INSPECTING THE ATTIC, INSULATION, VENTILATION & INTERIOR

The purpose of this publication is to provide accurate and useful information for performing an inspection of the attic, insulation, ventilation and interior at a residential property. This book is also a handy reference guide for inspectors to use on the job. Additionally, this guide serves as a study aid for InterNACHI's online *Inspecting the Attic, Insulation, Ventilation and Interior* course and exam.

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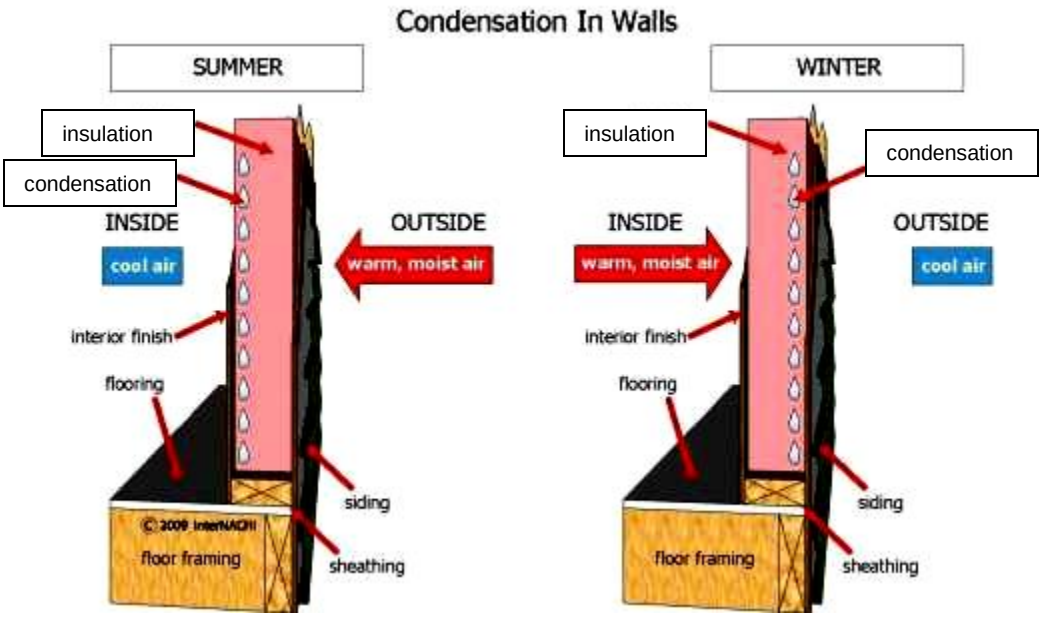
INTRODUCTION



Overall Objectives

The purpose of this book is to provide accurate and useful information for performing an inspection of the attic, insulation, ventilation and interior at a residential property.

The topics covered include:

- the different types of insulation;
- insulation thickness and R-values;
- the movement of air, water and heat;
- moisture control;
- roof, attic and crawlspace ventilation;
- vapor diffusion retarders;
- natural, whole-house and spot ventilation;
- air sealing and air barriers;
- vapor barriers and vapor retarders;
- windows, doors, floors, walls and ceilings;
- bathroom ventilation;
- safety-glass windows;
- garage door inspection;
- egress, steps, handrails and illumination;
- emergency escape and rescue openings; and
- much more.

The focus throughout is on the three major factors of a healthy home:

- insulation;
- ventilation; and
- moisture control.

This guide refers to the general inspection process and InterNACHI's Standards of Practice for Performing a General Home Inspection.

Learning Objectives

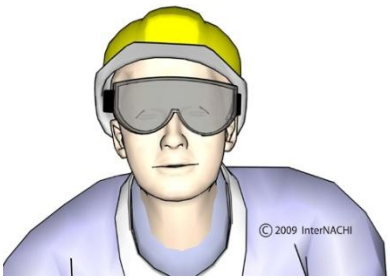
The student should demonstrate an understanding and comprehension of the content presented here by reading and studying the material, taking the practice quizzes at the end of selected sections, and by taking the online course in its entirety and successfully passing a timed, online exam.

After successful completion, the student should be able to perform an inspection of the attic, insulation, ventilation and interior of a residential property according to the InterNACHI Residential Standards of Practice. A section of this book lists the particular parts of InterNACHI's SOP relevant to the inspection of the attic, ventilation, insulation, windows, doors and interior of a residential property. The full text of the Standards can be found at www.nachi.org/sop.htm.

SECTION 1: INSPECTOR SAFETY

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Ironically, the process of inspecting for safety defects can itself compromise the safety of inspectors and their clients. Inspectors should always bring personal protective equipment (PPE) that can protect them against the hazardous conditions inherent in performing property inspections. Let's review some PPE that inspectors should always have on hand to help ensure that inspections proceed safely and problem-free.



Overalls and Coveralls

Overalls and coveralls protect your clothes. They're handy for moving through a crawlspace and getting under a low deck or porch. Coveralls are typically made of denim, canvas or Tyvek®, a tear-resistant, flexible plastic widely used to make items such as postal mailers, banknotes, and even DVDs. While canvas is puncture-resistant, Tyvek® is also disposable and lightweight, as well as anti-static, breathable and chemical-resistant. However, it should not be worn near heat or open flame. Both canvas and Tyvek® provide effective barriers against splashes, asbestos, chemicals, lead dust, and other harmful substances.

Shoe Covers or Booties

Put on some shoe booties prior to entering the house that you are inspecting. Booties protect the floors and demonstrate care and consideration for your client's property.

Gloves

Your PPE should include a simple pair of gloves. Gloves protect your hands from insect bites, scratches from vegetation and soil, dirt and debris, splinters, and sharp edges of building components. Rubber or leather gloves are important for inspecting electrical panels to reduce the chance of accidental shock. Also, they should be worn in crawlspaces and basements. A certain amount of crawling on all fours through these areas will be necessary during inspections, and gloves will certainly make this activity safer. Gloves should not be loose.

Knee Pads

It is important to protect your knees while crawling around, particularly when the ground surface is rough and covered with rocks and stones.

Goggles

Goggles can protect against many types of harmful airborne substances, such as mold spores and sawdust. Inspectors should be sure to wear goggles or some other type of eye protection while inspecting electrical panels, which can emit dangerous sparks and arcs.

Respirators

Respirators are necessary safety equipment for inspectors. Choices include a full-face respirator, which covers the eyes, nose and mouth, and a half-face respirator. Full-face respirators may provide greater protection against certain toxins because they protect the mucous membranes around the eyes, but they are generally less comfortable. Wearers may find that the mask's air filtration makes it hard to breathe, especially when the inspector must crawl and bend using physical movements that may restrict breathing. Respirators that have high-efficiency particulate air or HEPA filters are excellent personal protective equipment because, by definition, they trap at least 99.97% of small particles.

INSPECTION TOOLS AND SAFETY EQUIPMENT

Flashlights

A flashlight is handy for inspecting under the deck or porch, behind dense vegetation, and in shaded areas of the property. Inspectors should bring at least two flashlights with them before entering dimly lit attics and crawlspaces. This precaution will eliminate the possibility that one flashlight will lose power, forcing the inspector to feel his way back out. The multitude of dangerous elements that potentially lie in attics and crawlspaces is startling -- from exposed nails and broken glass, to dangerous reptiles, insects and mammals. No one should ever enter these areas without a flashlight.

Tape Measure

A tape measure can be used to measure the infill spacing of railing spindles and balusters, the rise and run of stairs, the height of a railing, the width of an egress door, the amount of damage visible, the dimensions of a joist, and much more.

Level and Plumb Bob

A level or plumb bob can be used to check walls, posts and columns for plumb and level. A level can be used to check the slope of a walk, a driveway, garage floor and hard surface at the house's perimeter.

Screwdriver and Awl or Probe

These can be used to check for wood rot or damage. A screwdriver may be needed to remove an access panel or some type of cover.

Magnet

A magnet can be used to tell the difference between aluminum siding and steel siding, or galvanized steel flashing from copper flashing.

Moisture Meter

A moisture meter is used to detect or confirm moisture. It could be used to confirm water intrusion problems or confirm that wood is saturated with water. There are meters that are non-invasive and meters that have invasive probes. Check out InterNACHI's free, online *Moisture Intrusion Inspection* course.

Infrared Camera

You should be professionally trained and certified to use an infrared camera. Thermography is an effective tool to use when inspecting for moisture intrusion and areas of energy loss. Check out NACHI.TV's *Introduction to Infrared Thermography.*

Roof Inspection Equipment

Inspectors who must walk on rooftops (especially those who perform roof and wind and hail inspections) regularly risk fall-related injuries. Some equipment that can keep you from stumbling off a roof are:

- **binoculars:** In addition to other uses, binoculars can be used to look where physical, up-close access is restricted. The soffit and fascia components cannot be inspected closely without the use of a ladder or binoculars;
- **ladder:** A ladder can be used to gain access to those higher-up areas that are not readily accessible or visible from the ground. Many inspectors attempt to reach the gutter or eaves of a roof with a ladder;

- **roof shoes:** Shoes form the only constant point of contact between the inspector and the roof, and the bond between them needs to be firm. Some companies make shoes that are specially designed for roof work, but these are not always necessary. Whatever type of shoes inspectors decide to wear, they should be flat and have high-traction rubber soles. Footwear with heels can become caught on roof surfaces, potentially causing the inspector to trip and fall;

- **ladder tie-offs:** Inspectors should bring with them straps to use to attach their ladders to the roof or structure. This attachment will help prevent the ladder from being blown away by a strong wind, embarrassing the marooned inspector. Also, a ladder tie-off can potentially prevent the ladder from slipping away from the building beneath the weight of the climber; and

- **personal tie-off:** Inspectors may want to attach themselves to the roof as an added security measure. A few notes about this procedure:

  Some roofs do not allow for the implementation of this safety measure. Roofs must have a protruding, sturdy, accessible place as a connection point, such as a chimney.

  The strap must have as little slack as possible. Rolling down 15 feet of steep roof and then plunging another 10 feet before being halted in mid-air is still going to hurt. Plus, the dangling inspector will need to somehow climb back up. It is best to attach the strap to a harness designed for that purpose, rather than a tool belt or limb. It is dangerous to tie the strap to a car on the other side of the house. While the car might hold the inspector in place during a fall, it would not hold the inspector in place if someone were to drive the car away. A riding lawnmower is also a poor choice for an anchor.

Road Cones

Inspectors may want to consider placing road cones some distance behind their vehicles to prevent others from parking too close behind. Large, unwieldy items, such as ladders, are more safely removed when there is ample room in which to maneuver. Nothing causes tension like a Realtor who gets knocked in the head after parking snugly behind the inspector's truck. Also, as universal symbols of caution, road cones will alert passing motorists and pedestrians of the need to maintain a safe distance.

"Danger" Signs

A sign can be placed near dangerous areas where the inspector is working to warn clients and others of potential hazards. In 2008, an inspector in Seattle was sued because his client fell through an opening in the floor leading to a crawlspace that he was inspecting, and the client broke his arm in three places. The lawsuit alleged that the inspector was guilty of "negligence and misconduct" because he failed to notify the client of the potential hazard.

To avoid such liability and to ensure the safety of all persons present at an inspection, InterNACHI has created compact, lightweight "STOP -- Inspector at Work" signs for inspectors to use at job sites. These signs are specifically designed to be placed on ladders and near crawlspace entrances that are being inspected. Made of strong, durable plastic, they fold up flat and fit securely over a rung of the inspector's ladder. Using them may also provide legal leverage for inspectors who are held responsible for harm inflicted to their clients during an inspection.

In summary, inspections can be dangerous for inspectors, as well as their clients. Safety equipment should be brought to all inspections to help avoid injury and liability issues.

SECTION 2: InterNACHI RESIDENTIAL STANDARDS of PRACTICE

This section contains excerpts from the InterNACHI Standards of Practice for Performing a General Home Inspection that are particularly relevant to the inspection of the components of the attic, insulation, ventilation and interior.

At the end of this section, you should be able to:

- list at least four things an inspector is required to inspect; and
- list at least four things an inspector is not required to inspect.

1. Definitions and Scope

1.1. A **general home inspection** is a non-invasive, visual examination of the accessible areas of a residential property, performed for a fee, which is designed to identify defects within specific systems and components defined by these Standards that are both observed and deemed material by the inspector. The scope of work may be modified by the Client and Inspector prior to the inspection process.

I. The general home inspection is based on the observations made on the date of the inspection, and not a prediction of future conditions.

II. The general home inspection will not reveal every issue that exists or ever could exist, but only those material defects observed on the date of the inspection.

1.2. A **material defect** is a specific issue with a system or component of a residential property that may have a significant, adverse impact on the value of the property, or that poses an unreasonable risk to people. The fact that a system or component is near, at or beyond the end of its normal useful life is not, in itself, a material defect.

1.3. A **general home inspection report** shall identify, in written format, defects within specific systems and components defined by these Standards that are both observed and deemed material by the inspector. Inspection reports may include additional comments and recommendations.

[...]

3.9. Attic, Ventilation & Insulation

I. The inspector shall inspect:

A. the insulation in unfinished spaces;
B. for the presence of attic ventilation;
C. mechanical ventilation systems;
D. and report on the general absence or lack of insulation or ventilation in unfinished spaces.

II. The inspector is not required to:

A. enter the attic or any unfinished spaces that are not readily accessible, or where entry could cause damage or, in the inspector's opinion, pose a safety hazard.
B. move, touch or disturb insulation.
C. move, touch or disturb vapor retarders.
D. break or otherwise damage the surface finish or weather seal on or around access panels or covers.
E. identify the composition or R-value of insulation material.
F. activate thermostatically operated fans.
G. determine the types of materials used in insulation or wrapping of pipes, ducts, jackets, boilers or wiring.
H. determine the adequacy of ventilation.

3.10. Doors, Windows & Interior

I. The inspector shall inspect:

A. a representative number of doors and windows by opening and closing them;
B. the walls, ceilings, steps, stairways and railings;
C. and report as in need of repair any improper spacing between intermediate balusters, spindles and rails for steps, stairways and railings;
D. the garage doors and garage door openers' operation using the installed automatic door control;
E. and report as improper any photo-electric safety sensor that fails to respond adequately to testing;
F. and report as in need of repair any door locks or side ropes that have not been removed or disabled when the garage door opener is in use;
G. and report as in need of repair any windows that are obviously fogged or display other evidence of broken seals.

II. The inspector is not required to:

A. inspect paint, wallpaper, window treatments or finish treatments.
B. inspect central vacuum systems.
C. inspect for safety glazing.
D. inspect security systems or components.
E. evaluate the fastening of islands, countertops, cabinets, sink tops or fixtures.

F. move furniture, stored items, or any coverings, such as carpets or rugs, in order to inspect the concealed floor structure.
G. move suspended-ceiling tiles.
H. inspect or move any household appliances.
I. inspect or operate equipment housed in the garage, except as otherwise noted.
J. verify or certify proper operation of any pressure-activated auto-reverse or related safety feature of a garage door.
K. operate or evaluate any security bar release and opening mechanisms, whether interior or exterior, including their compliance with local, state or federal standards.
L. operate any system, appliance or component that requires the use of special keys, codes, combinations or devices.
M. operate or evaluate self-cleaning oven cycles, tilt guards/latches, or signal lights.
N. inspect microwave ovens or test leakage from microwave ovens.
O. operate or examine any sauna, steam-generating equipment, kiln, toaster, ice maker, coffee maker, can opener, bread warmer, blender, instant hot-water dispenser, or other small, ancillary devices.
P. inspect elevators.
Q. inspect remote controls.
R. inspect appliances.
S. inspect items not permanently installed.
T. discover firewall compromises.
U. inspect pools, spas or fountains.
V. determine the adequacy of whirlpool or spa jets, water force, or bubble effect.
W. determine the structural integrity or leakage of pools or spas.

GENERAL INSPECTION REQUIREMENTS

Comments

If your client is buying a house or building a new one, s/he might ask you to check that the insulation is properly installed and meets current requirements or recommendations. You might be asked to provide information on the type, thickness and R-value of the insulation that is installed in the readily accessible parts of the house. You may check to see if the proper amount of insulation has been used and also whether it has been installed correctly. Many state and local building codes include minimum requirements for home insulation. You may check to see if the insulation meets those codes. Your client's energy costs (as the new homeowner) will be lower if the home is energy-efficient.

It is a good idea to get the home airtight. There are special products and techniques available to eliminate the big air leaks between the walls and floor and between the walls and ceiling. Encourage your client to make the areas around the windows and doors as tight as possible and to properly caulk or seal joints.

You are required to inspect the insulation in unfinished spaces, including the attic. You are not required to enter the attic or any unfinished spaces that are not readily accessible or where entry could cause damage or pose a safety hazard. You should try to enter the

crawlspace and check the ground covering, insulation and ventilation. Check for structural problems that might be caused by ventilation and insulation defects.

Tell your client about the absence or lack of insulation in areas of the house. You are not required to identify the exact composition or the exact R-value of the insulation. You do not have to move insulation or vapor diffusion retarders during your inspection.

You are required to inspect the ventilation of attic spaces and to check the mechanical ventilation systems. You're not required to determine the adequacy of the ventilation.

You are required to open and close a representative number of doors and windows. Many inspectors find it easy to operate every interior door but too time-consuming to operate all of the windows. Report to your client any windows that are fogged or display evidence of a broken seal.

While performing the inspection inside the house, check the walls, ceilings, steps, stairs and railings. You are not required to discover firewall compromises.

If there is a garage, inspect the garage door and opener, if installed.

You are not required to check the wallpaper, paint, window treatments or finish treatments. Cosmetic items are not part of a typical home inspection. You need not check the fastening of countertops, cabinets, sink tops or fixtures.

You do not have to move furniture, personal stored items, or any carpeting in order to inspect the floor structure. You do not have to move any drop-ceiling tiles.

In the kitchen, you have to check the fixtures, water supply and drainpipes. However, you are not required to inspect any household appliances, including operating oven cycles or microwave ovens.

QUIZ 1

1. T/F: You are required to inspect the insulation in unfinished spaces, including the attic.

- True
- False

2. T/F: You're required to inform your client about the absence or lack of adequate insulation in areas of the house.

- True
- False

3. T/F: You are required to check the mechanical ventilation systems by activating thermostatically operated fans.

- True
- False

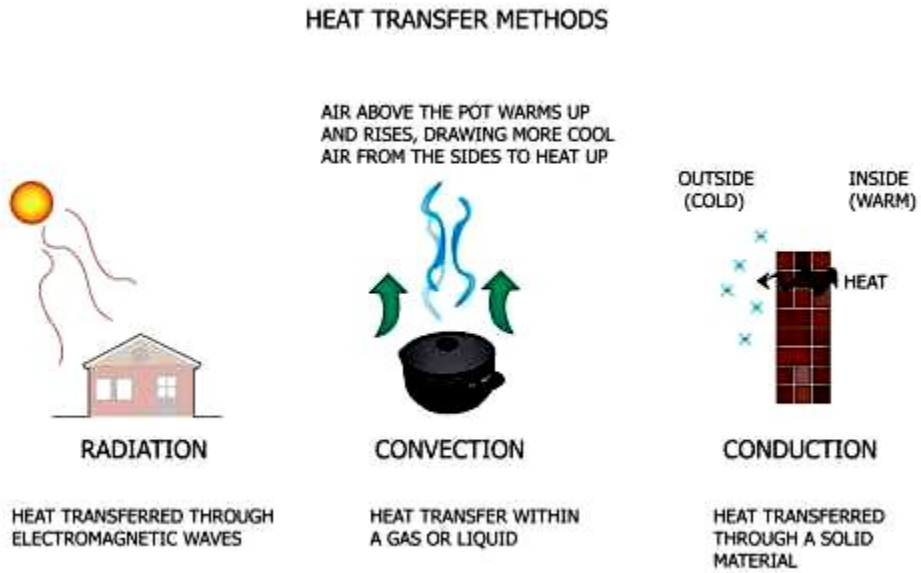
4. T/F: You are required to move a representative number of drop-ceiling tiles.

- True
- False

Answer Key to Quiz 1

1. T/F: You are required to inspect the insulation in unfinished spaces, including the attic.
   Answer: True
2. T/F: You're required to inform your client about the absence or lack of adequate insulation in areas of the house.
   Answer: True
3. T/F: You are required to check the mechanical ventilation systems by activating thermostatically operated fans.
   Answer: False
4. T/F: You are required to move a representative number of drop-ceiling tiles.
   Answer: False

SECTION 3: HEAT MOVEMENT



Heat, energy and insulation are all related to each other. As inspectors, we should understand how heat moves around the inside of a home, and how insulation can control that movement. One important reason we need to understand how heat moves is because warm air can carry moisture, and warm, moist air needs to be controlled in relation to a building envelope. Uncontrolled, moving warm air and moisture can cause a lot of problems. Another reason to learn about heat is that insulation provides resistance to the flow of heat, and the more insulation there is, the less energy is needed to heat and cool the house.

Heat needs to be controlled to keep the occupants of the home comfortable. When a home is well-insulated, your client will save on energy costs. After learning the information provided in the next few sections about heat, moisture, air and insulation, you'll be able to perform an inspection armed with the knowledge of what's needed to gain greater energy efficiency and speak authoritatively to your client about how well the building envelope is functioning toward that goal.

Now, let's talk heat. There are essentially three ways that heat moves from one area to another. When bodies of unequal temperatures are near each other, heat leaves one body and goes to the other. Heat moves from the hotter body, and the colder body absorbs it. The greater the difference in temperature, the greater the rate of flow of heat.

Heat moves from one body to another by the following ways:

- radiation;
- conduction; and
- convection.

Radiation

Radiation is the transfer of heat energy by electromagnetic wave motion. Heat is transferred in direct rays. It travels in a straight line from the source of heat to a body. The closer you are to a hot object, the warmer you'll feel. The intensity of the heat radiated from the hot object decreases as your distance from the object increases.

You'll feel cool in a room that has a cold floor, walls and ceiling. The amount of heat loss from your body in that room depends on the relative temperature of the objects in that room. The colder the floor is (relative to the temperature of your feet), the greater the heat loss from your body will be as you continue to stand there. If the floor, walls and ceiling of that room are relatively warmer than your body, then heat will be radiated to your body from those objects or surfaces.

When you step into a cold room, you can immediately feel the heat energy leaving your body. Use all of your senses as an inspector when moving about the house. Just entering a space with your body can give you some clues about the insulation, the heat, air movement, and even moisture and humidity levels. Some inspectors can provide a good estimate of the temperature in an attic space simply by entering it. Keep aware of your surroundings while moving about the interior of the house.

Radiant heat emits in all directions. Radiant heating in residential buildings includes the piping and electrical wiring in the floors, walls and ceilings. Reflective materials are commonly used in a radiant heat-emitting system in order to direct or control where the heat is emitted.

Radiation happens when heat moves as energy waves, called infrared waves, directly from its source to something else. This is how the heat from the Sun gets to Earth. In fact, all hot things radiate heat to cooler things. When the heat waves hit the cooler thing, they make the molecules of the cooler object speed up. When the molecules of that object speed up, the object becomes hotter.

Conduction

Conduction is the transfer of heat from one molecule to another, or through one substance to another. It is heat that moves from one body to another by direct contact. For example, heat is transferred by conduction from a boiler heat exchanger to the water passing through it. When an air conditioner is operating properly, the liquid line should feel warm to the touch and the suction line should feel cool.

Heat is a form of energy, and when that heat comes into contact with matter, it makes the atoms and molecules move. When atoms and molecules move, they collide with other atoms and molecules and make them move, too. This movement transfers heat through matter.

This is demonstrated when touching a ceramic coffee cup. The exterior surface of the cup is warm to the touch because the heat of the hot coffee has transferred through the cup’s material.

Convection

Convection is understood by most people by the phrase, "Heat rises." Convection is the transfer of heat by warming the air next to a hot surface and then moving that warm air. It's the transfer of heat by the motion of the heated matter itself. The air moves from one place to another, carrying heat along with it. Since warm air is lighter than the cool air around it, the warm air (or heat) rises.

Warm fluids tend to rise while the surrounding cool fluids fall. This rising-and-falling motion tends to form loops, or convective loops, where warm air rises and cool air falls. Early warm-air furnaces, called gravity furnaces, operate by the principles of convective loops. In a gravity system, the warm air rises and the cool air falls, and this is how the gravity warm-air heating system circulates air.

When a certain amount of air is heated up, it expands and takes up more space. In other words, hot air is less dense than cold air. Any substance that is less dense than the fluid (gas or liquid) of its surroundings will float. Hot air floats on cold air because it is less dense, just as a piece of wood floats because it is less dense than water. Warm air is often described as weighing less than cool air.

