typically a self-sealing, self-adhering water-proof underlayment.



The International Residential Code, which most of us call the “IRC” is the residential building code most widely adopted in the US. According to the IRC, the ice barrier should extend from the lower roof edge to a point at least 24 inches in from the outside of the exterior wall, measured level.

All other roofing industry organizations specify that the 24 inches be measured from the inside of the exterior wall.

On roofs with steep pitches this may result in up to four courses of underlayment. Depending on the roof-covering material and installation method, you may not be able to confirm proper ice barrier installation. Ice barrier requirements are the same no matter what roof-covering material is installed.

FLASHING

Flashing is sheet metal fabricated to a specific shape and designed to prevent water from penetrating the roof system. It’s used in areas of a roof that are especially likely to leak.
If enough moisture gets past the flashing, it can cause both cosmetic and structural damage.

In general, building codes don’t give specific flashing details which have to be followed, but just say that flashing has to be corrosion-resistant and installed in a manner that prevents moisture entry.

Multiple methods can be used to install flashing correctly so you won’t always be looking for one method and calling everything else a defect. You’ll be trying to confirm that flashing is installed in a manner, which will prevent moisture entry, and you’ll be looking for corrosion.

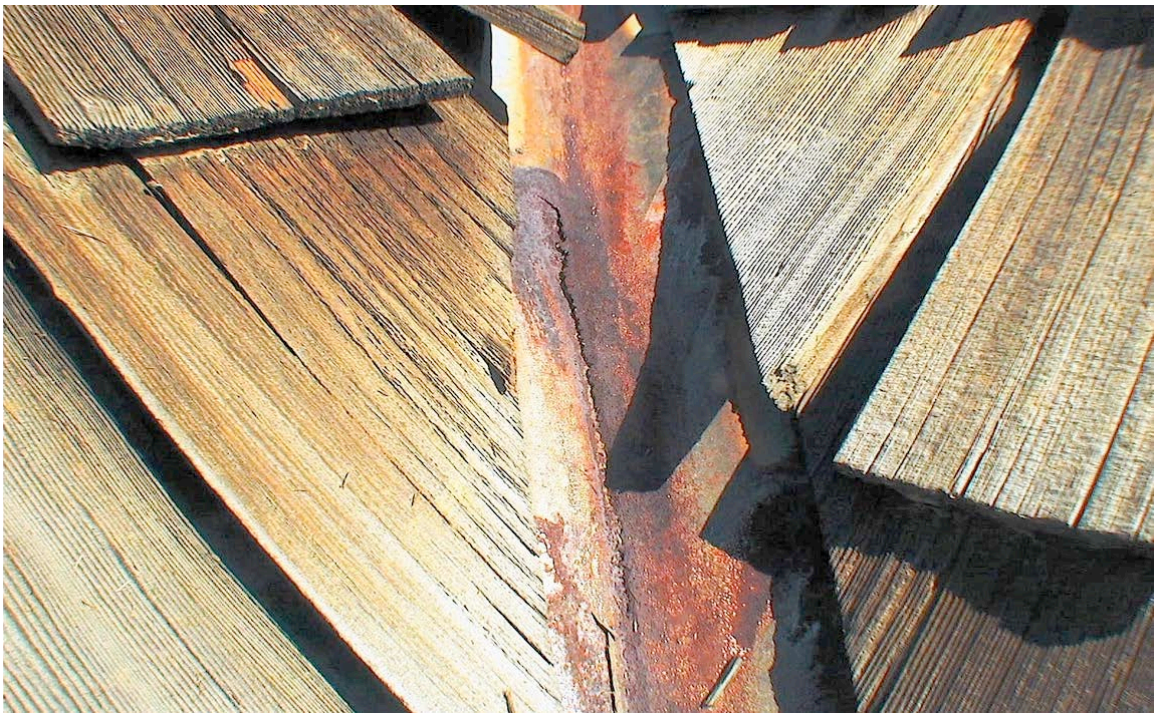
Corrosion

In commenting on corroded flashing, you won’t be recommending repair. Flashing is simply replaced when it becomes too corroded. Your comments will either mention the presence of:

Flashing is simply replaced when it becomes too corroded. You’ll either mention the presence of:

moderately corroded flashing which may need to be replaced soon

severely corroded flashing which needs replacement soon to avoid damage from moisture intrusion



flashing which has failed due to corrosion and should be replaced immediately

For inclusion in inspection reports, you’ll find illustrations of properly installed flashing on the InterNACHI website. Studying flashing details will also help you learn to recognize what works- and doesn’t work- in different situations.

During inspections, you’ll find conditions in which areas, which should have flashing are hidden behind the roof-covering materials and you won’t be able to confirm its presence.