Warm air rises, and cool air falls. The weight per unit-volume of air decreases as its temperature increases. And, conversely, the weight per unit-volume of air increases as its temperature decreases.

Inside a wall cavity, there can be convective loops where cool and warm air are moving around inside the wall cavity. If warm, moist air comes into contact with a cold surface of that wall assembly, then condensation may form inside the wall. And that's not good.

As another example, an old gravity furnace heats the air; the air gets lighter and rises out of the heating system. Cool air enters the heating system and pushes or displaces the warm, rising air. The warm air rises up through warm-air ducts or pipes (often called stacks) that are inside the walls. The warm air rises up through the building. The warm air enters a room through the supply registers on the wall or floor. The cool air falls out of the room and may return through a return grille and travel back through return ducts to the heating system.

Some houses with old gravity heating systems may not have a lot of ducts and pipes but may rely on large openings in the floors covered with iron grates or grilles that allow the cool air to fall down through the building. The cool air is allowed to simply fall back to the furnace -- hence, the name gravity warm-air heating system.

The air circulation in a house with a gravity warm-air heating system depends on the temperature difference between the warm air rising and the cool air falling. The greater the temperature difference, the greater the speed of the air circulating.

So, heat moves from one body to another by the following three ways: radiation; conduction; and convection.

Understanding how heat moves will help you understand how moisture moves, too.

QUIZ 2

1. T/F: Heat can move from one body to another by radiation.

- True
- False

2. _____ is the transfer of heat energy by electromagnetic wave motion.

- Radiation
- Convection
- Conduction

3. _____ is the transfer of heat from one molecule to another, or through one substance to another.

- Convection
- Conduction
- Radiation

4. _____ is the transfer of heat by warming the air next to a hot surface and then moving that warm air.

- Radiation
- Convection
- Evaporation
- Conduction

5. _____ air is less dense than _____ air.

- Flowing..... moist
- Hot..... cold
- Cold..... hot

Answer Key is on the next page.

Answer Key to Quiz 2

1. T/F: Heat can move from one body to another by radiation.
   Answer: True

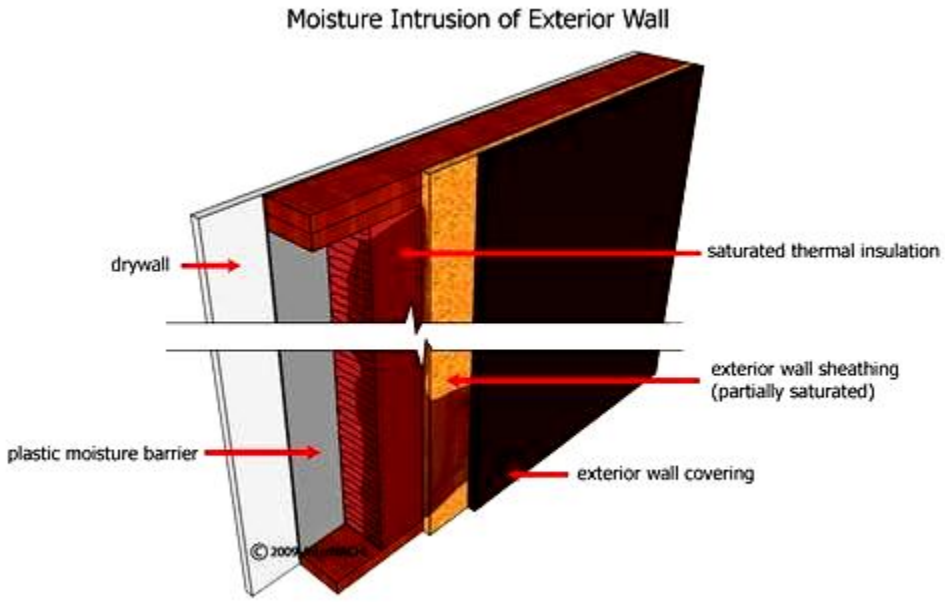
2. Radiation is the transfer of heat energy by electromagnetic wave motion.

3. Conduction is the transfer of heat from one molecule to another, or through one substance to another.

4. Convection is the transfer of heat by warming the air next to a hot surface and then moving that warm air.

5. Hot air is less dense than cold air.

SECTION 4: MOISTURE MOVEMENT



It is important to understand the principles of moisture when learning about inspecting insulation because wet insulation does not work effectively. Also, insulation is an important part of the building envelope system, and all parts of that system must work together to keep moisture from causing damage to the structure or creating a health hazard for the occupants. For example, mold can grow in damp areas and cause allergic reactions in sensitive people, as well as structurally and cosmetically damage the components of a house.

To be able to inspect for moisture intrusion and related problems, an inspector should understand the basics of how moisture can move through a house.

Water vapor moves in only three ways:

- air transportation;
- diffusion through materials; and
- thermal diffusion.

If a builder understands the different ways that water vapor moves and also knows the type of climate in which the house is located, then there shouldn’t be any major problems with the vapor diffusion retarder that he installs.

The problem is that there are ways to control vapor diffusion that are ineffective at controlling air-transported moisture, and vice versa. An effectively built wall is designed to control both vapor diffusion and air transportation at the same time in relation to the climate of the house's location.

Vapor Diffusion

Vapor diffusion is how moisture in a vapor state moves through a material because of a difference in pressure (known as the pressure gradient) or a difference in temperature (known as the thermal gradient). Vapor diffusion is not air movement. Vapor diffusion is water vapor moving through a material from a high pressure to a low pressure, or from the warm side of a wall to the cool side of the wall. Moisture in air will move from high pressure to low pressure or from high temperature to low temperature only if the air that is moving actually contains the water vapor.

Thermal or heat diffusion happens when moisture in a vapor state moves from a warm part of an assembly to the cold part. The second law of thermodynamics can explain how water vapor or moisture can be pressure- and thermally driven from high (or hot) to low (or cold).

Air Transportation

Diffusion is an important factor to understand, but diffusion is a slow process. Air, however, can move and flow quickly and in large volumes.

Air transportation accounts for more than 98% of all water-vapor movement in building cavities. Air naturally moves from a high-pressure area to a lower one by the easiest path possible — generally, through any available hole or crack in the building envelope. Moisture transfer by air currents is very fast – in the range of several hundred cubic feet of air per minute. Thus, to control air movement, a house should have any unintended air pathways (holes, gaps, cracks, separations, etc.) carefully and permanently sealed by a practice referred to as air sealing.

Diffusion through materials is a much slower process. Most common building materials slow moisture diffusion to a large degree, although they can never stop it completely.

Look at the illustration on the previous page that depicts a wall assembly. Significantly more water vapor travels through a wall by air leakage than by diffusion. The smaller arrow represents vapor diffusion: about 2/3 of a pint of water can travel through a wall during a heating season. The larger arrow represents air leakage through a ½-inch hole: about 50 pints of water can travel through a wall during a heating season. As inspectors, we need to look for air leakage through holes.

The laws of physics govern how moist air reacts within various temperature conditions. The study of moist air properties is technically referred to as psychrometrics. A psychrometric chart is used by professionals to determine at what temperature and moisture concentration water vapor begins to condense. This is called the dew point. By understanding how to find the dew point, you will better understand how to inspect for and diagnose moisture problems in a house.

Relative humidity (RH) refers to the amount of moisture contained in a quantity of air compared to the maximum amount of moisture the air could hold at the same temperature. As air warms, its ability to hold water vapor increases; this capacity decreases as air cools. For example, according to the psychrometric chart, air at 68º F (20º C) with 0.216 ounces of water (H_2O) per pound of air (14.8g H_2O/kg air) has a 100% RH.

The same air at 59º F (15º C) reaches 100% RH with only 0.156 ounces of water per pound of air (10.7g H_2O/kg air). The colder air holds about 28% less moisture than the warmer air does. The moisture that the air can no longer hold condenses on the first cold surface it encounters (the dew point). If this surface is within an exterior wall cavity, the result will be wet insulation and framing. And that's bad.

In addition to air movement, temperature and moisture content can also be controlled. Since insulation reduces heat transfer or flow, it also moderates the effect of temperature across the building envelope's cavity. In most U.S. climates, properly installed vapor diffusion retarders can be used to reduce the amount of moisture transfer. Except in deliberately ventilated spaces (such as attics), properly installed insulation and vapor diffusion retarders work together to reduce the opportunity for condensation to form in a house's ceilings, walls and floors.

MOISTURE CAN BE A PROBLEM

When moist air touches a cold surface, some of the moisture may leave the air and condense or become a liquid. If the moisture condenses inside a wall or in an inaccessible attic, you may not be able to see the water but it will be causing numerous problems.

Don't recommend that your client add insulation as a quick fix. Adding insulation can cure a problem, or it may actually cause one. When a wall is insulated, the temperature of the space inside that wall is changed. A surface inside that wall, such as the plywood sheathing behind the siding, can become much colder in the wintertime than it was before the wall was insulated. This cold surface could be the place where moisture traveling through the wall could condense and cause trouble. The same situation could happen in the attic.

FOUR THINGS YOUR CLIENT CAN DO

There are four general things that your client can do to avoid moisture problems.

1. Prevent water intrusion.

Water coming into the house, even in the form of a small leak, must be stopped.

Furthermore:

- the roof should be in good shape;
- the exterior windows and doors should be watertight;
- the gutters should be kept clear;
- downspouts should divert water far enough away from the house;
- condensate from the air conditioner should properly drain away;
- lawn sprinklers should be adjusted to spray efficiently;
- caulking around the tub and shower should be checked;
- exposed dirt in the crawlspace should be covered with a vapor diffusion retarder;
- all bathroom and kitchen ventilation fans must exhaust outside; and
- the clothes dryer must exhaust outside and not into the attic.

2. Ventilate.

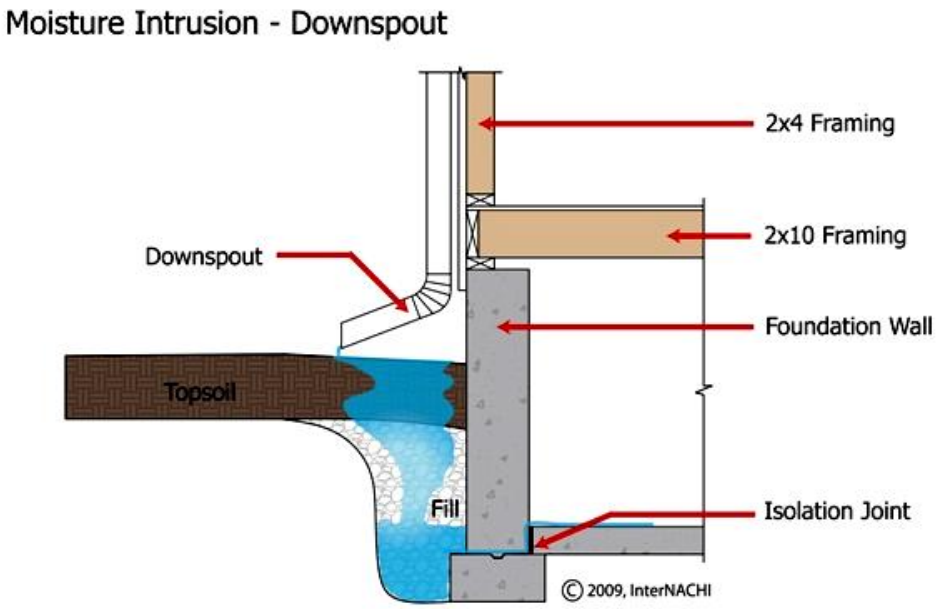
The home needs to be ventilated. Your clients will generate moisture when they cook, shower, do laundry, and even breathe. More than 99% of the water used to water plants eventually enters the air. Unvented natural gas, propane, or kerosene space heaters exhaust all the byproducts of combustion, including water vapor, directly into the house's interior. This water vapor can add 5 to 15 gallons of water per day to the air inside your client's home. Just the act of breathing by a typical family can add about 3 gallons of water per day into the home. Baffles or rafter vents can be used to prevent loose-fill insulation from blocking the attic vents.

3. Stop air leaks.

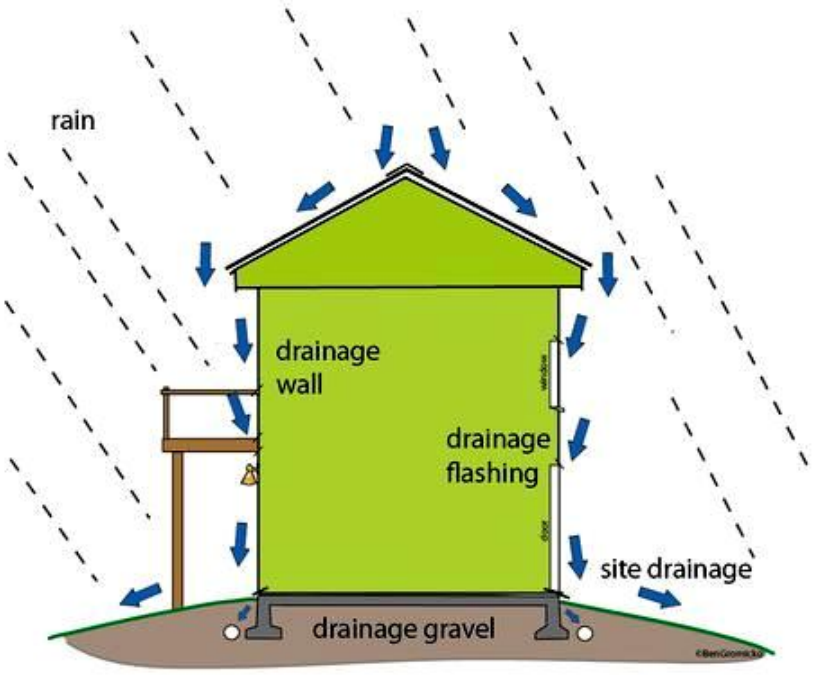
It is important that the air-leakage pathways between the living spaces of the house and other parts of the building are stopped or sealed closed. Air leakage into a wall or the attic can carry a significant amount of moisture. If there is air leaking around electrical outlets or around plumbing lines in the wall, moisture can be carried along those same pathways. Ductwork needs to be sealed and insulated, especially if the ducts pass through an unconditioned, unheated space, such as an attic. Returns ducts should be sealed, too. Air sealing is important.

4. Provide a path of escape for moisture.

An example of this can be found in a typical attic that has vents to provide a path for moisture to escape. Cold air usually contains less water than hot air, so diffusion usually carries moisture from a warm place to a cool place. A wall can be designed to allow moisture to escape from a wall cavity to the exterior during the winter. Or, a wall can dry to the indoors during summer by avoiding the use of vinyl wall coverings or low-perm paint.



SECTION 5: PROTECTION FROM WATER DAMAGE



Water may be essential to life, but, as a destructive force, water can diminish the value of your client's home or building. An inspector is required to report any present conditions or clear indications of active water penetration that s/he observes.

Homes as well as commercial buildings can suffer water damage that results in increased maintenance costs, a decrease in the value of the property, lowered productivity, and potential liability associated with a decline in indoor air quality. The best way to protect against this potential loss is to ensure that the building components that enclose the structure, known as the building envelope, are water-resistant. Make sure that the plumbing and ventilation systems, which can be quite complicated in some buildings, operate efficiently and are well-maintained.

This and the following sections provide some basic steps for identifying and eliminating potentially damaging excess moisture.

Check for Water Intrusion

The following are common building-related sources of water intrusion:

- **windows and doors.** Check for leaks around windows and doors.
- **the roof.** Improper drainage systems and roof sloping reduce the roof's life and become a primary source of moisture intrusion. Leaks are also common around chimneys, vents for exhaust and plumbing, skylights, and other roof penetrations.

- **the foundation and exterior walls.** Seal any cracks and holes in exterior walls, joints, and the foundation. Such cracks and holes often develop as a naturally occurring byproduct of differential soil settlement.
- **the plumbing.** Check for leaking plumbing fixtures, dripping pipes (including fire sprinkler systems, if installed), clogged drains (both interior and exterior), and defective water drainage systems.
- **the heating, ventilation and air-conditioning (HVAC) system.** Numerous HVAC system types -- some of them very sophisticated -- are a crucial component to maintaining a healthy and comfortable environment. They are comprised of a number of components (including chilled water piping and condensation drains) that can directly contribute to excessive moisture. In addition, in humid climates, one of the functions of the system is to reduce the ambient air-moisture level (or relative humidity) throughout the building. An improperly operating HVAC system will not perform this function.

Inspections as Part of a Regular Home Maintenance Plan

Advise your clients to have annual inspections of the following elements of their homes to ensure that they remain in good condition:

- **flashings and sealants.** Flashing, which is typically a thin metal strip found around doors, windows and roofs, is designed to prevent water intrusion in spaces where two building materials come together. Sealants and caulking are specifically applied to prevent moisture intrusion at building joints. Both must be maintained in good condition.
- **vents.** All vents should have appropriate hoods, exhaust to the exterior, and be in good working order, without any blockages or restrictions.
- **HVAC system.** Check for leakage in supply and return water lines, pumps, air handlers and other components. Drain lines should be clean and clear of obstructions. Ductwork should be insulated to prevent condensation on exterior surfaces. Air-filtering systems should be checked regularly and maintained properly.
- **humidity.** The relative humidity in a typical home should be between 30% and 50%. Condensation on windows, wet stains on walls and ceilings, and musty smells are signs that relative humidity may be too high. If your client is concerned about the humidity level in their home, they should consult with an air-conditioning contractor or repair technician who can determine whether the HVAC system is properly sized and in good working order.
- **damp areas.** Damp and wet areas should be regularly cleaned and thoroughly dried.
- **expansion joints.** Expansion joints are materials between bricks, pipes and other building materials that absorb movement. If expansion joints are not in good condition, water intrusion can occur.

- **interior finish materials.** Water-damaged drywall, plaster and carpet should be replaced. Water-damaged ceiling tiles should also be removed and replaced.
- **exterior walls.** Exterior walls are generally comprised of a number of materials combined into a wall assembly. When properly designed and constructed, the assembly is the first line of defense between water and the interior of the home. It is essential that they be maintained properly, including regular refinishing and/or re-sealing with the appropriate materials.
- **storage areas.** Storage areas should be kept clean. Allow air to circulate to prevent potential moisture accumulation.

Quick Action If Water Intrusion Occurs

Water shut-off valves should be readily accessible and identified so that the water supply can be easily turned off in the event of a plumbing leak. If water intrusion does occur, damage can be minimized by addressing the problem quickly and thoroughly. Inspectors should help their clients identify all main water and fuel shut-off valves.

Immediately following a leak, the standing water and all damp materials should be removed, cleaned up and dried out. Should the building become damaged by a catastrophic event, such as a fire, flood or storm, appropriate action should be taken to prevent further water damage, once it is safe to do so. This may include boarding up damaged windows, covering a damaged roof with plastic sheeting, and/or removing wet materials and supplies. Fast action will help minimize the time and expense for repairs, resulting in faster recovery.

Water Intrusion That's Not So Obvious

This manual includes a lot of information about water, air and insulation. These three things can cause problems for your client's property -- including water damage -- if the house is not built or maintained properly.

Water damage that is visible during an inspection should be reported to your client. That's obvious.

What's not so obvious is determining what's going on (if anything) inside the building assemblies, including the walls, floors and ceilings. Access is not typically available in order to see within a finished wall cavity to check the insulation and vapor barrier, and to take moisture and temperature measurements. It is not possible to see what happens to the attic space during the winter if you are inspecting the property during the summer.

There are a lot of things that are beyond the scope of a typical home inspection, including determining how moisture is controlled in the house, especially at the wall assemblies.

Be sure to communicate to your clients that your inspection is a visual-only, non-invasive inspection of the readily accessible components of the house.

QUIZ 3

1. T/F: Water damage that is visible during an inspection should be reported to your client.

- True
- False

2. T/F: Water shut-off valves should be readily accessible and identified so that the water supply can be easily turned off in the event of a plumbing leak.

- True
- False

3. T/F: An inspector is required to report any present conditions or clear indications of active water intrusion observed at the time of the inspection.

- True
- False

Answer Key to Quiz 3

1. T/F: Water damage that is visible during an inspection should be reported to your client.
Answer: True

2. T/F: Water shut-off valves should be readily accessible and identified so that the water supply can be easily turned off in the event of a plumbing leak.
Answer: True

3. T/F: An inspector is required to report any present conditions or clear indications of active water intrusion observed at the time of the inspection.
Answer: True

SECTION 6: INSULATION

INTRODUCTION TO INSULATION

As a property inspector, you are required to inspect and report on the insulation. In this section, you'll learn about insulation and how it functions to keep the building durable and the occupants comfortable.

Heating and cooling account for 50% to 70% of the energy used in the average home in the United States. Inadequate insulation and air leakage cause a lot of wasted energy in most homes.

Insulation:

- helps us save money;
- helps to conserve our limited energy resources;
- makes a house comfortable;
- maintains uniform temperatures throughout a house;
- makes a house warm in the winter; and
- makes a house cool in the summer.

How Insulation Works

Insulation provides resistance to heat flow. The more heat-flow resistance the insulation provides, the lower the heating and cooling costs. Heat flows naturally from a warmer space to a cooler space. In the cold winter, this heat flow moves directly from all heated living spaces to adjacent unheated spaces, such as the attic, garage, basement, under-floor crawlspace, and even to the outdoors. Heat flow can also move indirectly through interior ceilings, walls and floors — wherever there is a difference in temperature. During the cooling season, heat flows from the exterior to the interior of a building.

To keep the occupants of a home comfortable, the heat lost in the winter must be replaced by the heating system, and the heat gained in the summer must be removed by the cooling system. A properly insulated home will decrease this heat flow by providing an effective resistance to the flow of heat.

Insulation in the form of batts, blankets, loose-fill, and low-density foams all work by limiting air movement. The still air inside the insulation is an effective insulator because it eliminates convection. Still air also has low conduction, so heat doesn’t flow very well via conduction through insulation. Some foams are filled with special gases that provide additional resistance to heat flow.

Reflective insulation limits heat that travels in the form of radiation. Some reflective insulation also reduces air movement, but not as much as other types of insulation.

Don’t confuse insulation’s ability to limit air movement with air sealing.

Insulation reduces air movement only within the space it occupies. It cannot limit air movement through other pathways nearby. For example, the insulation in the wall cavity does not affect the air leakage that may take place around a window frame. Adding insulation will likely not have the same effect as air sealing.

Insulation's resistance to heat flow is measured or rated in terms of its thermal resistance, better known as its R-value.

R-VALUE OF INSULATION

Insulation is rated in terms of thermal resistance, called the R-value. The R-value is an indicator of insulation's resistance to heat flow. The higher the R-value, the greater the insulating effectiveness.

The R-value depends on the type of insulation, which includes its material, thickness and density. If you are measuring the R-value of multiple layers of insulation, whether it's in a wall or at the attic floor, add the R-values of all the individual layers together. The installation of additional insulation increases the R-value and the resistance to heat flow.

The effectiveness of insulation's resistance to heat flow also depends on how and where the insulation is installed.

R-Values of Common Building Materials	
Material	**R-value per inch of material**
Air	1.44
Fiberglass (batt)	3.16
Fiberglass (blown)	2.20
Cellulose (blown)	3.67
Rock wool (batt)	3.38
Rock wool (blown)	2.75
Vermiculite	2.20
Perlite	2.75
Wood (pine)	1.28
Wallboard	1.0
Brick	0.11
Glass	7.2

The U.S. Department of Energy (DOE) has recommendations for new and existing homes in relation to R-value. The insulation recommendations for attics, cathedral ceilings, walls and floors generally exceed those required by most building codes.

The DOE’s range of recommendations is based on comparing future energy savings to the current cost of installing insulation. You can use the map and tables that follow for new and existing homes as a reference for your inspection and evaluation of their insulation.

New Wood-Framed Houses (U.S. DOE)						
Zone	**Heating System**	**Attic**	**Cathedral Ceiling**	**Wall Cavity**	**Wall Insulation Sheathing**	**Floor**
1	All	R30 to R49	R22 to R15	R13 to R15	None	R13
2	Gas, oil, heat pump, *electric furnace	R30 to R60	R22 to R38	R13 to R15	None	R13, *R19-R25
3	Gas, oil, heat pump, *electric furnace	R30 to R60	R22 to R38	R13 to R15	None, *R2.5 to R5	R25
4	Gas, oil, heat pump, *electric furnace	R38 to R60	R30 to R38	R13 to R15	R2.5 to R6, *R5 to R6	R25 to R30
5	Gas, oil, heat pump, *electric furnace	R38 to R60	R30 to R38 *R30 to R60	R13 to R15 *R13 to R21	R2.5 to R6 *R5 to R6	R25 to R30
6	All	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 to R30
7	All	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 to R30
8	All	R49 to R60	R30 to R60	R13 to R21	R5 to R6	R25 to R30

Existing Wood-Framed Houses (U.S. DOE)			
Zone	**Add Insulation to Attic**		**Floor**
	Un-insulated Attic	**Existing 3-4 Inches of Insulation**	
1	R30 to R49	R25 to R30	R13
2	R30 to R60	R25 to R38	R13 to R19
3	R30 to R60	R25 to R38	R19 to R25
4	R38 to R60	R38	R25 to R39
5 to 8	R49 to R60	R38 to R49	R25 to R39

International Residential Code 2006				
Zone	Ceiling (minimums)	Wood-Frame Wall Cavity (minimums)	Basement Wall	Floor
1	R30	R13	0	R13
2	R30	R13	0	R13
3	R30	R13	0	R19
4 except marine	R38	R13	R10/13[a]	R19
5 and marine 4	R38	19 or 13 + 5[b]	R10/13[a]	R30[c]
6	R49	19 or 13 + 5[b]	R10/13[a]	R30[c]
7	R49	R21	R10/13[a]	R30[c]
8	R49	R21	R10/13[a]	R30[c]

a. The first R-value applies to continuous insulation; the second to framing cavity insulation.
b. "13 + 5" means R-13 wall cavity insulation plus R-5 insulated sheathing.
c. Or insulation sufficient to fill the framing cavity, R-19 minimum.

COMPRESSED INSULATION

Insulation that is compressed will not provide its full rated R-value. The overall R-value of a wall or ceiling will be somewhat different from the R-value of the insulation itself because some heat flows around the insulation through the studs and joists. If denser, heavier insulation is installed on top of lighter insulation in an attic floor area, the overall value may be different. If R-19 batt insulation that is sized for 6¼ inches is stuffed inside a 5½-inch wall cavity, its effectiveness is decreased.

If the insulation is installed in a wall with electrical wires or plumbing pipes, the fiberglass batt insulation may be compressed.

It's important that the insulation is properly installed to achieve its maximum R-value.

The amount of insulation or R-value that is recommended by building standards will depend on the local climate and the particular location of the insulation in the house.

THERMAL BRIDGING

Insulation in between studs in a wall does not restrict the heat flow through those studs. This heat flow is called thermal bridging. The overall R-value of that wall may be different from the R-value of the insulation itself.

It is recommended that the insulation installed in an attic covers the tops of the attic floor joists. It is also recommended that insulation sheathing be installed on stud walls. Wood studs can transfer energy through the wall assembly.

Metal studs can transfer energy much better than wood studs can. As a result, the metal wall's overall R-value can be as low as half of the insulation's R-value.

INSPECTING THE INSULATION

You may be asked by your client, "Does the home I'm about to buy need more insulation?" Unless it was built with special attention, adding insulation will probably reduce the energy costs. Most older houses in the U.S. were not insulated to the levels that are required or recommended today. Older homes usually use more energy than newer homes.

Adding more insulation where you already see insulation, such as in the attic, will likely reduce energy bills.

A certified energy auditor can perform an energy audit, which may include a check of the insulation. The energy audit will identify the amount of insulation that is currently installed, and the auditor can offer recommendations about necessary improvements.

There are a few areas in the house where the insulation is exposed and readily accessible. Those areas can be checked during a standard residential home inspection.

Check the attic, walls and floors that are adjacent to unheated spaces, such as the garage and basement. The structural elements may be exposed in these areas, which makes it easy to see what type of insulation exists in the house. The depth or thickness of the insulation can be measured in those areas.

PRECAUTIONS ABOUT ADDING INSULATION

Adding insulation may require hiring a professional contractor. If the house is old, the electrical system should be checked by an electrician if the wiring is degraded, overloaded, or uses knob-and-tube wiring. It may be hazardous to add insulation when conditions such as these exist. Adding thermal insulation within a closed cavity around wires could cause the wires to overheat. Code does not allow the installation of loose-fill, rolled or foam-in-place insulation around knob-and-tube wiring. Adding insulation in a mobile home is complex and usually requires specialized expertise. Adding insulation over existing insulation should not include a vapor diffusion retarder between the two layers.

QUIZ 4

1. The R-value per inch of material for blown-in cellulose insulation is _____.

- 3.67
- 3.02
- 3.85
- 3.16

2. The R-value per inch of material for fiberglass batt insulation is _____.

- 2.52
- 2.42
- 3.16
- 4.10

3. According to the U.S. DOE, the minimum R-value for a cathedral ceiling in a home that has an electric furnace and is located in Zone 5 is _____.

- R-30 to R-60
- R-38 to R-62
- R-22 to R-38
- R-13 to R-15

4. According to the 2006 IRC, the minimum R-value for a ceiling in a home located in Zone 3 is _____.

- R-49
- R-24
- R-30
- R-13

5. T/F: The insulation recommendations made by the U.S. DOE for attics, cathedral ceilings, walls and floors generally exceed those required by most building codes.

- True
- False

(continued)

6. T/F: Insulation that is compressed will not provide its full rated R-value.

- True
- False

7. Insulation installed in the attic should cover the tops of the attic floor joists to stop _____.

- thermal movement
- thermal bridging
- wood condensation
- air exfiltration

8. Adding more _____ where you already see insulation, such as in the attic, will likely reduce energy costs.

- vapor barrier materials
- ventilation
- insulation
- retarding material

9. T/F: Code allows the installation of loose-fill, rolled or foam-in-place insulation around knob-and-tube wiring.

- True
- False

Answer Key is on the next page.

Answer Key to Quiz 4

1. The R-value per inch of material for blown-in cellulose insulation is 3.67.

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4. According to the 2006 IRC, the minimum R-value for a ceiling in a home located in Zone 3 is R-30.

5. T/F: The insulation recommendations made by the U.S. DOE for attics, cathedral ceilings, walls and floors generally exceed those required by most building codes.
   Answer: True

6. T/F: Insulation that is compressed will not provide its full rated R-value.
   Answer: True

7. Insulation installed in the attic should cover the tops of the attic floor joists to stop thermal bridging.

8. Adding more insulation where you already see insulation, such as in the attic, will likely reduce energy bills.

9. T/F: Code allows the installation of loose-fill, rolled or foam-in-place insulation around knob-and-tube wiring.
   Answer: False

SECTION 7: ATTIC

CHECK THE ATTIC

At unfinished attic floors, be careful where you step. Walk only on the joists so that you do not fall through the ceiling below.

The following table can help you determine what type of insulation you will typically find in attics based on its appearance, and the related R-value of the insulation.

What you see in the attic:		What it probably is:	Total R-value
Loose fibers	light-weight yellow, pink or white	fiberglass	= 2.5 x depth
	dense gray or near-white, may have black spots	rock wool	= 2.8 x depth
	small gray flat pieces or fibers (from newspapers)	cellulose	= 3.7 x depth
Granules	light-weight	vermiculite or perlite	= 2.7 x depth
Batts	light-weight yellow, pink, or white	fiberglass	= 3.2 x depth

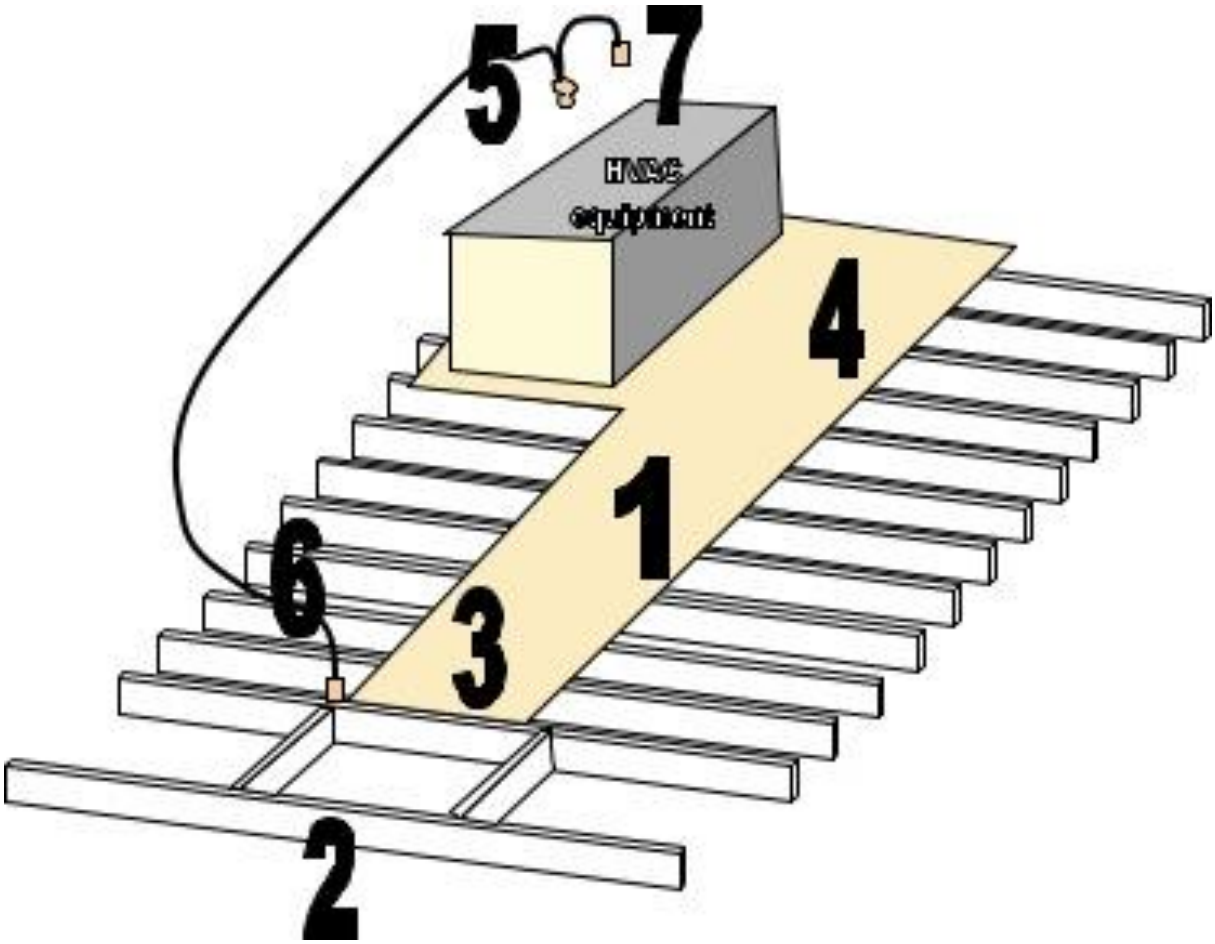
If there isn’t any insulation in the attic space, then insulation should be installed between the joists. If there is insulation installed and it's near the top of the joists, then a good practice is to install new batts perpendicular to the existing ones. That will help to cover the tops of the joists and reduce thermal bridging through the framing members.

THE ATTIC ACCESS

The attic access hatch or door should be insulated. A non-insulated attic door will reduce energy savings substantially. Ideally, the attic access will be located in an unconditioned part of the house, if possible. Otherwise, the attic access should have weatherstripping and insulation. The access opening could be covered by an insulated cover box.

There should be an access opening to all attic spaces that exceed 30 square feet and have a vertical height of 30 inches or more. The rough-framed opening should be at least 22 inches by 30 inches. It should be located in a hallway or other readily accessible location. An attic access that is located in a clothes closet is often inaccessible due to permanent shelving installed. There should be headroom that is a minimum of 30 inches above the attic access.

If there is a plumbing or electrical system or mechanical equipment in the attic space (or in the under-floor crawlspace), then the space should be accessible for inspection, service and removal.



Based on the diagram on the previous page, the following guidelines apply:

1. In addition to an adequately sized access opening, a passageway should be provided. In an attic, the passageway should be made of solid flooring.

2. There should be an opening to the space, and a clear, unobstructed passageway large enough to allow removal of the mechanical appliance. The opening should be at least 22 inches by 30 inches. The opening should be large enough for a person to get through it and for equipment to be removed.

3. The passageway beyond the opening should be at least 30 inches high, at least 24 inches wide, and not more than 20 feet in length when measured along the centerline of the passageway from the opening to the appliance. There are some exceptions.

4. A service area is required in front of the mechanical equipment. The dimensions should be at least 30 inches by 30 inches.

5. A light fixture should be installed to illuminate the passageway and the mechanical appliance.

6. A control switch should be installed near the entry to the passageway.

7. An electrical receptacle should be installed at or near the mechanical appliance to allow for safe and convenient maintenance and servicing of the appliance.

Attic Pull-Down Stairs

Attic pull-down ladders, also called attic pull-down stairs, are collapsible ladders that are permanently attached to the attic floor. Occupants can use these ladders to access their attics without being required to carry a portable ladder.

Common Defects for Attic Pull-Down Stairs

Homeowners -- not professional carpenters -- usually install attic pull-down ladders. Evidence of this distinction can be observed in consistently shoddy work that rarely meets safety standards. Some of the more common defective conditions observed by inspectors include:

- cut bottom cord of the structural truss. Homeowners will often cut through a structural member in the field while installing a pull-down ladder, unknowingly weakening the structure. Structural members should not be modified in the field without an engineer's approval;

- fastened with improper nails or screws. Homeowners often use drywall or deck screws rather than the standard 16d penny nails or ¼-inch by 3-inch lag screws.

Nails and screws that are intended for other purposes may have reduced shear strength and may not support pull-down ladders;

- fastened with an insufficient number of nails or screws. Manufacturers provide a certain number of nails with instructions that they all be used, and they probably do this for a good reason. Inspectors should be wary of "place nail here" notices that are nowhere near any nails;
- lack of insulation. Hatches in many houses (especially older ones) are not likely to be weatherstripped and/or insulated. An uninsulated attic hatch allows air from the attic to flow freely into the home, which may cause the heating or cooling system to run overtime. An attic hatch cover box can be installed to increase energy savings;
- loose mounting bolts. This condition is more often caused by age rather than a defective installation, although improper installation will hasten the loosening process;
- attic pull-down ladders are cut too short. Stairs should reach the floor;
- attic pull-down ladders are cut too long. This causes pressure at the folding hinge, which can cause breakage;
- missing fasteners;
- compromised fire barrier, when the attic access is installed in the garage;
- the attic ladder frame is not properly secured to the ceiling opening;
- the closed ladder is covered with debris, such as blown insulation or roofing material that's shed during roof work. Inspectors can place a sheet on the floor beneath the ladder to catch whatever debris may fall onto the floor; and
- cracked steps. This defect is a problem with wooden ladders.

In sliding pull-down ladders, there is a potential for the ladder to slide down too quickly. Always pull the ladder down slowly and cautiously.

An important safety tip for inspectors is to place an "InterNACHI Inspector at Work!" stop sign nearby while mounting the ladder. These are available at InspectorOutlet.com.

Relevant Codes

The 2009 edition of the International Building Code (IBC) and the 2006 edition of the International Residential Code (IRC) offer general guidelines regarding attic accesses.

2009 IBC (Commercial Construction):

1209.2 Attic Spaces. An opening not less than 20 inches by 30 inches (559 mm by 762 mm) shall be provided to any attic area having a clear height of over 30 inches (762 mm). A 30-inch (762-mm) minimum clear headroom in the attic space shall be provided at or above the access opening.

2006 IRC (Residential Construction):

R807.1 Attic Access. Buildings with combustible ceiling or roof construction shall have an attic access opening to attic areas that exceed 30 square feet (2.8 m^2) and have a vertical height of 30 inches (762 mm) or more. The rough-framed opening shall not be less than 22 inches by 30 inches, and shall be located in a hallway or readily accessible location. A 30-inch (762-mm) minimum unobstructed headroom in the attic space shall be provided at some point above the access opening.

Tips That Inspectors Can Pass on to Their Clients

- Do not allow children to enter the attic through an attic access. The lanyard attached to the attic stairs should be short enough that children cannot reach it. Parents can also lock the attic ladder so that a key or combination is required to access it.
- If possible, avoid carrying large loads into the attic. While properly installed stairways may safely support an adult, they might fail if the person is carrying a heavy load. Such trips can be split up to reduce the load's weight and the stress on the stairs.
- Replace an old, rickety wooden ladder with a new one. Newer aluminum models are often lightweight, sturdy and easy to install.

In summary, attic pull-down ladders are prone to a number of defects, most of which are due to improper installation, which can be corrected by the homeowner following inspection.

ATTIC INSULATION RULERS AND THICKNESS

A professional installer will attach vertical rulers (or attic rulers) to the joists of the attic prior to installing blown-in insulation. The installer should provide a signed and dated statement describing the insulation installed, its thickness, the coverage area, its R-value, and the number of bags installed. This informational notice, located in the attic, is referred to as the attic card.

The following is a sample chart that might be used by a professional installer of blown-in fiberglass insulation.

R-value	Minimum # of bags/1,000 square feet	Maximum coverage/bad (net sq. ft.)	Minimum weight/sq./ft. (lbs.)	Minimum thickness (inches)
R-49	25.0	40	0.878	19.50
R-44	22.2	45	0.786	17.75
R-38	19.2	52	0.676	15.50
R-30	15.2	66	0.531	12.25
R-26	13.2	76	0.459	10.75
R-22	11.1	90	0.388	9.25
R-19	9.5	105	0.334	8.00
R-11	5.5	182	0.193	4.75

Insulation manufacturers provide similar charts on their product bags. The chart states the minimum number of bags that need to be installed per 1,000 square feet of area in order to obtain a specific R-value. For example, to achieve R-38 for insulation installed in a 3,200-square-foot attic, the following formula applies:

3,200 ft^2 ÷ 1,000 = 3.2, and 19.2 (bags per 1,000 ft^2 for R-38) x 3.2 = 61.4 bags.

Building inspectors typically check the insulation's depth to verify compliance with local codes. Making sure the appropriate amount of insulation is installed requires a bag count or a comparison with the recommendations on the attic card.

DIFFICULT-TO-INSPECT ATTIC AREAS

If the attic has blown-in insulation, check the back corners, and the hard-to-see and hard-to-access areas. It is common for these areas to have insulation installed that is too thin. Insulation should be evenly distributed throughout the attic, with the correct density and depth.

Additionally:

- Baffles should be installed to prevent blocking the air flow through the attic vents, particularly at the eaves.
- The insulation should be blown all the way to the top plate of the exterior wall.
- The recessed lights should be properly filled in and covered (insulated contact-rated fixtures). Only IC-rated recessed lights should be installed because they are airtight and can be covered with insulation.
- Check underneath any pieces of plywood or platforms in the attic. Those areas need to be insulated.
- If mechanical equipment or storage areas are located in the attic, the flooring or platform decking should be elevated to allow the full height or thickness of the insulation to be installed.
- Check around ductwork, wires and plumbing.

Attic Knee Walls

Knee walls are vertical walls with an attic space directly behind them. You'll typically find them in houses with finished attic spaces and dormer windows, as with 1½-story houses.

There are a couple of ways that you may see a knee wall insulated. The most important areas and most overlooked areas to insulate are the open joist ends below the knee wall.

The open joist ends below a knee wall should be plugged or stuffed with:

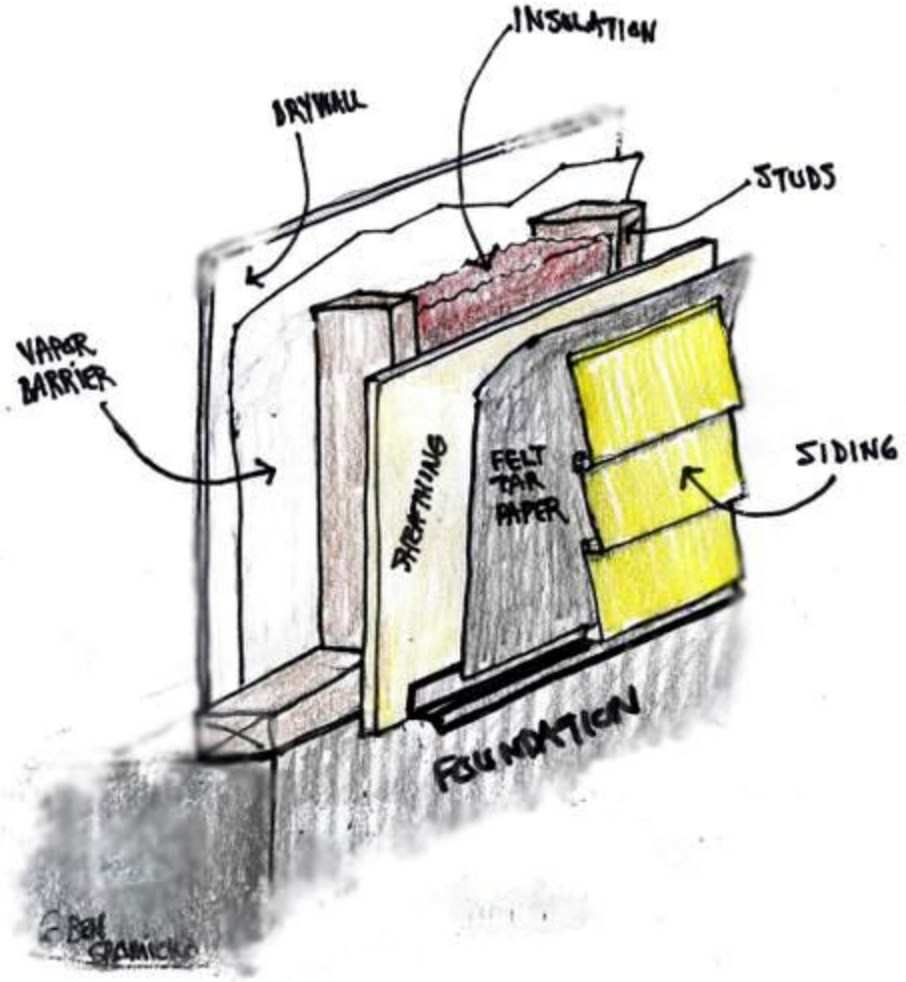
- squares of cardboard, metal flashing or rigid insulation;
- cellulose insulation blown at high density; or
- batt insulation stuffed into plastic bags.

The plugs should be sealed to the joists using caulk, sealant or spray foam. The knee wall and attic floor in the attic space behind the knee wall should be insulated. Sometimes, string, wire or cardboard is used to hold the insulation in place at the backside of the knee wall.

Another way to insulate this area is to seal and insulate the rafter spaces along the sloping ceiling of the knee wall attic space. The rafters should have proper insulation and ventilation, as required. One advantage of this approach is that, after properly insulating, any ductwork that was in that small space is now inside a conditioned space.

SECTION 8: EXTERIOR

CHECK THE EXTERIOR



An exterior wall of a building should be properly sealed, protected from moisture, and insulated adequately to increase comfort, reduce noise, and save on energy costs. Exterior walls are one of the most complex systems in a house.

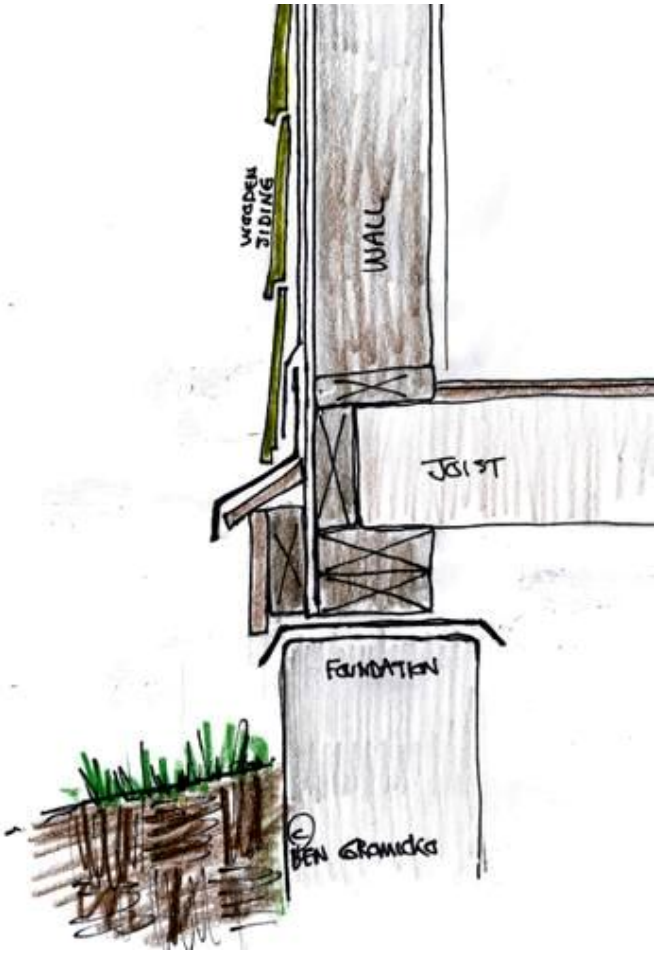
An effective wall has all of the following characteristics:

- It is airtight. All air leaks should be sealed in the wall during construction and before the insulation is installed in it.
- It controls moisture. An exterior rain-drainage system, an air barrier, and a vapor diffusion retarder should be installed on the wall on the correct side of the wall.
- It has complete insulation coverage. The wall framing should provide enough room for complete, maximum insulation coverage and reduce thermal bridging, with no open gaps or compressed insulation, and continuous insulated sheathing.

AIRTIGHTNESS

Air sealing reduces heat flow from air movement, or convection. Air sealing prevents water vapor in the air from entering the wall assembly. In a 100-square-foot wall, 1 cup of water can diffuse through drywall without a vapor diffusion retarder in a single year. Fifty cups can enter through a ½-inch-round hole. Air sealing is 10 to 100 times as important as installing a vapor diffusion retarder.

CONTROLLING MOISTURE



It is incorrect to think that installing a vapor diffusion retarder is the most important step for controlling moisture in a wall. Vapor diffusion retarders only retard moisture via diffusion, while most moisture enters a wall either through fluid capillary action or in the form of water vapor through air leaks.

A drainage plane in a wall system makes an easy pathway for water to drain away from the house. Rain leaks cause a lot of problems for walls. Water penetration into a wall can be the result of improper installation of the siding, poor flashing installation, bad weatherstripping, poor caulking around joints at the building exterior, and wind-driven rain into and through the exterior siding material. A drainage plane in the wall assembly protects against water intrusion.

Houses in all climates require the following to control moisture:

- a polyethylene sheet covering the exposed dirt in the crawlspace;
- the grading around the house sloping away from the foundation;
- a continuous vapor diffusion retarder with a perm rating of less than 1; and
- a termite shield, sill gasket, or other vapor-impermeable membrane installed on the top of the foundation wall to prevent moisture from wicking into the wood framing components via capillary action.

OVE TECHNIQUES

The U.S. Forestry Products Association has come up with optimum-value engineering (OVE) framing techniques that reduce unnecessary lumber use and improve the R-value of walls by reducing thermal bridging and maximizing the wall area that is insulated.

The OVE techniques include:

- eliminating unnecessary framing at intersections using 2-stud rather than 3-stud corners;
- interior bracing (or let-in bracing) to allow the use of insulated sheathing in corners;
- framing based on a 24-inch instead of a 16-inch on-center measurement;
- building a house using compact designs, and simpler shapes and volumes;
- aligning windows and doors with existing stud spacing; and
- using insulated headers.

2x6 WALL CONSTRUCTION

You may see the house walls built with 2x6 studs instead of 2x4s. In most jurisdictions, 2x6 studs can be spaced on 24-inch centers, instead of the standard 16-inch on-center measurement for 2x4 studs.

The advantages of using 2x6s are:

- the thicker wall provides more room for thicker insulation, such as R-19 or R-22;
- thermal bridging is reduced because fewer studs are used; and
- there is more space for insulating around piping, wiring and ductwork.

WALL SHEATHING

Many builders use common ½-inch wood sheathing, which has an R-value of 0.6. They may use an asphalt-impregnated sheathing called blackboard that has an R-value of 1.3. These two sheathings are installed on the exterior framing before the siding system is installed. Many builders use ½-inch foam-insulated sheathing that has an R-value of 2 to 3.5.

Foam sheathing provides a continuous layer of insulation that reduces thermal bridging through the wood studs. Foam sheathing also protects against condensation on the inside wall by keeping the interior of the wall warmer.

If you are inspecting this type of insulated wall sheathing during construction, the sheathing should completely cover the wall and should be sealed to the top plate and band joist at the floor. Once installed, the sheathing should be sealed around all holes and penetrations. The seams should be sealed with caulk or housewrap tape, according to the manufacturer's recommendations.

It is difficult to check the insulation in a wall of a home whose construction is completed. It's also difficult to add insulation to an existing wall.

There is a way to inspect the insulation inside a wall cavity, but this goes far beyond the scope of a typical home inspection.

To inspect the insulation inside an exterior wall, utilize an electrical outlet located at that wall and:

- turn off the power to the electrical receptacle (outlet);
- remove the receptacle cover and shine a flashlight into the crack around the outlet box. You should be able to see if there is insulation in the wall and, possibly, how thick it is;
- pull out a small amount of insulation, if needed, to help determine its type; and
- check the receptacles on the first and upper floors, if any, and in old and new parts of the house. Just because you find insulation in one wall doesn't mean that it's installed everywhere in the house.

Inspect and measure the thickness (in inches) of any insulation in unfinished basement ceilings and walls, or above crawlspaces. If the crawlspace isn't ventilated, it may have insulation installed at the perimeter walls. If the house is relatively new, it may have been built with insulation outside the basement or foundation walls. If so, the insulation in these spaces won't be visible. The homeowner might be able to tell you about the insulation.

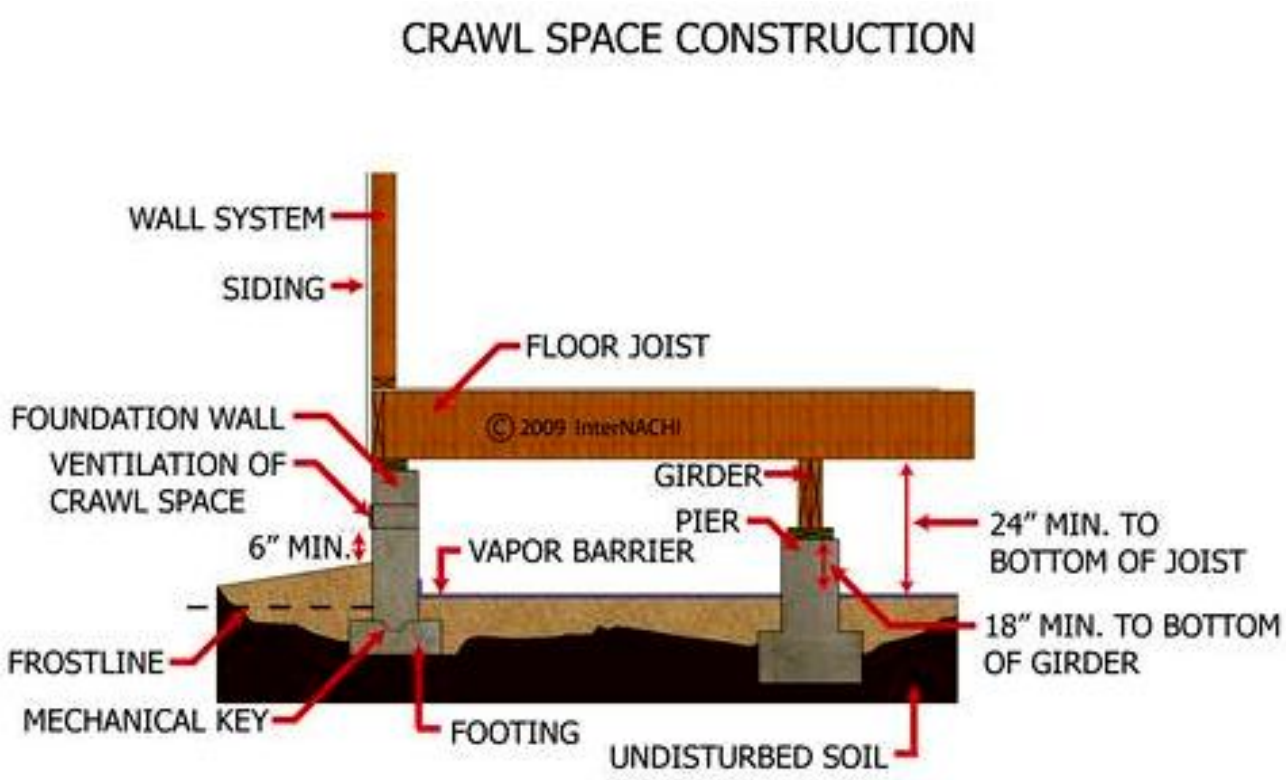
If the house has newer siding, there may have been some new thermal insulation installed prior to the siding's installation. Sometimes, insulation is blown into a wall cavity, and you'll see drilled circular holes 1½ to 2½ inches in diameter in the siding outside. The holes are the places through which the new insulation was blown into the wall.

The first-floor band joist may be readily accessible from the basement or crawlspace. It should be properly insulated.

If batt or rigid insulation is installed to insulate the inside of concrete basement foundation walls, it may be necessary to have furring strips installed at the walls by nailing or bonding. Or, you may find that an interior stud wall on which the insulation and interior wall finish are attached was installed around the basement perimeter.

The kraft paper or standard foil vapor diffusion-retarder facings on the blanket insulation should be covered with gypsum or interior paneling because of the fire hazard.

Some types of blanket insulation have a special flame-resistant facing (labeled FS25 = flame spread index 25). There are some blanket insulation products for basement wall installations that can be left exposed, and they have a flame-resistant facing and are labeled ASTM C 665, Type II, Class A.



QUIZ 5

1. T/F: Air sealing is 10 to 100 times as effective as installing a vapor diffusion retarder.

- True
- False

2. ____ cups of water can enter through a ½-inch-round hole via air transportation in a year.

- Five
- Ten
- Fifty
- Thirty

3. In a 100-square-foot wall, _____ of water can diffuse through drywall without a vapor diffusion retarder in a single year.

- 1 cup
- 30 quarts
- 12 pints
- 60 gallons

4. T/F: Air sealing reduces heat flow from air movement, known as convection.

- True
- False

5. T/F: The exterior wall is one of the most complex systems in a house.

- True
- False

6. T/F: Installing a vapor diffusion retarder is the most important step for controlling moisture in a wall.

- True
- False

(continued)

7. OVE stands for _____.

- opus volute entra
- other volume engineering
- optimum value engineering
- outside velocity entrance

8. In most jurisdictions, _____ studs can be spaced on 24-inch centers, instead of the standard 16-inch on-center measurement for 2x4 studs.

- 2x11
- 1x2
- 2x6
- 2x2

9. Many builders use common ½-inch wood sheathing, which has an R-value of _____.

- 4.2
- 1.6
- 2.6
- 0.6

10. T/F: If the house has newer siding, there may have been some new thermal insulation installed prior to the siding's installation.

- True
- False

11. The kraft paper or standard foil vapor diffusion-retarder facings on blanket insulation should be covered with gypsum or interior paneling because of the _____ hazard.

- health
- fire
- water
- mold

Answer Key is on the next page.

Answer Key to Quiz 5

1. T/F: Air sealing is 10 to 100 times as effective as installing a vapor diffusion retarder.
   Answer: True

2. Fifty cups of water can enter through a ½-inch-round hole via air transportation in a year.

3. In a 100-square-foot wall, 1 cup of water can diffuse through drywall without a vapor diffusion retarder in a single year.

4. T/F: Air sealing reduces heat flow from air movement, known as convection.
   Answer: True

5. T/F: The exterior wall is one of the most complex systems in a house.
   Answer: True

6. T/F: Installing a vapor diffusion retarder is the most important step for controlling moisture in a wall.
   Answer: False

7. OVE stands for optimum value engineering.

8. In most jurisdictions, 2x6 studs can be spaced on 24-inch centers, instead of the standard 16-inch on-center measurement for 2x4 studs.

9. Many builders use common ½-inch wood sheathing, which has an R-value of 0.6.

10. T/F: If the house has newer siding, there may have been some new thermal insulation installed prior to the siding's installation.
    Answer: True

11. The kraft paper or standard foil vapor diffusion-retarder facings on blanket insulation should be covered with gypsum or interior paneling because of the fire hazard.

SECTION 9: FLOORS

CHECK THE FLOORS

Look at the underside of any floor that is located over an unheated space, such as a crawlspace, basement or garage. Check and measure the insulation that is installed there. It will likely be fiberglass batt insulation. The insulation may be identified with its R-value printed on it. If it's not, multiply the thickness of the insulation by 3.2 to figure out its R-value.

If the insulation is foamboard or a sprayed-foam application and you can't find any labeling, multiply its thickness by 5 to get a good estimate of its R-value.

FLOORS AND CRAWLSPACES

If there is a floor over a crawlspace, check for the presence of insulation installed underneath the floor. Also, check to see whether the crawlspace is ventilated. You may discover that the floor is not insulated and the crawlspace is not ventilated, but the perimeter walls are insulated.

There should be an access hole through the perimeter wall of the crawlspace. It should be at least 16x24 inches. If the access is through the floor, then the minimum dimension should be 18x24 inches.

When batts or rolls of insulation are installed on the underside of a floor above an unheated crawlspace or basement, insulation should be:

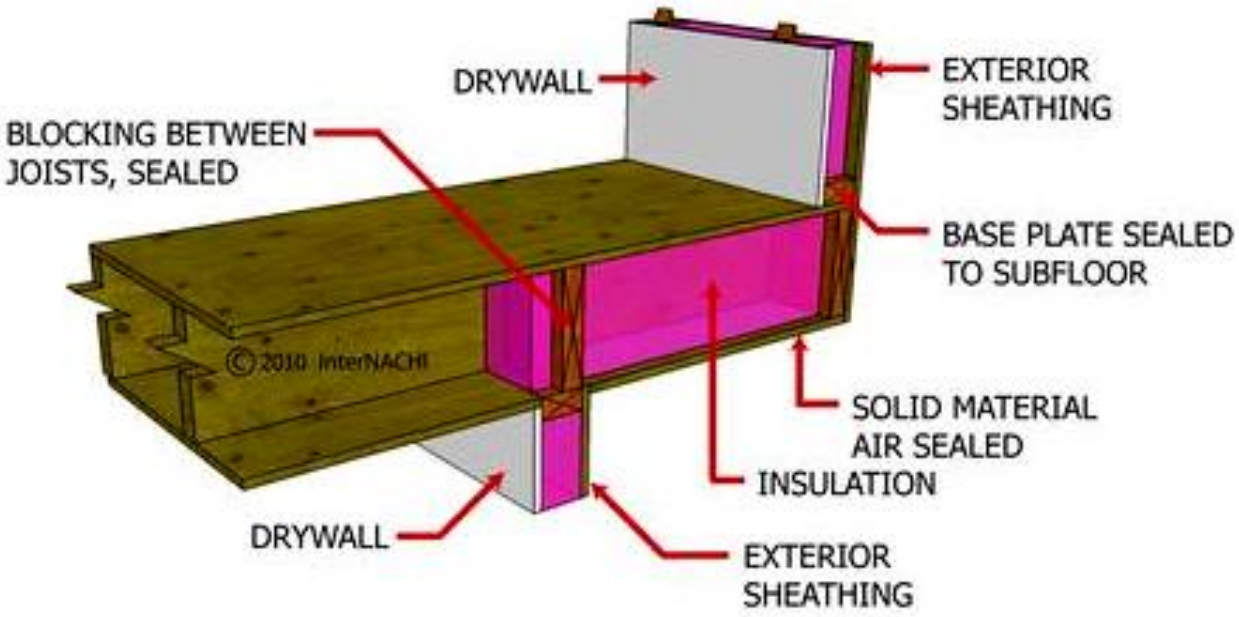
- fitted between the beams or joists;
- pushed up against the floor overhead as securely and snugly as possible;
- installed without compressing it;
- held in place with netting or snap-in wire holders;
- cut off and stuffed into tight spaces by hand;
- cut and fitted around cross-bracing between floor joists and any obstructions;
- installed against the perimeter band/rim joist that rests upon the sill plate; and
- installed on all ducts and pipes passing through the unheated space.

Reflective systems are installed in a way similar to batt insulation. It is important to install reflective insulation properly in order for it to be effective. Sometimes, reflective insulation will have flanges stapled to the framing members. This conductive material must not come in contact with any electrical current!

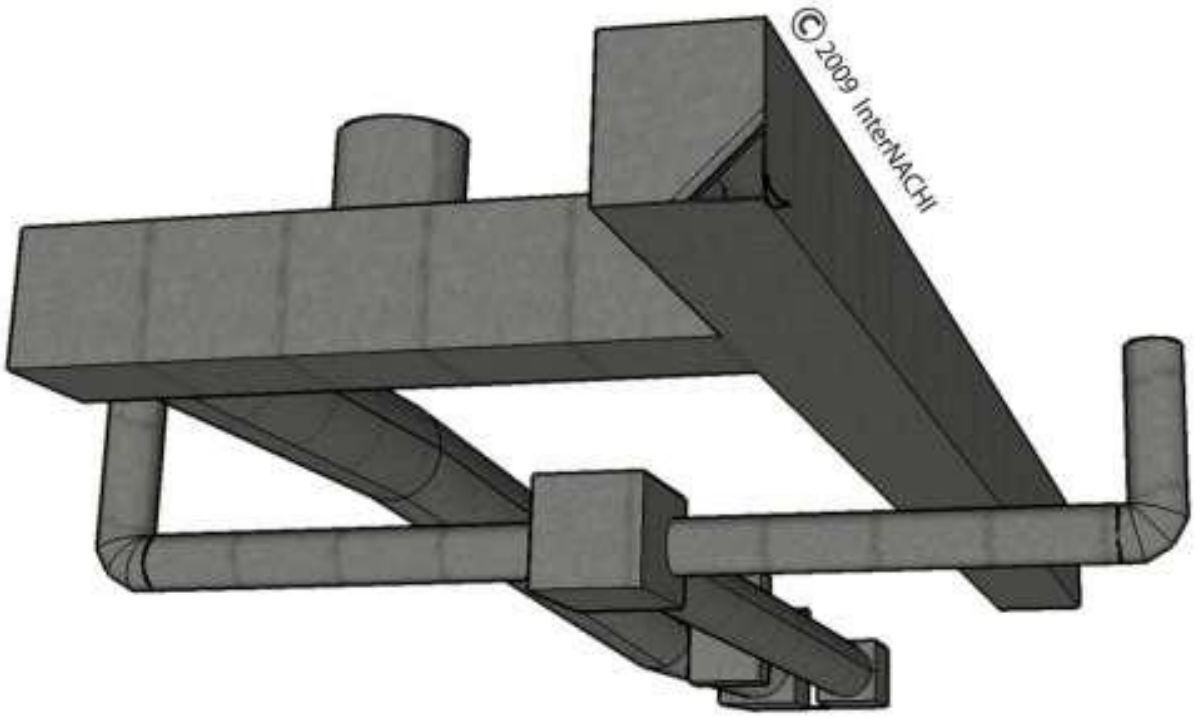
You may find spray-foam insulation at a floor system. The spray can do an excellent job of insulating and filling the spaces around the electrical wires, pipes, and other obstructions.

In a non-ventilated crawlspace, you may see fiberglass blanket insulation installed on the perimeter walls attached to furring strips. You may also see insulation fastened to the sill plate and draped down the perimeter wall of the crawlspace. The insulation may continue over the crawlspace floor for a couple of feet on top of the required ground vapor diffusion retarder. Foam insulation installed on the walls of a non-ventilated crawlspace may be bonded to the wall using adhesive. If any insulation is exposed, consider checking the local fire codes and the flame-spreading ratings of the insulation. If your client's home is in an area prone to termite infestation, be sure you communicate to your client about any inspection restrictions caused by the insulation.

CANTILEVERED FLOOR ASSEMBLY



SECTION 10: DUCTWORK



The ductwork of the HVAC system in a house may be checked by the inspector. If the ducts run through unconditioned spaces in the house (such as the crawlspace or attic), then the ductwork should be insulated.

The ductwork should not leak air. Leaking joints should be repaired with mechanical fasteners and then sealed with water-soluble mastic and embedded fiber mesh. Gray-cloth duct tape should never be used for this purpose. It degrades, cracks and loses its integrity and bond with age. If the joint is going to be opened up in the future for maintenance or other reasons, then aluminum foil tape may be used.

The ductwork should be wrapped with insulation that has a minimum R-value of 6, with a vapor diffusion retarder facing on the outer (exterior) side. The insulation should not be compressed. It should be overlapped and sealed with fiberglass tape where sections of the insulation meet. The insulation should not be torn or damaged. The vapor diffusion retarder should not be cut, torn or damaged. The ductwork should not be compressed or damaged.

If you are going to enter the attic space, be careful not to step on and compress ductwork that may be hidden under your feet by blown-in insulation. Sometimes, blown-in insulation will be layered over ductwork in the attic space, and it will be hard to see the ductwork.

SECTION 11: TYPES OF INSULATION

The type of insulation used, its R-value, and the thickness needed are all directly related to the nature and location of the spaces in the house that are insulated. Different forms of insulation can be used together. For example, you may find batt or roll insulation over loose-fill insulation.

BLANKETS

Blankets come in the form of batts and rolls. They are flexible. They are made from mineral fibers, including fiberglass and rock wool. They are available in different widths and lengths. They are made in standard sizes (widths) for inserting in between studs and floor joists. They are available with or without vapor-retarder faces (paper face). A batt insulation, when installed in the ceiling of a basement with the insulation exposed, may have a flame-resistant face.

BLOWN-IN, LOOSE-FILL

Blown-in, loose-fill insulation may be made of cellulose, fiberglass, rock wool or fiber pellets. The insulation can be blown in using a pump and hose system. This type of insulation can be blown into wall cavities. You may often see it blown onto the attic floor.

When the wall is being insulated, cellulose and fiberglass can be blown onto the wall. The insulation material is mixed with an adhesive or foam to make the insulation resistant to settling.

FOAM INSULATION

Foam insulation can be installed by a professional using special equipment that meters, mixes and sprays the foam insulation. Polyicynene is an open-cell foam. Polyisocyanurate and polyurethane are closed-cell foams. In general, open-cell foams allow water to move through the wall more easily than closed-cell foams. Some of the closed-cell foams are, therefore, able to provide a better R-value where the space is limited.

RIGID INSULATION

Rigid insulation is made from fibrous materials and plastic foams. They are made into boards and molded pipe coverings. Rigid insulation boards may be faced with reflective foil that reduces heat flow when installed next to an air space. You'll often find rigid insulation installed up against foundation walls and used as an insulated wall sheathing.

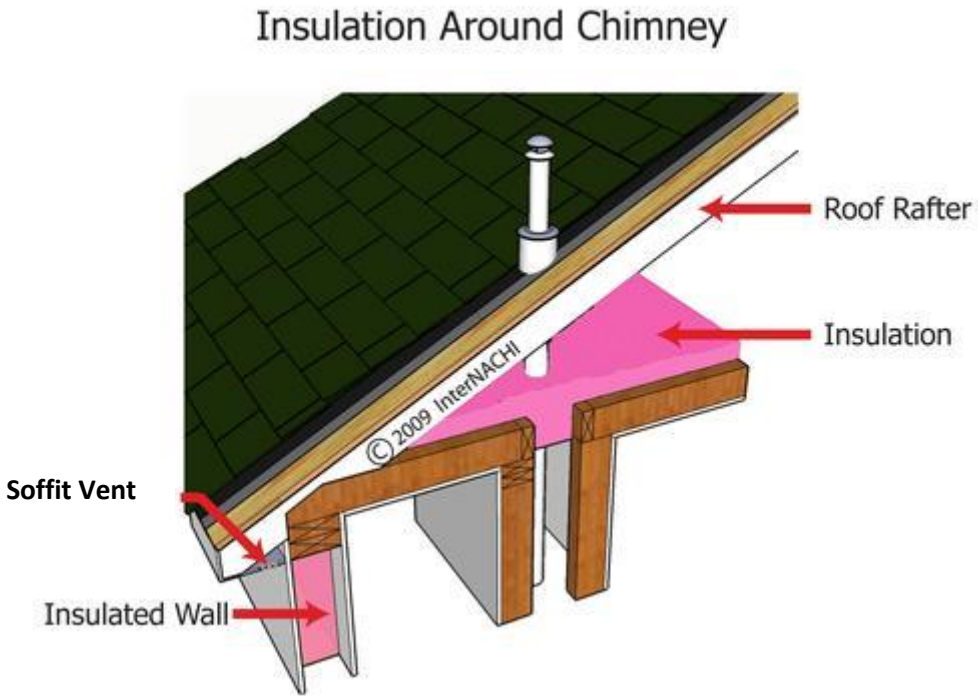
REFLECTIVE INSULATION

Reflective insulation is made up of aluminum foil with a variety of different backings, including kraft paper, plastic film, polyethylene bubbles, and cardboard. Reflective insulation is most effective in reducing downward heat flow. You'll often find them located between roof rafter boards, floor joists and wall studs. If a single reflective surface is installed and it faces an open air space, then it is called a radiant barrier.

RADIANT BARRIERS

Radiant barriers are intended to reduce the summer heat gain and the winter heat loss. In new homes, you may see foil-faced wood components at the roof sheathing system installed with the foil facing down into the attic. There may be other areas where the radiant barrier is integrated into the building components and structure of the home. In older homes, a radiant barrier will typically be found stapled across the bottom of some joists. All proper radiant barriers should have a low emittance of 0.1 or less, and a high reflectance of 0.9 or more.

The radiant barrier should not be laid on top of the attic floor insulation, or on the attic floor anywhere, because it will soon be covered with dust and will not work.

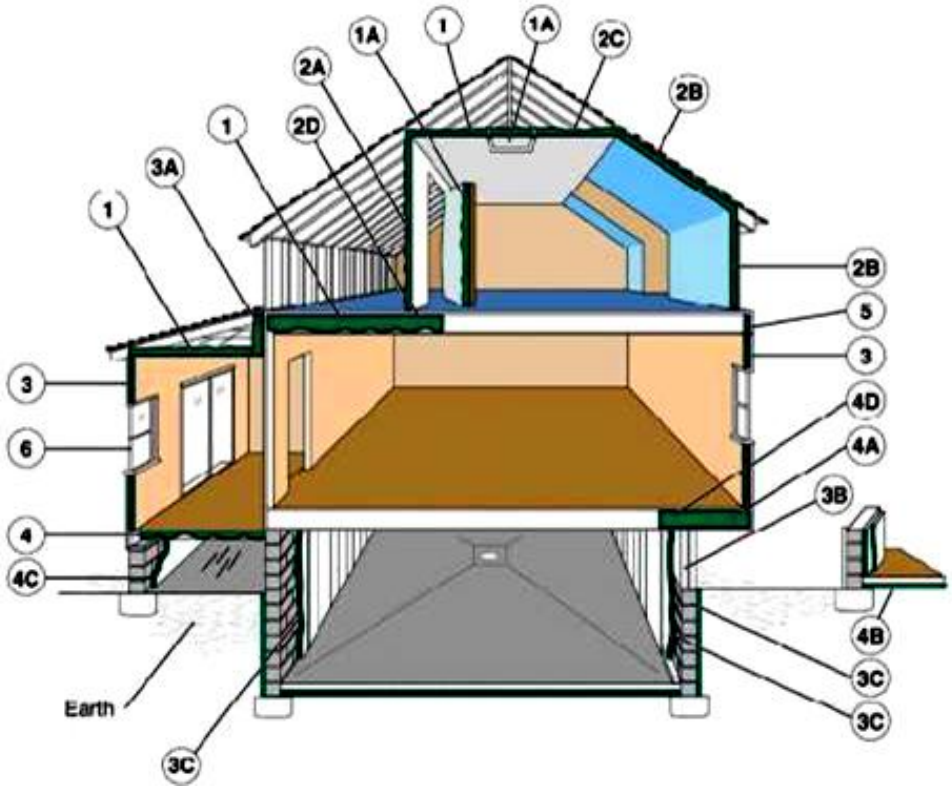


INSULATION TYPES				
Form	**Insulation Materials**	**Location**	**Installation Methods**	**Advantages**
Blanket: batts and rolls	• Fiberglass • Mineral (rock or slag) wool • Plastic fibers • Natural fibers	Unfinished walls, including foundation walls, and floors and ceilings	Fitted between studs, joists and beams	Do it yourself; suited for standard stud and joist spacing, which is relatively free from obstructions
Concrete block insulation	Foam beads or liquid foam: • Polystyrene • Polyisocyanurate Polyurethane • Vermiculite or perlite pellets	Unfinished walls, including foundation walls, for new construction or major renovations	Involves masonry skills	Autoclaved aerated concrete and autoclaved cellular concrete masonry units have 10 times the insulation value of conventional concrete.
Foam-board or rigid foam	• Polystyrene • Polyisocyanurate Polyurethane	Unfinished walls, including foundation walls, floors and ceilings, non-vented low-slope roofs	Interior application must be covered with 1/2-inch gypsum or other building code-approved material for fire safety. Exterior applications must be covered with weatherproof facing.	High insulating value for relatively little thickness Can block thermal short circuits when installed continuously over frames or joists
Insulating concrete forms (ICFs)	Foamboards or foam block	Unfinished walls, including foundation walls, for new construction	Installed as part of the building structure	Insulation is literally built into the home's walls, creating a high thermal resistance.
Loose-fill	• Cellulose • Fiberglass • Mineral (rock or slag) wool	Enclosed existing or open new wall cavities, unfinished attic floors, and hard-to-reach places	Blown into place using special equipment; sometimes poured in	Good for adding insulation to older finished areas, irregularly shaped areas, and around obstructions

Reflective system	Foil-faced kraft paper, plastic film, polyethylene bubbles or cardboard	Unfinished walls, ceilings and floors	Foils, film or papers fitted between wood-frame studs, joists and beams	Do-it-yourself All suitable for framing at standard spacing. Bubble-form suitable if framing is irregular or if obstructions are present Most effective at preventing downward heat flow; however, effectiveness depends on spacing
Rigid fibrous or fiber insulation	• Fiberglass • Mineral (rock or slag) wool	Ducts in unconditioned spaces and other places requiring insulation that can withstand high temperatures	HVAC contractors fabricate the insulation into ducts either at their shops or at the job sites.	Can withstand high temperatures
Spray foam and foamed-in-place	• Cementitious • Phenolic • Polyisocyanurate • Polyurethane	Enclosed existing wall or open new wall cavities, unfinished attic floor	Applied using small spray containers, or in larger quantities as a pressure-sprayed (foamed-in-place) product	Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions
Structural insulated panels (SIPs)	• Foamboard or liquid foam-insulation core • Straw-core insulation	Unfinished walls, ceilings, floors and roofs for new construction	Builders connect them together to construct a house.	Provide superior and uniform insulation compared to more traditional construction methods; take less time to build

The U.S. Federal Trade Commission has clear rules about the R-value label that must be placed on all residential insulation products. The label should have a clearly stated R-value and information about health, safety and fire-hazard issues. If you are inspecting a house during construction, you may request that the contractor provide the product label from each package. This can also tell you how many packages were used.

SECTION 12: WHERE TO LOOK FOR INSULATION



This illustration shows the spaces inside a home that should be insulated. The spaces should be properly insulated to the R-values recommended.

1: In unfinished attic spaces, the insulation should be installed between and over the floor joists to seal off the living spaces below.
1A: Attic access door
2: In finished attic rooms with or without a dormer, the insulation should be installed:
2A: between the studs of knee walls;
2B: between the studs and rafters of the exterior walls and roof;
2C: at ceilings with cold spaces above; and
2D: extended into the joist space to reduce air flow.
3: All exterior walls should have insulation, including:
3A: the walls between living spaces and unheated garage, shed roofs and storage areas;
3B: the foundation walls above ground level; and
3C: the foundation walls in heated basements, full wall (either interior or exterior).
4: Floors above cold spaces, such as vented crawlspaces and unheated garages, should have insulation installed, including:
4A: any portion of the floor in a room that is cantilevered beyond the exterior wall below;
4B: slab floors built directly on the ground;
4C: as an alternative to floor insulation, and foundation walls of non-vented crawlspaces;
4D: and extended into the joist space to reduce air flow.
5: Insulation should be installed between band joists.
6: Additionally, check the condition of the storm windows. Caulking and sealing may be needed around all windows and doors.

QUIZ 6

1. T/F: Insulation should be installed without compressing it.

- True
- False

2. If the ducts of the HVAC system run through unconditioned spaces in the house, such as a crawlspace or an attic, then the ductwork should be _____.

- metal
- insulated
- dampered
- shortened

3. In general, _____-cell foams allow water to move through the wall more easily than _____-cell foams.

- open..... closed
- closed..... open
- single..... multi

4. T/F: Radiant barriers are intended to reduce the summer heat gain and the winter heat loss.

- True
- False

Answer Key to Quiz 6

1. T/F: Insulation should be installed without compressing it.
   Answer: True

2. If the ducts of the HVAC system run through unconditioned spaces in the house, such as a crawlspace or an attic, then the ductwork should be insulated.

3. In general, open-cell foams allow water to move through the wall more easily than closed-cell foams.

4. T/F: Radiant barriers are intended to reduce the summer heat gain and the winter heat loss.
   Answer: True

SECTION 13: ROOF INSULATION AND VENTILATION

Roof system ventilation and insulation are important for a number of reasons, including:

- condensation control;
- temperature (or heat) control;
- energy efficiency; and
- the prevention of chronic ice dam formation.

Ventilation of attic areas is intended to prevent the accumulation of moisture vapor in the attic-roof space and to dry low levels of condensation that may form on the underside of a roof deck. Ventilation is also intended to reduce the temperature of the roof deck during hot periods to improve shingle durability. Reducing attic temperature through ventilation and insulation also improves energy efficiency during hot periods. And in the case of ice dams, elevated attic and roof temperatures during the winter can cause snow on the roof to melt. Insulation and roof ventilation help to keep the roof's exterior surface cold and minimizes the development of melted water and, consequently, ice dams.

Ventilating roofs in hot and humid conditions may add -- rather than remove -- moisture from attics and enclosed roof spaces. However, not ventilating a roof may void the manufacturer's warranty and slightly decrease the life expectancy of asphalt shingles due to the increased temperature of the roof surface.

In colder climates, roof ventilation serves to remove humidity and condensation from the roof-attic space and helps to prevent the chronic formation of ice dams at eaves.

Tile, concrete and metal roofing materials are not similarly affected. It is possible to have an unvented attic space, but such a choice may require designing the attic-roof space as a conditioned space, similar to that required when creating a habitable space in the attic. There are several sources that provide detailed information for designing an unvented attic. Traditional attic ventilation remains a cost-effective though imperfect solution for moisture control.

Unvented Roof Systems/Attic Assemblies

Spray foam (open- and closed-cell) and fiberglass insulation can perform successfully at unvented roof systems (or unvented attic assemblies) when airtightness is provided and humidity is controlled.

There are many other important factors involved when inspecting unvented roof systems, including: the climate zone; roofing solar and exposure properties; air vapor barriers; and interior humidity levels.

Wood-framed pitched-roof systems are traditionally constructed with fibrous insulation materials installed on the ceiling plane (attic floor) or along the sloped underside of the roof deck. Proper ventilation is critical for these types of systems.

For vented wood-framed pitched-roof systems, the primary concern is the potential for moisture to build up at the sloped underside of the roof deck during cold weather. The underside of the roof deck is the condensing plane.

For unvented roof systems, the condensing plane is the underside of the air-impermeable foam. When they're properly installed, condensation should not exist because the temperature of the interior face of the foam should be about the same as the interior air temperature.

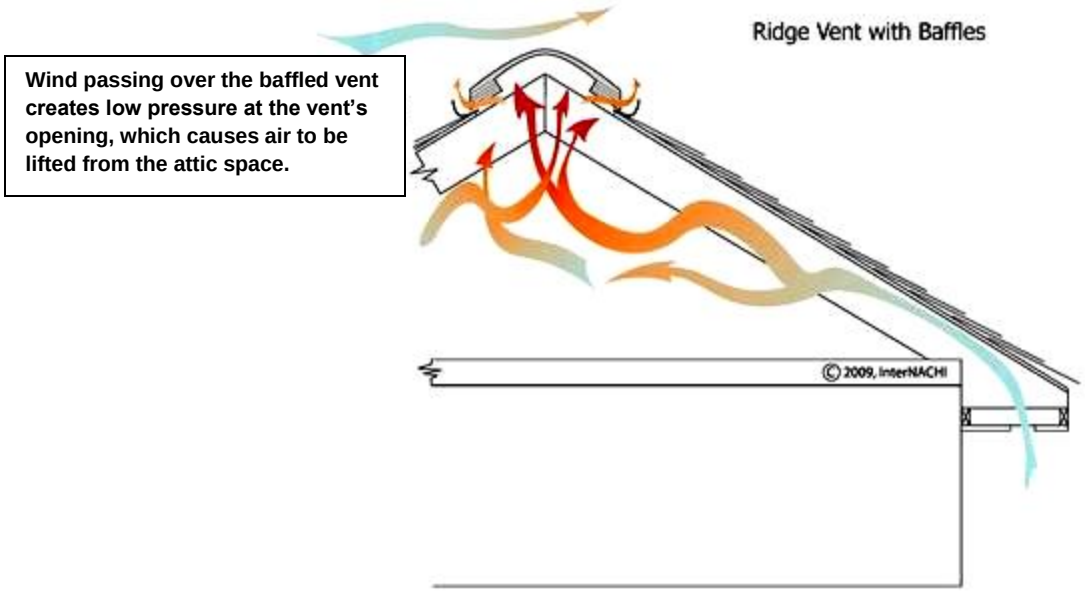
To control airtightness, an air-barrier system must be installed in the roof insulation assembly. An air-impermeable layer may be installed on the inside of air-permeable insulation (such as fiberglass or cellulose) to control both air and moisture movement. For roofs sealed with spray-foam insulation, air leakage is effectively stopped. Failure will be likely via accidental or unintended air flows at unvented wood-framed pitched-roof systems, such as around roof penetrations, including plumbing vents.

Unvented attic assemblies should meet the following conditions:

- The unvented attic space must be completely contained within the building's thermal envelope.
- Interior vapor retarders must not be installed on the ceiling (attic floor) of the unvented attic assembly.
- At wood shingle/shake roofs, a vented air space of ¼-inch should separate the shingles/shakes from the roofing underlayment above the roof deck.
- Air-impermeable insulation can be applied in direct contact with the underside of the roof deck. For Climate Zones 5, 6, 7 and 8, air-impermeable insulation must have a vapor retarder in direct contact with the underside of the insulation.

As long as airtightness is provided and humidity during the winter is controlled, unvented roof systems can perform successfully.

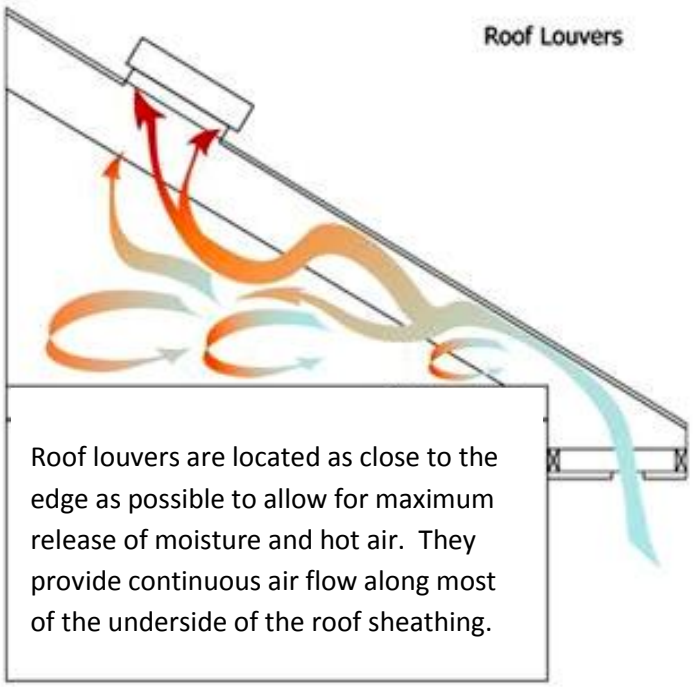
ROOF VENTS AND INSULATION CLEARANCE



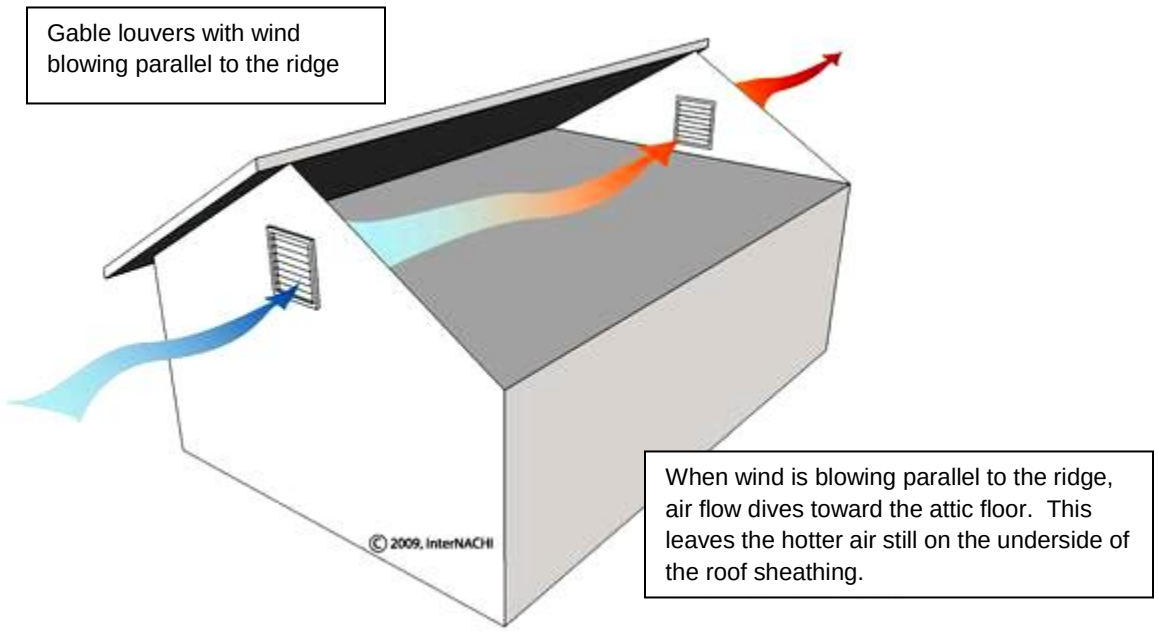
Where vents are installed at the eaves, the insulation should not block the vents and the free flow of air. There should be a minimum space of 1 inch provided between the insulation and the roof deck sheathing and at the location of the vent.

VENTILATION REQUIRED

Code requires ventilation to be provided for each enclosed attic space and enclosed rafter space that's formed where ceilings are installed at the bottom of the roof rafter boards. Each separate rafter space must be ventilated. The ventilation openings should be a minimum of 1/8-inch and a maximum of 1/4-inch and protected with corrosion-resistant wire mesh.



ROOF VENTILATION DEFINITIONS



- **1:150** is the traditional, standard minimum for attic ventilation. To determine the minimum square footage of vent required, take the horizontal floor area of the attic space under the roof and divide it by 150.
- **1:300:** To determine the minimum square footage of ventilation required when an approved vapor barrier is installed on the warm-in-winter side of the ceiling, take the horizontal floor area of the attic space under the roof and divide it by 300.
- The **enclosed rafter space** is the space formed between the roof-deck sheathing (on top of the rafter boards), the sides of the roof-framing rafter boards, and the wallboard or ceiling finish on the bottom of the rafter boards.
- The **net-free ventilation area** is the actual unobstructed, open area of a vent with the louvers, grates or screens deducted from the overall ventilation area.
- A **vapor barrier** is a material that impedes the flow of moisture vapor through the material. The vapor barrier has a perm of 1 or less.

INSPECTING ROOF VENTILATION IN 10 STEPS

Step 1: Measure the area to be ventilated in square feet.

Step 2: Determine if there is a vapor barrier installed on the warm-in-winter side of the ceiling.

Step 3: Check the location of the vents.

Step 4: Check the type of vents. Remember to inform your client that turbine vents and electrically powered fan-vents need to be inspected, tested and maintained annually.

Step 5: Determine if the enclosed attic spaces and the enclosed rafter spaces (formed by the ceiling finish applied directly to the bottom of the rafter boards) have cross-ventilation for each separate space. Attics and enclosed rafter spaces must have cross-ventilation.

Step 6: Measure the net-free area of the vents.

Step 7: Determine whether the ventilation openings are protected against rain and snow. They should measure a minimum of 1/8-inch and a maximum of 1/4-inch and be protected with corrosion-resistant wire mesh.

Step 8: Calculate the required roof ventilation.

If a vapor barrier is installed, multiply the area by 1:300.

If no vapor barrier is installed and the vents are installed only in the lower portion of the space to be ventilated (below 3 feet of the vertical height of the space), then multiply the area by 1:150; or

if 50% to 80% of the vents are in the upper portion of the space to be ventilated, and the balance of the ventilation is provided by the eave vents, multiply the area by 1:300.

Step 9: Compare the calculations of the observed ventilation with the requirements for ventilation.

Step 10: Where eave or soffit vents are installed, the insulation should not block the free flow of air. A minimum space of 1 inch should be provided between the insulation and the roof-deck sheathing. Baffles are commonly used to provide that 1-inch space.

ICE DAMS

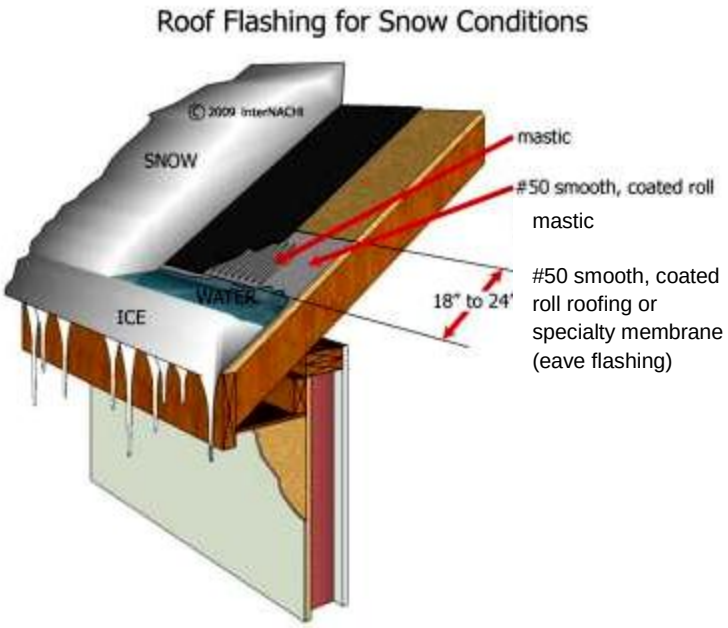
An ice dam is caused by the warming of an attic space. And while attic ventilation and insulation contribute to the prevention of ice dams by keeping attics cold, they can be overpowered by other attic-warming effects, such as air leakage from the house into the attic through ceiling bypasses, chases, open gaps and uninsulated ducts installed in the attic.

If significant conditioned air escapes into the attic, the attic ventilation may not be capable of preventing the warming of the roof decking and the subsequent formation of ice dams. Therefore, sealing air leaks between the house and the vented attic is essential for making attic ventilation work. Air leakage from the interior into the attic also introduces moisture. If a significant amount of interior air leaks into an attic, the ventilation in the attic may not be sufficient to prevent moisture and condensation problems there.

ROOF VENTILATION BASED ON CLIMATE

Most building codes require roof vents to expel moisture that could cause insulation or other building materials to deteriorate during winter. In summer, ventilation may reduce the roof temperature and lengthen its service life.

Researchers are still investigating whether attic ventilation is good for all climates. Until the research results are available and accepted, installation practices for attic ventilation should follow local code requirements.



A combination of continuous ridge vents along the peak of the roof and continuous soffit vents at the eaves provides the most effective ventilation.

RULE OF THUMB

The rule of thumb is to use 1 square foot of net-vent opening for every 150 square feet of insulated ceiling, or 1:300 if the insulation has a vapor diffusion retarder. The vent area should be divided equally between the ridge and the soffits. Attic spaces and roof cavities should be ventilated in accordance with minimum local building code requirements, as represented in the following table.

Minimum Roof Ventilation Requirements	
Applicability Requirements	**Ventilation Amount[a]**
Vertical separation of inlet and outlet vents is less than 3 feet	1:150
Vertical separation of inlet and outlet vents is at least 3 feet with balanced inlet and outlet vent areas[b] or a vapor diffusion retarder is installed on the warm-in-winter side of the ceiling	1:300
a. Values are given as ratio of total net (unobstructed) open area of inlet plus outlet vents to total horizontal projected area of the ventilated space. Therefore, vent size must be increased to account for obstructed vent area due to louvers and screens (refer to vent manufacturer technical data).	
b. Inlet and outlet vent areas shall be considered balanced provided that at least 50 percent and not more than 80 percent of the required ventilating area is provided by ventilators located in the upper portion of the space to be ventilated.	

For enhanced protection against the formation of ice dams, the table to follow provides recommended insulation levels and vent-area ratios as a function of the venting layout. These recommendations should be found in areas with a ground snow load greater than 30 pounds per square foot (psf), and in other areas where ice dams are a concern. The ventilation recommendations in the table can be used in addition to eave ice-dam flashing to create multiple lines of defense. Also, the arrangement of vent areas must balance the high (outlet) with the low (inlet) vent openings.

Recommended Roof Ventilation Levels to Prevent Chronic Ice Dams (for climates with ground snow load ≥ 30 psf and other areas prone to ice dams) [a,b]				
R-value of Roof/Attic Insulation[c]	Vertical Separation of Inlet (Eave/Cornice) and Outlet (Ridge or Gable) Vents			
	3 ft	6 ft	9 ft	12 ft
Vented Attic Roofs				
R-19	1:100	1:140	1:180	1:200
R-30	1:160	1:230	1:280	1:300
R-38	1:200	1:290	1:300	1:300
R-49	1:260	1:300	1:300	1:300
Vented Cathedral Roofs				
R-19	1:100	1:140	1:250	1:250
R-30	1:160	1:230	1:250	1:250
R-38	1:200	1:250	1:250	1:250
R-49	1:250	1:250	1:250	1:250

Minimum Vent Depth for Air Passage in Cathedral Roofs	
Roof Pitch	Vent Depth[d]
3:12 to 5:12	2"
> 5:12	1 to 1/2"

a. This table applies to roofs with a pitch of at least 3:12, an R-value of at least R 19, and a distance between inlets and outlets of no more than 40 feet.

b. Values are given as a minimum ratio of total net open (unobstructed) area of inlet and outlet vents to total horizontal projected area of the ventilated space. Inlet and outlet areas shall be balanced to the maximum extent practicable. For example on a simple gable roof, one-half of the calculated vent area shall be at the ridge and one-fourth at each of the two eaves.

c. For the purpose of determining ventilation requirements, roof/attic insulation shall meet or exceed insulation amounts required by the local building code.

d. Minimum vent depth shall be maintained for entire ventilation airflow path from eaves to ridge or gable vents.

Cap vents and gable vents can supplement a roof design that has an insufficient ridge-vent area. Turbine vents can also be used, but they need annual inspection and maintenance. Electrically powered roof fans are not ideal because they typically use more energy than they save.

Powered roof fans can also cause other problems, such as:

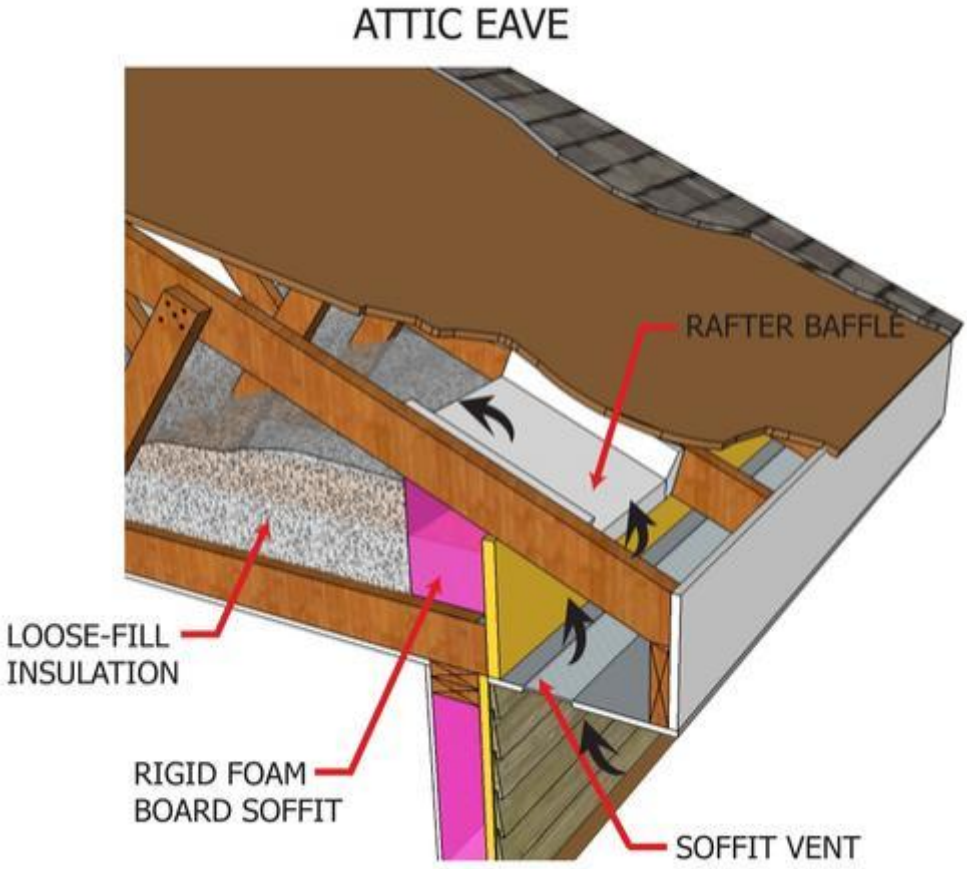
- sucking conditioned air from the house's interior through leakage pathways in the ceiling;
- pulling airborne pollutants from the crawlspace into the house's interior; and
- causing exhaust gases from fireplaces and combustion appliances to enter the home.

ROOF HEIGHT AT THE EAVES

A common problem with many roof designs can be found at the eaves. There is often very little space for insulation of the required thickness to be installed at the eaves without blocking the soffit vents. Often, the insulation is compressed in that area in order to fit into the tight space, which diminishes its R-value.

To correct that situation, some builders install a truss roof with a raised heel or oversized cantilever. This type of truss has an elevated overhang that uses a combination of soffit and eave vents, with baffles and soffit dams installed at the eaves. This type of truss provides plenty of room for insulation at the wall-to-roof intersection, as well as additional window shading.

In stick-built roofs, some builders install an additional top plate across the top of the ceiling joists at the eave to raise the roof height. This additional top plate raises the roof height, prevents compression of the insulation, and allows room for ventilation.



QUIZ 7

1. T/F: Ventilation of attic areas is intended to prevent the accumulation of moisture vapor in the attic-roof space and to dry low levels of condensation that may form on the underside of a roof deck.

- True
- False

2. There should be a minimum space of ____ provided between the insulation and the roof deck sheathing and at the location of the vent.

- 1/2-inch
- 1 inch
- 1-1/2 inches
- 2 inches

3. T/F: A combination of continuous ridge vents along the peak of the roof and continuous soffit vents at the eaves provides the most effective ventilation.

- True
- False

4. The rule of thumb to remember is to use 1 square foot of net-vent opening for every _____ square feet of insulated ceiling, or 1:____ if the insulation has a vapor diffusion retarder.

- 150..... 300
- 150..... 250
- 350..... 100
- 300..... 150

5. T/F: Powered roof fans can cause problems, such as sucking conditioned air from the house's interior through leakage pathways in the ceiling.

- True
- False

6. A common problem inspectors will see is insulation compressed into the eaves area that was done in order to fit it into the tight space, which _____ its R-value.

- doubles
- diminishes
- has little to do with
- increases

Answer Key is on the next page.

Answer Key to Quiz 7

1. T/F: Ventilation of attic areas is intended to prevent the accumulation of moisture vapor in the attic-roof space and to dry low levels of condensation that may form on the underside of a roof deck.
   Answer: True

2. There should be a minimum space of 1 inch provided between the insulation and the roof deck sheathing and at the location of the vent.

3. T/F: A combination of continuous ridge vents along the peak of the roof and continuous soffit vents at the eaves provides the most effective ventilation.
   Answer: True

4. The rule of thumb to remember is to use 1 square foot of net-vent opening for every 150 square feet of insulated ceiling, or 1:300 if the insulation has a vapor diffusion retarder.

5. T/F: Powered roof fans can cause problems, such as sucking conditioned air from the house's interior through leakage pathways in the ceiling.
   Answer: True

6. A common problem inspectors will see is insulation compressed into the eaves area that was done in order to fit it into the tight space, which diminishes its R-value.

SECTION 14: BASEMENT WALL INSULATING AND FINISHING

FINISHED BASEMENT WALLS

Finished basement walls are exposed to many different things that come from all directions. The finished basement wall is exposed to different temperatures, moisture levels, water vapor movement, heat, cold, cool concrete, warm interior air, etc. And they all relate to the biggest concern with basement finished walls: moisture -- specifically, exterior moisture.

This section focuses on the use of insulation, vapor diffusion retarders, and air leakage-sealing practices that are used to construct finished basement areas. Understanding these building practices will improve your inspection skills.

The approaches for insulating and finishing basement spaces vary, depending on whether you're dealing with new or existing construction, and whether a basement is being only insulated but not finished.

You may find foam insulation installed as the interior basement insulation. It offers good moisture performance, but it also requires being covered with a fire-resistant material, such as drywall gypsum. Foam is good for insulating a finished basement.

A finished basement that is high-quality usually has some type of exterior waterproofing, relative-humidity control in the basement, and air sealing. A dry basement is less likely to have problems with wood-destroying organisms. Once the exterior grading and groundwater factors have been addressed, the basement should remain dry and protected by properly installed wall assemblies.

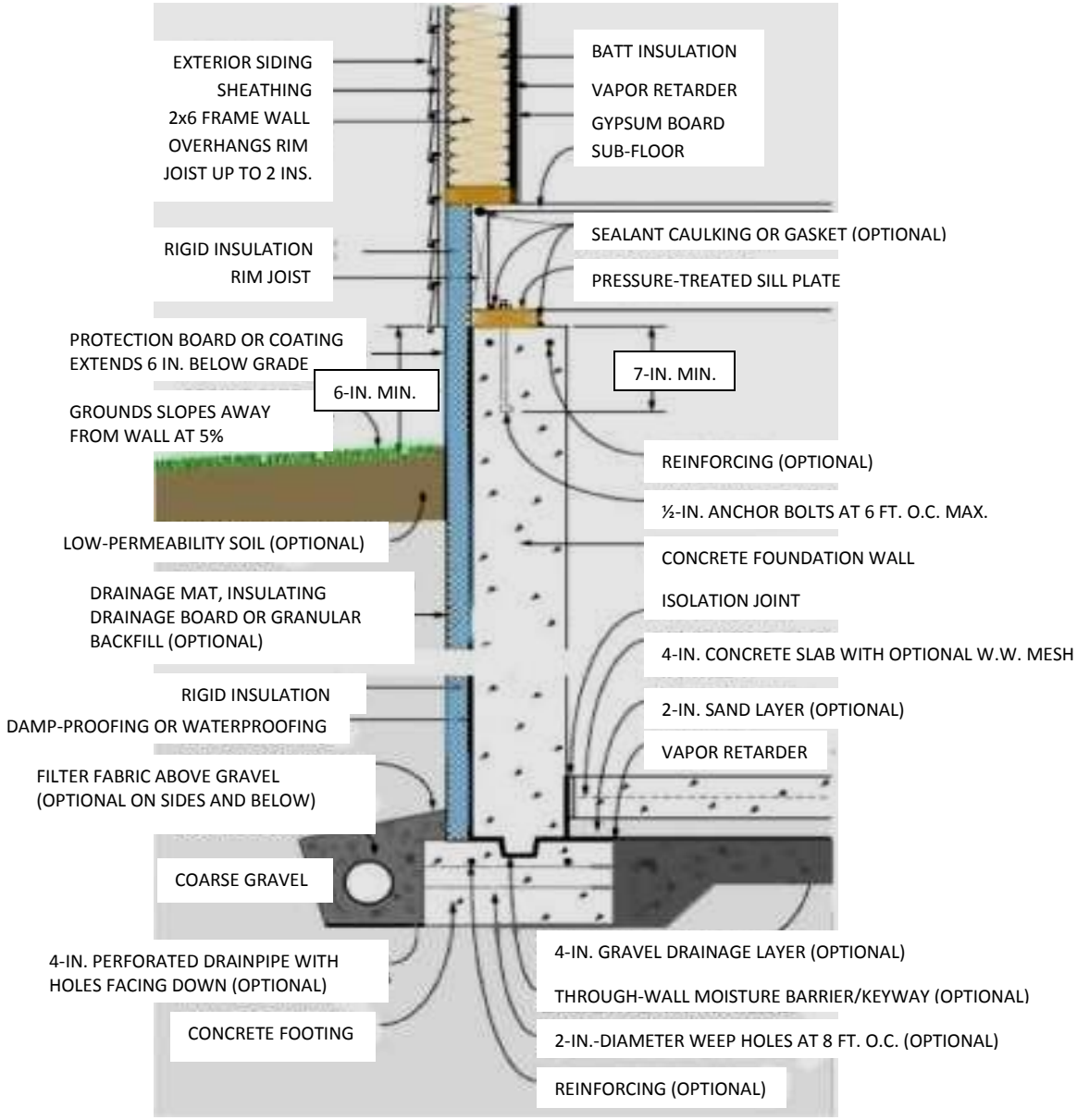
The basement's finished walls need to be insulated to minimize cold surfaces. Cold surfaces, such as on the foundation wall, can create water condensation and raise the humidity level in the basement. The concrete foundation walls are below grade and are, therefore, relatively cool to the touch, especially if the finished walls are insulated. If the basement air, which tends to be warm and humid (particularly in the summertime), passes through the finished walls and comes in contact with the cool foundation walls, condensation may form and cause moisture problems, including damage and mold growth. The rim/band joist area, which is the area directly above the foundation walls, is of particular concern because that area tends to stay relatively cool all the time.

A finished basement should be insulated around the perimeter of the basement's exterior walls. And the basement ceiling should not be insulated. There should not be any insulation in between the finished basement space (the conditioned space) and the floor above. The finished basement walls should not be insulated with a type of insulation that is sensitive to water. It should be an insulation that is relatively water-resistant.

This technique, as well as traditional basement finish practices, is not intended to compensate for inadequate waterproofing, foundation drainage, indoor relative-humidity control, or air-leakage control. If there are problems with water intrusion, drainage, humidity or air leakage, then the method of insulating the basement foundation wall will not matter.

Exterior Foundation Insulation

Home inspectors work in both new and existing construction, but this section primarily addresses interior insulation systems in basements in existing homes. Exterior insulation that uses foam insulation panels on the outside of the foundation wall is commonly installed for new construction and is difficult to evaluate on existing homes. This exterior insulation (foam panels on the outside of the foundation) provides a moisture-tolerant insulation layer on the outside of the foundation wall. This insulation layer moderates the temperature of the inside wall surface and can also be integrated with exterior water- or damp-proofing. If this type of insulation is installed, it requires shifting the house structure outward such that the sill plate overlaps the upper edge of the foundation insulation, protecting exterior insulation during construction, and providing long-term protection for the exposed insulation. If there is foam insulation installed on the outside of the exterior foundation, look for building practices that overlap and protect the insulation.



The illustration on the previous page shows a concrete foundation wall with exterior insulation.

The above-grade wood frame wall is constructed of 2x6s that overhang the foundation wall. The overhang can be up to 2 inches. Additional rigid insulation can be added that extends over the entire wall assembly.

BASEMENT WALLS DRY TO THE INTERIOR

Some common practices for insulating a basement on the interior-side of the foundation wall are illustrated. The concept is relatively new to residential construction as a best practice. Therefore, this strategy is included here primarily for your consideration.

Traditional practices, such as the use of a warm-in-winter vapor diffusion retarder on the inside of the finish wall system, have resulted in moisture problems. A basement foundation wall assembly that dries toward the interior is the best and most desirable.

The insulation to use when finishing a basement is a rigid foam insulation board. That type of insulation will allow the foundation wall assembly to dry inward, away from the foundation wall and toward the interior of the finished basement space. The foam insulation should be vapor-permeable (greater than 1 perm). The greater the perm, the easier it is for the wall to dry inward.

Because the foam insulation needs to be continuous and sealed at the seams, the insulation should be installed behind the wood-framed wall. Additional insulation can be installed in the spaces between the studs.

NO INTERIOR VAPOR BARRIER

Low permeability and continuous vapor diffusion retarders (such as polyethylene sheeting and vinyl wallpaper) on the interior-side of basement finishes should be avoided because they will trap moisture vapor moving through the foundation wall. They also slow the drying process for newly formed foundations.

The most important point to remember is that there should not be an interior vapor barrier installed. This would not permit inward drying.

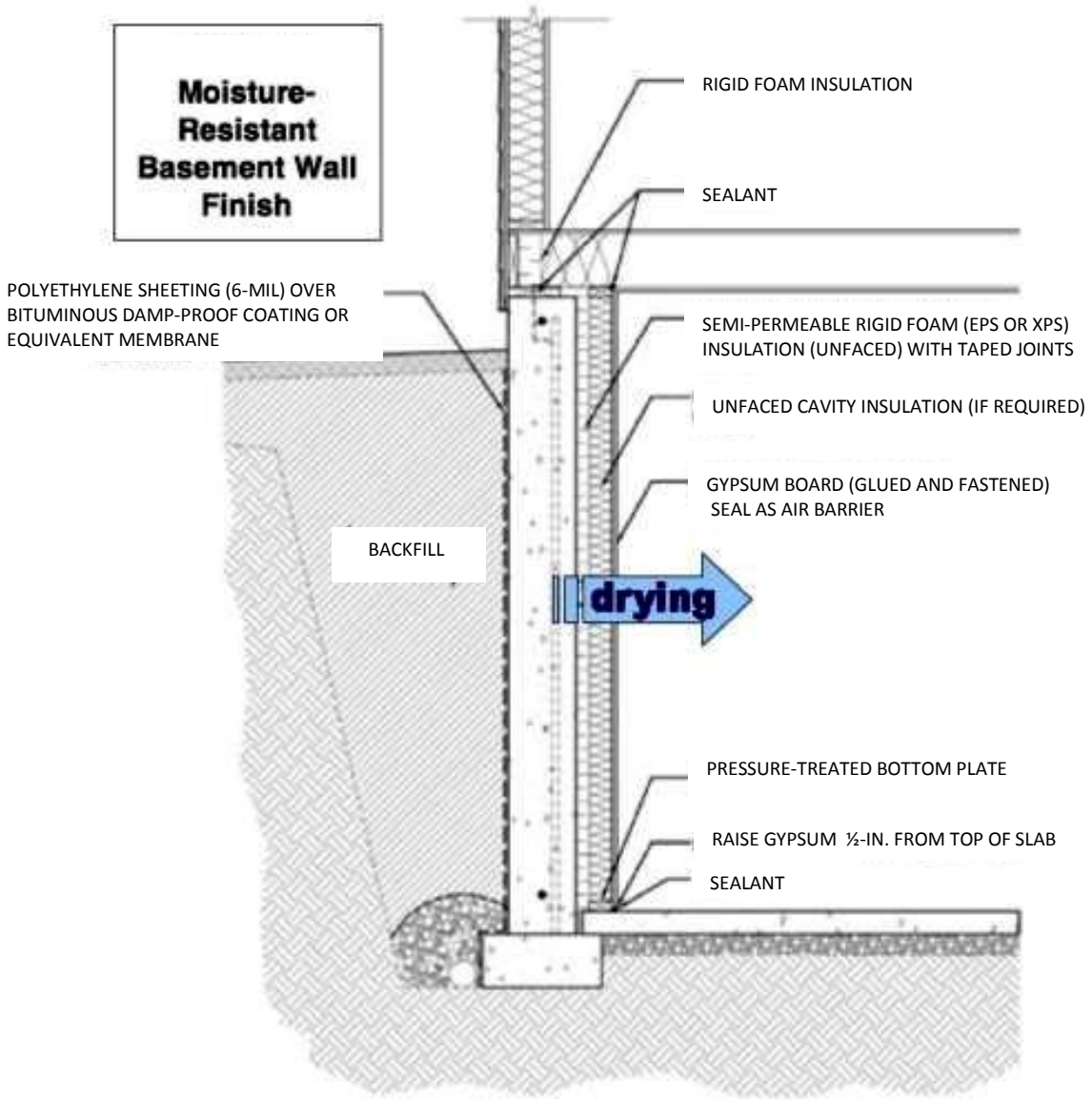
Unfaced fiberglass batt insulation and permeable paint finishes on gypsum wallboard can be installed on basement finished wall assemblies.

There are proprietary basement finish systems that use products such as rigid fiberglass insulating boards that have performed well in testing and use.

FINDING FOAM INSULATION

Finding Semi-Permeable Rigid Foam Insulation Between the Foundation Wall and Finish Wall Assembly

The use of rigid foam creates a buffer of moisture-resistant material between the finish wall materials and the basement foundation wall. Because below-grade portions of the foundation wall must be able to dry to the interior, semi-permeable, rigid foam-insulating sheathing products (such as EPS or XPS) should be used. Since their permeability levels vary by manufacturer, the product specifications of the perm rating for the required thickness should be greater than 1 perm. Joints in the foam sheathings should be taped and sealed. If additional insulation is required or desired, a frame wall may be built and cavity insulation installed, as shown in the illustration below.



FOAM IS A FIRE HAZARD

During the inspection of the foundation of a house, semi-permeable rigid foam insulation is often found on the inside of basement foundation walls. Its use is a good strategy for a moisture-resistant finished basement. However, fire and smoke characteristics of this type of insulation require that it be covered with a fire-resistant layer, such as gypsum wallboard (drywall). This works fine when the basement is being finished.

If the basement will only be insulated but not finished, a fire-rated foam panel or similar fire-rated covering needs to be used. Because the above-grade portions of the basement wall can dry to the outside, fire-rated insulation on these surfaces may be of an impermeable type. For example, it can have a foil facing. But insulating approaches that restrict the drying potential of below-grade portions of the foundation wall toward the inside should be avoided.

LOOK FOR HOLES

Humid air at the basement's interior should be prevented from leaking into the finished basement wall assembly and, subsequently, condensing. The interior-side of the wall assembly should not have large holes in it. The wall should be sealed to prevent air leakage. The ideal approach uses the gypsum wallboard as an air barrier and requires sealing any penetrations through and leaks around the panels. Air sealing of ceiling penetrations in the basement should also be addressed. Also, joints in the foam insulation should be taped and sealed. Look for holes that allow air leakage into the wall.

MOISTURE AT THE BOTTOM

Gypsum wallboard, wood trim and wood framing will wick moisture from the basement concrete slab. The concrete slab will tend to cool materials that are in contact with it, creating higher surface-humidity levels that may support mold growth. Therefore, finishes and baseboard trim should be held up about 1/2-inch from the slab surface. This gap could be sealed with caulk or sealant to prevent air leakage from indoors into the wall assembly. In addition, a thin foam plastic sill sealer may be used underneath the finished wall's bottom plate for added moisture protection. During the inspection of a basement, check the bottom of the finished wall for moisture.

QUIZ 8

1. The basement concrete slab will tend to _____ materials that are in contact with it, creating higher surface-humidity levels that may support mold growth.

- cool
- burn
- warm
- dry out

2. T/F: Humid air in the basement's interior should be prevented from leaking into the finished basement wall assembly and, subsequently, condensing.

- True
- False

3. T/F: Fire and smoke characteristics of rigid-foam insulation board require that it be covered with a fire-resistant layer, such as gypsum wallboard.

- True
- False

4. T/F: Low permeability and continuous vapor diffusion retarders (such as polyethylene sheeting and vinyl wallpaper) on the interior-side of basement finishes should be avoided because they tend to trap moisture vapor moving through the foundation wall.

- True
- False

Answer Key to Quiz 8

1. The basement concrete slab will tend to cool materials that are in contact with it, creating higher surface-humidity levels that may support mold growth.

2. T/F: Humid air in the basement's interior should be prevented from leaking into the finished basement wall assembly and, subsequently, condensing.
   Answer: True

3. T/F: Fire and smoke characteristics of rigid-foam insulation board require that it be covered with a fire-resistant layer, such as gypsum wallboard.
   Answer: True

4. T/F: Low permeability and continuous vapor diffusion retarders (such as polyethylene sheeting and vinyl wallpaper) on the interior-side of basement finishes should be avoided because they tend to trap moisture vapor moving through the foundation wall.
   Answer: True

SECTION 15: SLAB-ON-GRADE FOUNDATION AND INSULATION

It's important to know something about insulation, moisture and slab-on-grade (thickened edge and monolithic slab) foundation construction. Given their similarity, concrete and masonry stem-wall foundations with an independent above-grade slab floor are covered in this section.

Moisture-resistant installations are illustrated. They are relatively simple in comparison to the requirements for basement construction; however, many of the same principles apply.

Appropriate moisture-resistant site design and foundation installation should be checked during an inspection. In mixed and cold climates, careful attention should be given to the slab edge and foundation perimeter insulation to avoid thermal bridges, which can cause cold slab surfaces and condensation.

A typical home inspection will not necessarily go into great detail about site design and the builder’s methods and practices in relation to moisture-resistant foundations. However, a good understanding of the best practices for moisture-resistant construction will greatly improve the inspector’s ability to discover and evaluate moisture problems.

SLAB ON A MOUND

The elevation of a slab-on-grade foundation (thickened-edge slab and independent slab and stem-wall foundation) should be a minimum of 8 inches above the exterior finish grade. In areas with heavy rainfall, a clearance of greater than 8 inches or some other rain-control measures may be installed, such as back-vented cladding, and an ice and water shield 18 inches up the wall.

During new construction, the foundation elevation needed to achieve this 8-inch clearance must be coordinated with site plans and the exterior grading around the house perimeter. In particular, the topsoil must be removed and the foundation pad must be built up with suitable (compactible) structural fill material as needed to achieve that 8-inch clearance. Fills of more than 12 inches thick are generally required to be engineered. As a simple test, the slab-foundation pad should be able to support a loaded dump truck with minimal depression from the wheel load (1/2-inch or less).

With a properly mounded slab and functional site grading, surface water should drain away and minimize the moisture load around and beneath the slab.

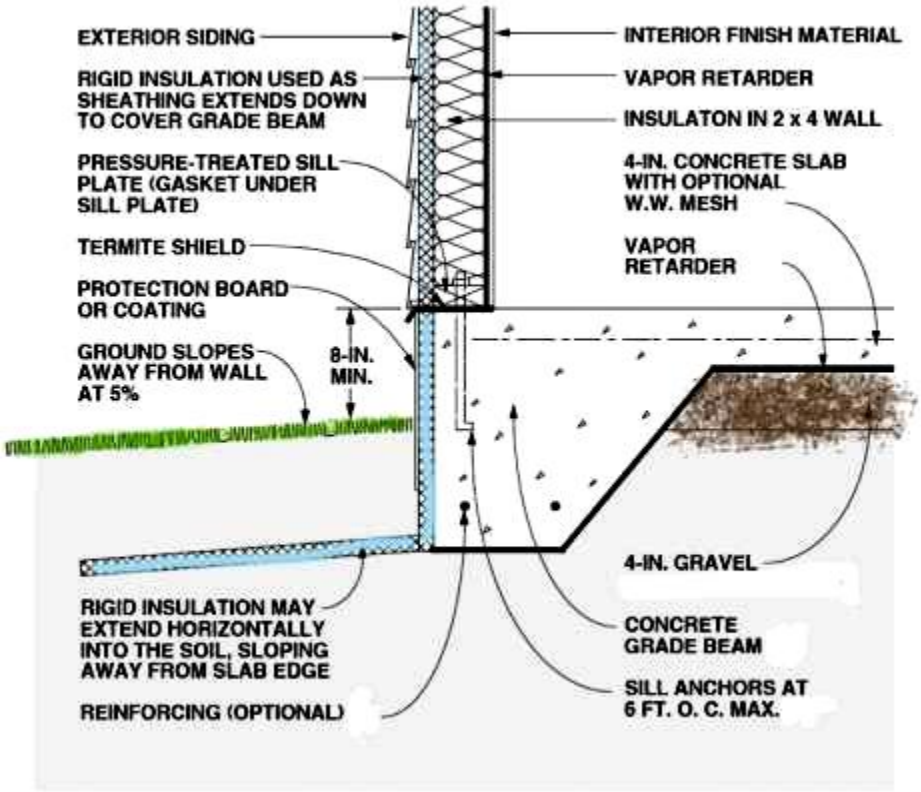
VAPOR RETARDER AND CAPILLARY BREAK

A vapor diffusion retarder of 6-mil poly (or equal) or other approved vapor diffusion retarder is generally required by standards below any slab intended as a floor for habitable space. The joints should be lapped not less than 6 inches. It should be placed in direct contact with the underside of the concrete slab. The vapor diffusion retarder will prevent moisture vapor from adding to the building's interior moisture load and also serve as a break to the capillary movement of moisture.

A capillary break layer -- generally, 4 inches of clean, graded sand, gravel, crushed stone or crushed blast-furnace slag -- further prevents bulk-soil moisture from wicking up to the bottom of the slab.

Sometimes, a sand layer is installed on top of the vapor diffusion retarder, which is an incorrect installation and will create problems.

Building codes typically require a capillary layer directly below the slab, and this should be provided under the vapor diffusion retarder so that water cannot be trapped in a gravel layer between the vapor diffusion retarder and the slab. The vapor diffusion retarder will help to cure the concrete properly if it is properly damp-cured on the top surface (by preventing exposure to excessive drying conditions), and excessive water in the cement mix is avoided.



CRACKS IN THE CONCRETE FLOOR

Concrete will crack as a normal outcome of the curing process. Cracking can be worsened if uneven bearing conditions exist under the slab, such as un-compacted fill areas.

Excessive water used for the workability of cement tends to produce excessive cracking, which can allow moisture to more readily penetrate the concrete slab, weakening the concrete, and leading to differential drying issues and cracking. Excessive cracking can allow additional moisture, as well as radon gas, to penetrate more easily through the slab.

The use of welded-wire fabric reinforcement provides a means of controlling the severity of cracking. The use of fiber-reinforced concrete may also provide adequate crack control.

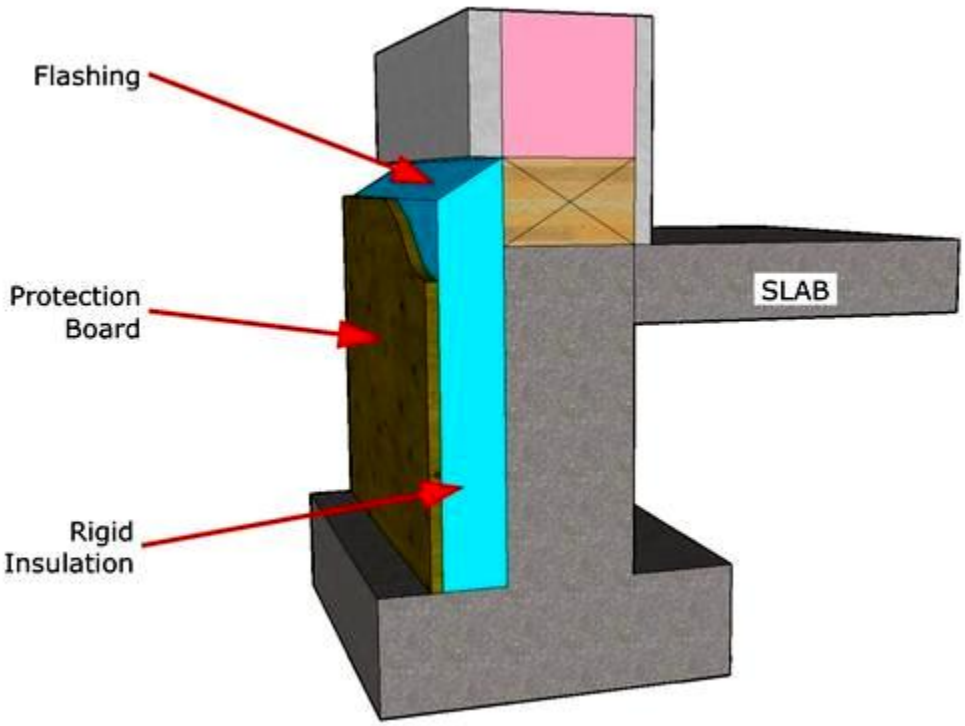
Concrete control joints may also be used to control random cracking by creating planned lines of weakness in the slab. Shrinkage or curing cracks generally occur in any continuous length of concrete longer than about 12 feet.

REBAR REDUCES CRACKING

As with basement foundations and footings, the local building code does not always require horizontal reinforcement of the thickened-edge footing of a monolithic slab on grade. The same applies to stem-wall and independent-slab construction.

Some building practices may incorporate a minimum of a continuous #5 rebar located horizontally at the top and bottom of the thickened edge of a monolithic slab or stem wall. This allows the thickened slab edge (footing) to act as a moderately reinforced grade beam to reduce cracking from differential settlement. Concrete and masonry stem walls may be reinforced with horizontal reinforcement bars in a manner similar to that recommended for basement walls. For difficult site soil conditions (e.g., expansive or weak soils), other types of concrete-slab foundations may be more appropriate, such as mat foundations and post-tensioned slabs.

INSULATION AT THE SLAB



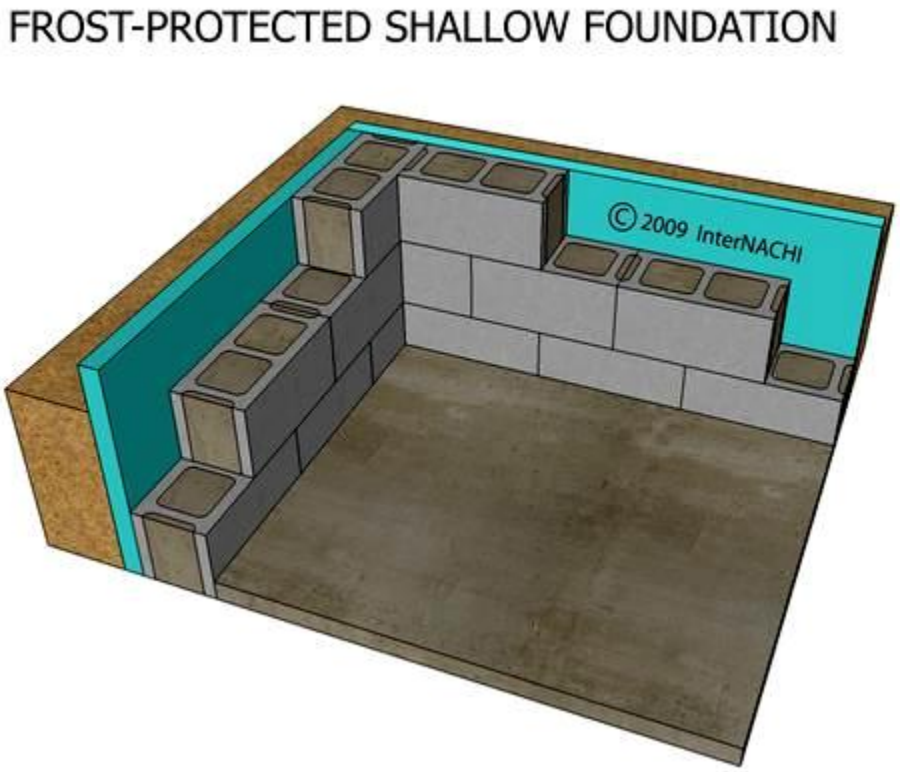
Building codes allow foundation insulation to be placed in various locations at the perimeter of a slab-on-grade foundation.

The best location for insulation in slab-on-grade foundations is on the vertical outside face of the foundation.

In this location, thermal bridges are minimized, energy efficiency is maximized, and slab surface temperatures are moderated to prevent the risk of condensation during cold weather. If slab-on-grade insulation is placed in a different location (e.g., on the inside face of the perimeter foundation wall), then there should be a continuous thermal break between the indoor portions of the slab and the exterior.

When used, exterior foundation insulation must be protected from the elements at additional expense. One way a builder could reduce costs while installing exterior-slab perimeter insulation is to use a frost-protected shallow foundation (FPSF). These foundations are found in northern regions. They are most cost-effective in climates where required frost depths are substantially greater than 12 inches and foundation insulation requirements are more stringent.

FPSF AND INSULATION



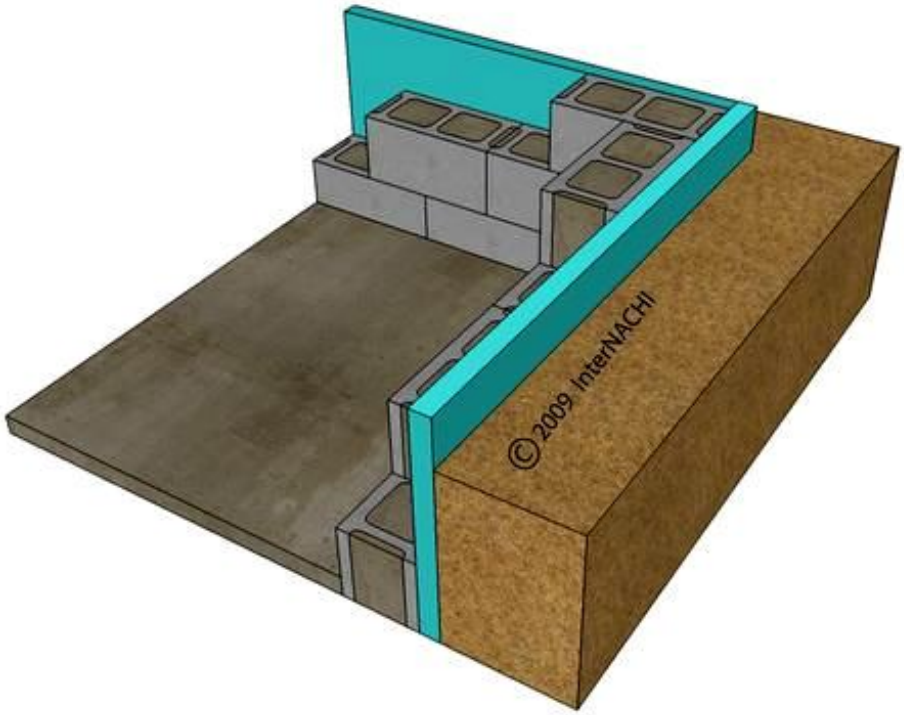
Frost-protected shallow foundation (FPSF) systems offer a design option that allows for shallower footing depths by raising the frost depth around the building through the use of insulation.

FPSF systems offer many advantages for slab-on-grade construction in cold climates, including:

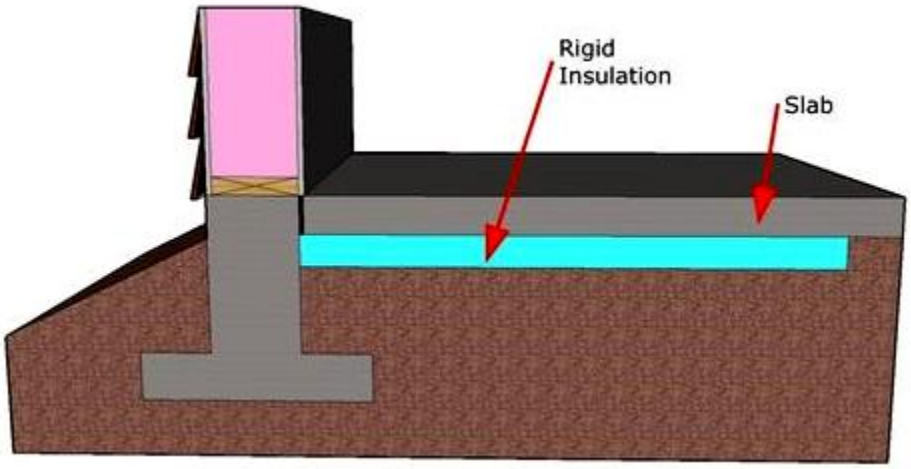
- reduced construction costs;
- increased energy efficiency;
- improved slab comfort; and
- increased slab temperatures to prevent condensation.

Ideally, heated slab systems may be used with insulation amounts increased above that minimally required for FPSFs.

FROST-PROTECTED SHALLOW FOUNDATION



SLAB FINISHES AND INSULATION



Like basement wall finishes, finishes on concrete floors of slabs on grade are exposed to a unique environment due to direct ground contact. This section teaches the inspector what to look for when inspecting a moisture-resistant floor finish on a concrete slab on grade.

Slab with Moisture-Resistant Finishes

From a moisture perspective, tile, terrazzo, stained decorative concrete, and other moisture-resistant finishes are ideal for slab-on-grade construction. These materials are resistant to flooding and other sources of moisture damage, and are typical in southern (hot-humid) climates. In such cases, the primary concerns are limiting indoor humidity, providing a sub-slab vapor diffusion retarder directly below the concrete slab (such as 6-mil polyethylene), and providing a capillary break (such as a 3- to 4-inch-thick clean gravel layer).

Slab with Moisture-Sensitive Finishes

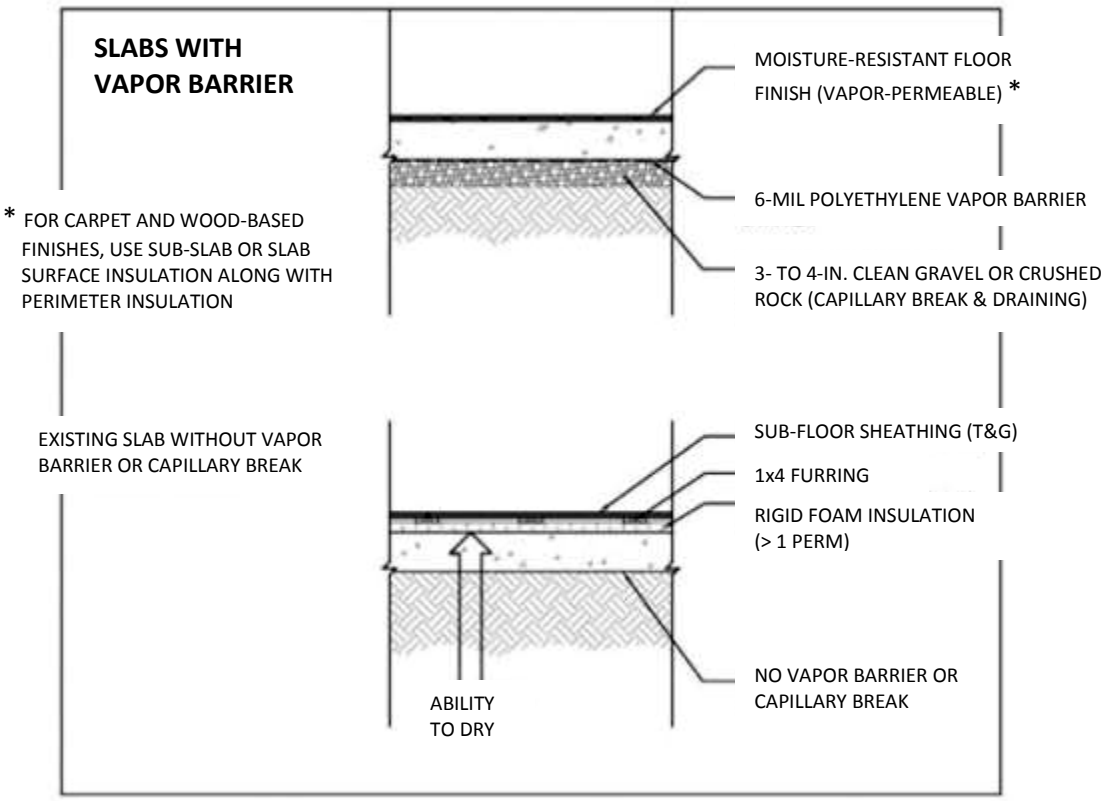
Carpet and wood-based floor finishes should not be applied directly to slabs on grade unless the slab or finish surface temperature is raised near room temperature. Moderated floor temperatures that can accommodate moisture-sensitive finishes can be achieved with sub-slab or slab-surface insulation, as well as perimeter insulation, to prevent thermal short circuits in the slab. Where slab temperatures are chilled by cold exterior winter conditions, or cooled by ground temperatures during the spring and summer, surface condensation or high humidity may result in mold growth or condensation damage.

Missing Slab Insulation

Slabs that do not have a moisture vapor diffusion retarder underneath are often not suitable for finished flooring in living spaces. This can be the case in both slab-on-grade foundations and for basement slabs. Newer-model building codes require a moisture vapor diffusion retarder (such as 6-mil poly) underneath slab-on-grade floors serving living spaces. Very old (80+ years) and historic homes typically have basement concrete floors with no moisture vapor diffusion retarder installed. In the event that this requirement is not met in an existing slab on grade or basement slab, water vapor may be controlled from the top of the slab surface.

Signs of Moisture Problems

If a slab shows signs of a pre-existing moisture problem, such as dampness or condensation, salt deposition, or standing water, that issue should be addressed before moving ahead with finish flooring. Once any pre-existing moisture issues with the slab are addressed, a floor finish assembly that can accommodate a small amount of upward moisture flow can be installed. One viable approach involves the use of a rigid, semi-permeable (>1 perm) insulating sheathing, such as extruded polystyrene, on top of the slab, with 12- to 16-inch on-center furring above the foam, followed by a layer of T&G plywood for the subfloor. The finish flooring above the plywood should be of a breathable finish, and impermeable materials, such as vinyl flooring, should be avoided. With this type of assembly installed, a relatively dry slab without a sub-slab layer of poly can be finished and designed to accommodate a limited amount of moisture, which dries upward.



SECTION 16: CRAWLSPACES, INSULATION AND MOISTURE

INSPECTION TIPS

The primary causes of moisture problems in crawlspaces include poor site drainage, lack of a ground vapor diffusion retarder, improperly installed insulation, and crawlspace ventilation during humid summer conditions. Crawlspace moisture damage and mold formation can be caused by any one of these issues. Therefore, these issues should be checked during an inspection.

Crawlspace construction should ideally result in an interior crawlspace floor-ground surface that is at or above the exterior finish grade. This is not often the case. Extra attention should be paid to foundation drainage for crawlspaces below the exterior finish grade. Also, venting crawlspaces in humid conditions can result in condensation of warm, moist air on cool surfaces in the crawlspace, including ductwork, and the underside of floor framing. In very humid conditions, this can lead to water accumulation, wet insulation, material degradation, and mold.

FLOORS AND WALLS

Crawlspace Floor May Be a Mud Slab

Groundcover material, such as a thick layer of plastic, laid on a crawlspace floor can become damaged or disturbed over time, resulting in loss of effectiveness. In addition, it's difficult to drain a crawlspace's groundcover that may become occasionally wet on top, such as from a plumbing leak. To correct that condition, a mud slab (such as a 2-inch-thick concrete slab) may be placed on top of the groundcover and slightly sloped to drain to a sump pit. The concrete floor that you see inside a crawlspace may be a mud slab.

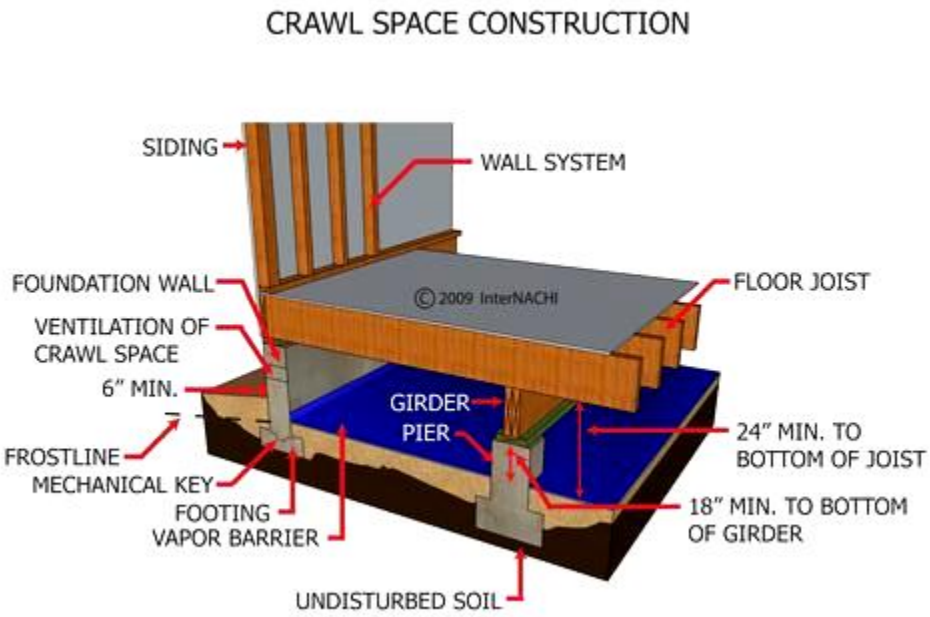
Crawlspace Floor Covered with Plastic

All exposed ground areas in crawlspaces should be covered with a minimum 6-mil layer of polyethylene sheeting. The edges of this sheeting should be overlapped at least 6 inches. The polyethylene should then be sealed with tape or adhesive at all overlaps, and to walls and to all penetrations in the sheeting. This is a simple measure that helps control ground moisture effectively. If the groundcover initially installed is damaged during the construction process, an additional layer should be added, or damaged sections should be patched and sealed.

Crawlspace Wall Is Damp-Proofed

If the crawlspace's elevation is below the exterior finish grade, foundation drainage and foundation wall damp-proofing using a bituminous coating on the below-grade exterior face of the crawlspace foundation wall should be installed in a fashion similar to that required for basements.

VENTED AND NON-VENTED



There are essentially two choices for ventilation of crawlspaces. The first follows conventional ventilation practices, and the second follows a non-vented crawlspace design strategy.

Vented

The under-floor space between the bottom of the floor joists and the earth under any building, except for a basement, should have ventilation openings that allow air to pass through the exterior foundation walls. The ventilation openings should be at least 1 square

foot (0.0929 m^2) for each 150 square feet (14 m^2) of under-floor space area, unless the earth/ground surface is covered by a vapor retarder. One such ventilation opening must be installed in each corner of the space.

Class I Vapor Retarder

When a vapor retarder is installed and covers the earth/ground surface of the crawlspace, the minimum net area of the openings should be at least 1 square foot for each 1,500 square feet of under-floor space area. The ventilation openings can be reduced from 1:150 to 1:1,500 where the earth/ground surface is covered by a Class I vapor retarder and the ventilation openings are installed.

As a best practice, exposed earth (dirt) on the crawlspace floor should always be covered by a vapor retarder. Joints of the vapor retarder should overlap 6 inches and should be sealed or taped. The edges should extend at least 6 inches up the wall and should be secured and sealed to the wall.

Vapor Retarder Class

A vapor retarder class is a measure of a material's ability to limit the amount of moisture that passes through it. It is established by the manufacturer's testing of the material. The vapor retarder in the crawlspace should be a Class I material with a permeance rating of 0.1 perm or less.

- Class I: 0.1 perm or less (sheet polyethylene, non-perforated aluminum foil)
- Class II: 0.1 < perm ≤ 1.0 perm (kraft-faced fiberglass batts)
- Class III: 1.0 < perm ≤ 10.0 perm (latex or enamel paint)

Openings

For under-floor spaces, one ventilation opening must be installed within 3 feet of each corner of the building. The installation of a covering material over the open vents keeps rodents and other intruders from entering the crawlspace. A variety of materials can be installed. Openings can be covered with the following materials, provided that the smallest dimension is not greater than 1/4-inch (6.4 mm):

- perforated sheet metal plates;
- expanded sheet metal plates;
- cast-iron grates;
- load-bearing brick vents;
- hardware wire cloth; or
- corrosion-resistant wire mesh.

Check Local Standards

The inspector should refer to the locally applicable building code or standard before making evaluations regarding defective installations.

Non-Vented

As a second option, there is mounting evidence (as well as recent recognition of model building codes) that non-vented crawlspaces are an acceptable method of crawlspace foundation construction. The method is particularly suitable for hot-humid climates where ventilating with outdoor air actually adds moisture to the crawlspace during much of the year, so this method should be considered an option in other climates. However, there's more to it than simply taking out the vents.

When inspecting an unvented crawlspace, the inspector should check the following factors:

- functional exterior grading and site drainage;
- air leakage between the exterior and the crawlspace area, mainly at the top of the foundation wall and the floor's perimeter;
- insulation on the crawlspace's perimeter walls, and not the floor above, such as the use of 2-inch rigid-foam insulation on the interior side of the crawlspace's perimeter wall;
- the use of 6-mil polyethylene groundcover in the crawlspace, with joints lapped and sealed (this is the standard recommendation);
- damp-proofing of the foundation walls and the installation of an exterior drainage system if the crawlspace's ground elevation is lower than the exterior finish grade; and
- some ventilation of the crawlspace with conditioned air.

Recent model building codes also recommend that the non-vented crawlspace be treated as a conditioned basement space -- that is, it's supplied with conditioned air, along with a return-air transfer grille placed in the floor above the crawlspace. Alternatively, the crawlspace could be mechanically ventilated or designed as an under-floor space plenum for the distribution of conditioned air. While non-vented crawlspace designs without these features have performed well, inspectors should check with local code requirements when inspecting a non-vented crawlspace.

Understanding Vented and Non-Vented Crawlspaces

The principal perceived advantage of a vented crawlspace over a non-vented one is that venting can minimize radon and moisture-related decay hazards by diluting the crawlspace air.

Venting can complement other moisture- and radon-control measures, such as groundcover and proper drainage. However, although increased air flow in the crawlspace may offer

some dilution potential for ground-source moisture and radon, it will not necessarily solve an established problem.

The principal disadvantages of a vented crawlspace over a non-vented one are:

- pipes and ducts must be insulated against heat loss and freezing;
- a larger area usually must be insulated, which may increase the cost; and
- in some climates, warm, humid air circulated into the cool crawlspace can actually cause excessive moisture levels in wood.

Vented crawlspaces are often provided with operable vents that can be closed to reduce winter heat loss but may potentially increase radon infiltration. Although not their original purpose, the vents can also be closed in summer to keep out damp exterior air having a dew point above the crawlspace's temperature.

It is not necessary to vent a crawlspace for moisture control if it is open to an adjacent basement, and venting is clearly incompatible with crawlspaces used as heat-distribution plenums.

In fact, there are several advantages to designing crawlspaces as semi-heated zones. Duct and pipe insulation can be reduced, and the foundation is insulated at the crawlspace's perimeter instead of at its ceiling. This usually requires less insulation, simplifies installation difficulties (in some cases), and can be detailed to minimize condensation hazards.

Although unvented crawlspaces have been recommended "except under severe moisture conditions" by the University of Illinois Small Homes Council, moisture problems in crawlspaces are common enough that many agencies are unwilling to endorse closing the vents year-round.

Soil type and the groundwater level are key factors influencing moisture conditions. It should be recognized that a crawlspace can be designed as a short basement with a slurry-slab floor, and having a higher floor level is subject to less moisture hazard, in most cases. Viewed in this way, the main distinction between unvented crawlspaces and basements is in the owner’s accessibility and likelihood of noticing moisture problems.

QUIZ 9

1. T/F: Carpet and wood-based floor finishes should not be applied directly to slabs on grade unless the slab or finish surface temperature is raised near room temperature.

- True
- False

2. T/F: Slabs that do not have a moisture vapor diffusion retarder underneath are often suitable for finished flooring in living spaces.

- True
- False

3. All exposed _____ areas in crawlspaces should be covered with a minimum 6-mil layer of polyethylene sheeting.

- water intrusion
- pipe
- ground
- venting

4. T/F: Traditional crawlspace ventilation requires a net open-vent area of at least 1:150 of the crawlspace area to be provided when a vapor diffusion retarder is present, which should always be the case.

- True
- False

5. T/F: There is mounting evidence (as well as recent model building-code recognition) that non-vented crawlspaces are an acceptable method of crawlspace foundation construction.

- True
- False

Answer Key is on the next page.

Answer Key to Quiz 9

1. T/F: Carpet and wood-based floor finishes should not be applied directly to slabs on grade unless the slab or finish surface temperature is raised near room temperature.
   Answer: True

2. T/F: Slabs that do not have a moisture vapor diffusion retarder underneath are often suitable for finished flooring in living spaces.
   Answer: False

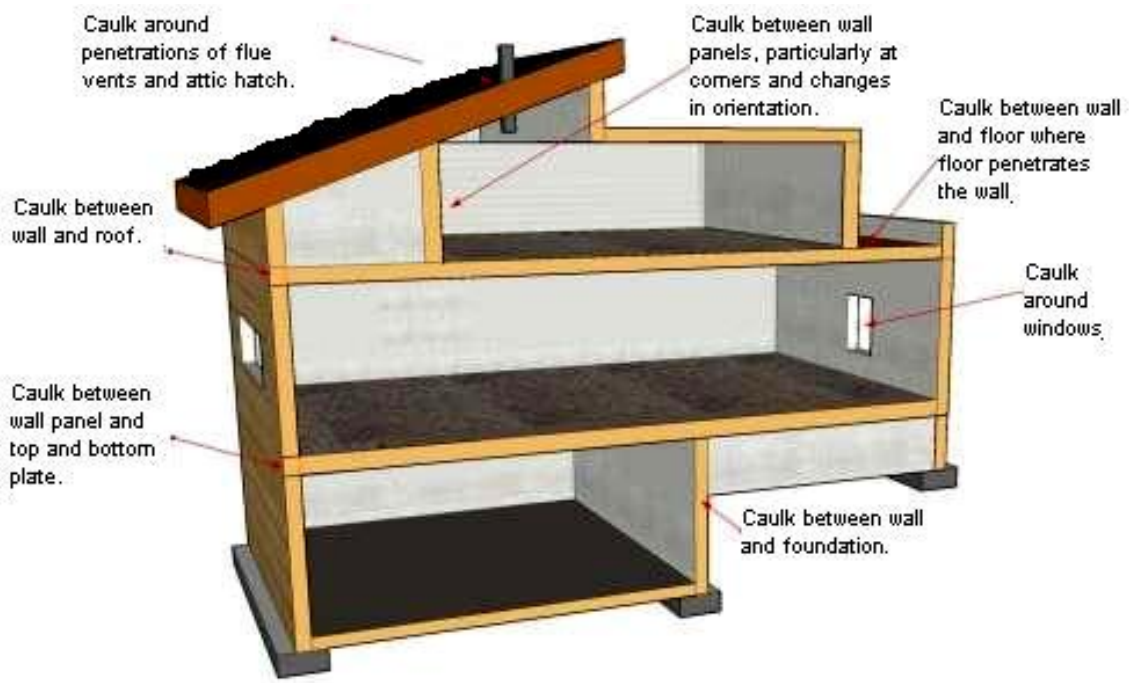
3. All exposed ground areas in crawlspaces should be covered with a minimum 6-mil layer of polyethylene sheeting.

4. T/F: Traditional crawlspace ventilation requires a net open-vent area of at least 1:150 of the crawlspace area to be provided when a vapor diffusion retarder is present, which should always be the case.
   Answer: True

5. T/F: There is mounting evidence (as well as recent model building-code recognition) that non-vented crawlspaces are an acceptable method of crawlspace foundation construction.
   Answer: True

SECTION 17: AIR LEAKAGE AND MAJOR MOISTURE PROBLEMS

WHAT TO LOOK FOR AND HOW TO ADDRESS PROBLEMS



Air leakage through building assemblies can move large quantities of water vapor and is a major factor in many vapor-related moisture problems. Building envelopes should be designed and constructed to reduce air leakage from inside to outside in cold climates, and from outside to inside in hot-humid climates. To achieve this objective, the big air leaks in the building's envelope must be sealed. Most insulation will not stop air leaks. In addition, a suitable air-barrier system should be carefully considered and installed during the construction of the home.

Any one or a combination of the following drives air leakage:

- wind;
- stack effect; and
- forced-air HVAC equipment, such as the central air handler.

Wind and stack effect-driven air leakage is best handled by the use of air barriers. HVAC equipment should be properly installed, and seams and connections in the distribution piping should be sealed airtight.

There are a few precautions worth mentioning when the building envelope is "tightened."

First, the use of air barriers and air-leakage sealing practices can reduce the supply of combustion air for fuel-fired equipment (oil or gas furnaces, gas water heaters, gas dryers, etc.) located within the conditioned space. This can result in negative pressure and back-drafting of combustion products. The operation of spot exhaust fans (kitchen and bath), whole-house exhaust ventilation, and even the stack effect can also cause depressurization of the indoor space near combustion equipment and lead to backdrafting and the introduction of combustion products into the home, such as carbon monoxide. Because of these health and safety concerns, sealed combustion equipment is often installed when the house is "tight."

Second, mechanical ventilation may be required or recommended to address other consequences of tightening the building envelope, such as IAQ (indoor air quality) and humidity control. For example, modern residential building codes still permit the use of operable windows as a means of providing fresh-air ventilation, though this has been contested in recent years. It may be risky to rely solely on the behavior of the occupant to provide adequate ventilation in this manner in the absence of higher levels of natural ventilation.

As a final precaution, air-barrier materials must also be considered in terms of their impact on vapor movement and water shedding. For instance, if an air barrier is used on the exterior of the wall as a weather barrier underneath cladding or housewrap, it must have adequate water-resistant qualities. And if an air barrier is used on the inside of a wall in a hot-humid climate, it needs to be a permeable material and not one that will prevent vapor from drying to the inside.

Air Sealing

Air sealing is important because air carries both moisture and energy, usually in the direction that the homeowner does not want. Air leaks can carry hot, humid outdoor air into the house in the summertime. Air leaks can carry warm, moist air from a bathroom into the cool attic in the winter.

Your client will probably already know that air can leak in and out of their house through small openings around doors and windows, and through a fireplace chimney. Air can leak into the house from unconditioned spaces, such as the attic, basement and crawlspace. What your client might not be fully aware of are the other pathways for air leakage, including:

- any openings and cracks where two walls meet;
- any openings and cracks where the wall meets the ceiling;
- any openings and cracks near interior door frames;
- gaps around electrical receptacle outlets, switches, and recessed light fixtures;
- gaps behind recessed cabinets;
- false ceilings and soffits in the kitchen;
- behind bathtubs and shower stall units;
- through floor cavities of finished attics adjacent to unconditioned attic spaces;
- utility chaseways for ducts, pipes and wires; and
- plumbing and electrical wire penetrations.

Air sealing is an essential first step. It is important to stop the air leakage prior to adding insulation in these particular areas because the insulation might make the pathways hidden and difficult to access.

Because these leakage pathways exist due to the tendency of warm air to rise and cool air to fall, the attic is often the best place to find air leaks and seal them up. Usually, adding more insulation at the attic floor area will not stop leaks because the air will flow through and around the insulation. Most insulation will not stop air leaks.

Look for Big Air Leaks

To ensure that an air barrier functions as intended, leaks in the building envelope and air-barrier system must be reasonably controlled. The methods are generally low-tech and commonsense-oriented.

Current building codes (such as the IRC 2006) require air sealing around the following areas:

- all joints, seams and penetrations, including utility penetrations;
- site-built windows, doors and skylights;
- openings between window and door assemblies, and their respective jambs and framing;
- knee walls;
- drop ceilings and chases adjacent to the thermal envelope;
- wall cavities and chases that extend into unconditioned space;
- walls and the ceiling separating an attached garage from conditioned space;
- openings behind tub and shower enclosures on exterior walls;
- common walls between dwelling units in multi-family housing; and
- other sources of air leakage.

Sealing materials include acceptable air-barrier materials and durable caulks, weatherstripping, sealants, tapes and gaskets, as appropriate. The material could be a suitable film or solid material.

The list above is exhaustive. All obvious air-leakage pathways should be sealed. Yet, practicality suggests that the major focus should be on the big leaks and big holes.

Big leakage points that should be air-sealed include:

- vertical mechanical chases;
- attic access hatches and pull-down ladders;
- floor overhangs;
- openings behind tub and shower enclosures;
- plumbing stack penetrations;
- utility penetrations in walls; and
- any exposed wall cavities that open into an adjacent attic space.

Major leakage points in a house are illustrated. Property inspectors should look here.

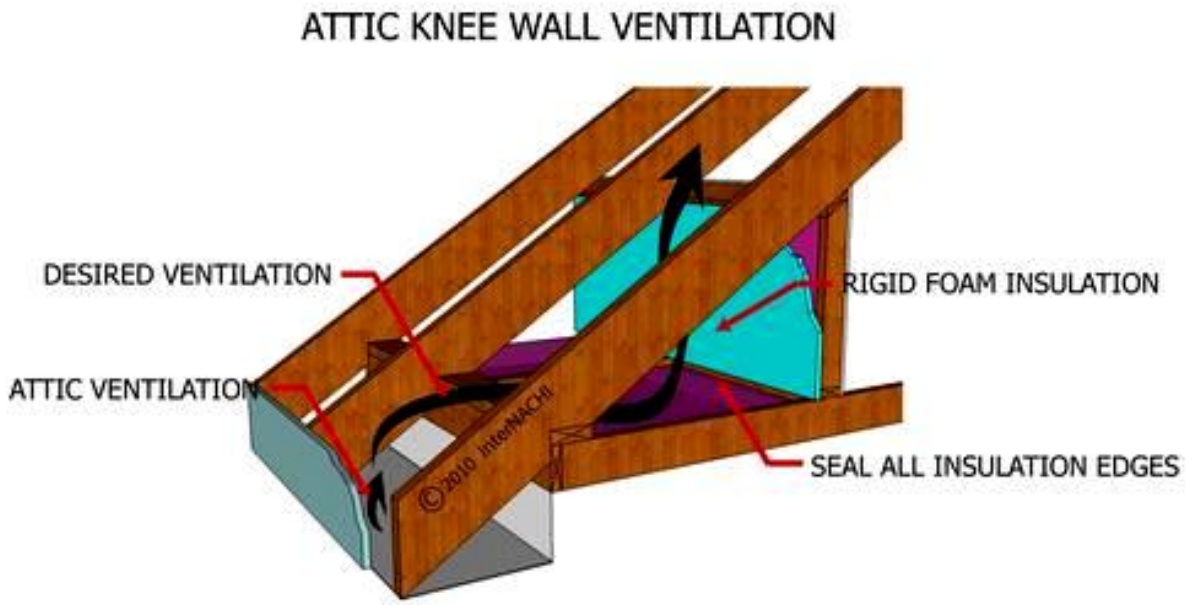
Air Sealing From the Attic

It is important to seal up the air leakage pathways between the living space and the attic space, especially before your client adds any insulation in the attic.

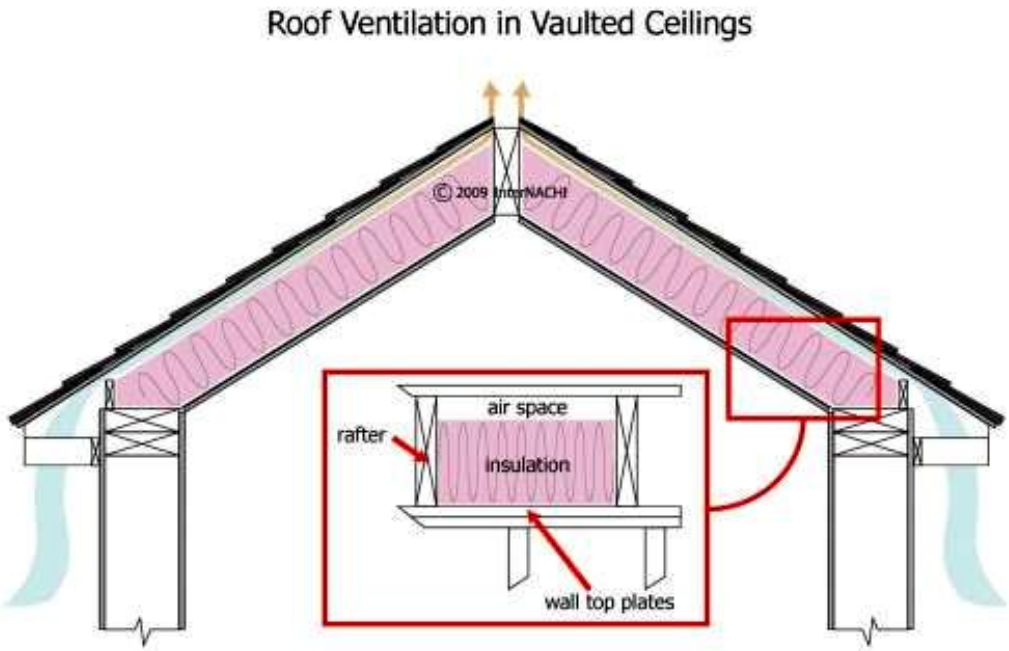
The materials for sealing air-leakage pathways should be products that are durable and compatible with the joined materials, especially around hot surfaces.

Examples include:

- high-quality caulks;
- construction adhesives;
- spray polyurethane foam;
- gaskets;
- sill sealers;
- tapes; and
- a number of specialty products, such as gasketed electrical receptacles, switch boxes, and ceiling light-fixture boxes.



SECTION 18: CATHEDRAL CEILINGS AND AIR LEAKS



Cathedral roofs can hide leaks and condensation, particularly if a vapor diffusion retarder, such as polyethylene sheeting, is used on the ceiling side -- something that should be considered only for very cold climates. If there are cathedral ceilings in the house, the ceiling and any penetrations through it should be carefully sealed to prevent air leakage. This may involve special air-sealed light fixtures, the use of caulks and sealants at all penetrations and joints, and avoiding leaky ceiling systems, such as exposed tongue-and-groove boards. Leakage of humid indoor air into cold cathedral roof cavities is a major cause of condensation and moisture problems in this type of roof.

For cathedral ceilings, there needs to be enough space between the roof deck and the ceiling for adequate insulation and ventilation. Adequate insulation thickness can be achieved when the builder uses raised trusses, truss joists, scissor-truss framing, and/or sufficiently large rafters. Remember that cathedral ceilings with 2x12 rafter boards have a maximum amount of space for standard 10-inch-thick R-30 batt insulation.

You may see foil-faced batt insulation used in a cathedral ceiling because it has a 0.5 perm rating and provides the permeability often required for use in ceilings without attic spaces. You should see a vent baffle installed between the insulation and the roof decking to ensure proper ventilation.

If the roof framing at the cathedral ceiling cannot provide enough room for proper insulation and ventilation, then you may see furring strips attached to the underside of the rafter boards. The furring will provide enough room for thicker insulation to be installed. Some builders will install high-density batts in tight areas or add rigid foam insulation under the rafters. Rigid foam insulation is a good choice because of its ability to resist thermal bridging through the rafters.

SECTION 19: WHY RECOMMEND AIR SEALING?

FINDING THE RIGHT BALANCE

Air flow can transfer moisture vapor through and into building assemblies in amounts 10 to 100 times more than what would typically occur by vapor diffusion. Significant air leaks -- from a bathroom into a cold attic, for example -- can deposit a large amount of moisture vapor on cool surfaces and create condensation and water accumulation that can damage building materials and make some insulation materials ineffective. Without reasonable air-leakage control, the use of vapor diffusion retarders is of limited benefit. Similarly, attempts to pressurize a building in a hot-humid climate to control against the intrusion of outdoor humidity and to depressurize a building in a cold climate are far more effective with a tighter building shell.

Some amount of natural air leakage under the right climate conditions can be a good thing. Old houses naturally breathe, and that can be beneficial. Under ideal conditions that may occur during some periods of the year, it can help to dry the house. Air leakage in the form of intended ventilation in attics and crawlspaces -- outside of the building's thermal envelope -- is a good way to reduce moisture and is very effective in many climates. Air leakage through the thermal envelope can also allow for uncontrolled natural ventilation of the building for indoor air quality.

However, the benefits of air infiltration through a building's thermal envelope are either unreliable or risky in many climates. Therefore, dependence on excessive or uncontrolled air leakage through thermal-envelope systems in modern buildings and new construction is generally discouraged. And, in fact, modern building standards and energy codes usually require fairly extensive practices to prevent the uncontrolled leakage of air through a building's thermal envelope.

BLOWER DOOR TESTING

A blower door test to evaluate the effectiveness of air-leakage sealing is highly effective. Blower door testing can be conducted on a finished house, or, alternatively, on a house that is insulated and sealed but with walls not yet closed in. Such testing at a pre-completion stage of construction will not provide a useful numerical result, but the use of a smoke-pencil device that indicates drafts can be very helpful for clearly observing where leakage in the envelope is occurring. Blower door tests on a finished house may also be used to determine whether supplemental ventilation may be necessary for improving indoor air quality.

Blower door testing goes beyond the scope of a typical home inspection. However, InterNACHI inspectors who are trained and have the proper equipment can perform this testing as part of a home energy audit, which they can offer as an ancillary service. Read more about blower door testing and take InterNACHI's free, online *How to Perform Energy Audits* course.

SECTION 20: AIR BARRIERS

AIR BARRIERS DEFINED

This section explains basic air barrier strategies and where to look for air barriers.

Reducing air leakage through the building envelope is a good practice regardless of where in the envelope it takes place. Air barrier systems are strategies to block air leaks at a certain point in the building assembly while also addressing other envelope concerns, such as rainwater protection and vapor diffusion retarders.

Examples of Air Barriers

Appropriate air barrier materials include some panel products, membranes, and other coatings that have low air-permeability.

Examples of air barriers include:

- gypsum wallboard;
- spray polyurethane foams;
- exterior wood structural panels (sheathing);
- extruded polystyrene foamboard;
- polyisocyanurate foamboard;
- building wraps; and
- other building products.

Seams and laps in these products must be sealed.

Examples of products that may be considered too air-permeable to serve as an air barrier include fiberboard, expanded polystyrene insulation (Type I), fiberglass insulation board, and tarred felt paper.

Rigid materials, such as drywall (gypsum wallboard), exterior wood sheathing, and rigid foamboards, are effective air barriers because they have the ability to resist air-pressure differences.

FOUR TYPES

There are basically four methods of providing an air-barrier system. Two of these approaches involve installing the air barrier on the inside of the thermal envelope, and the other two involve installing the barrier on the exterior, as shown.

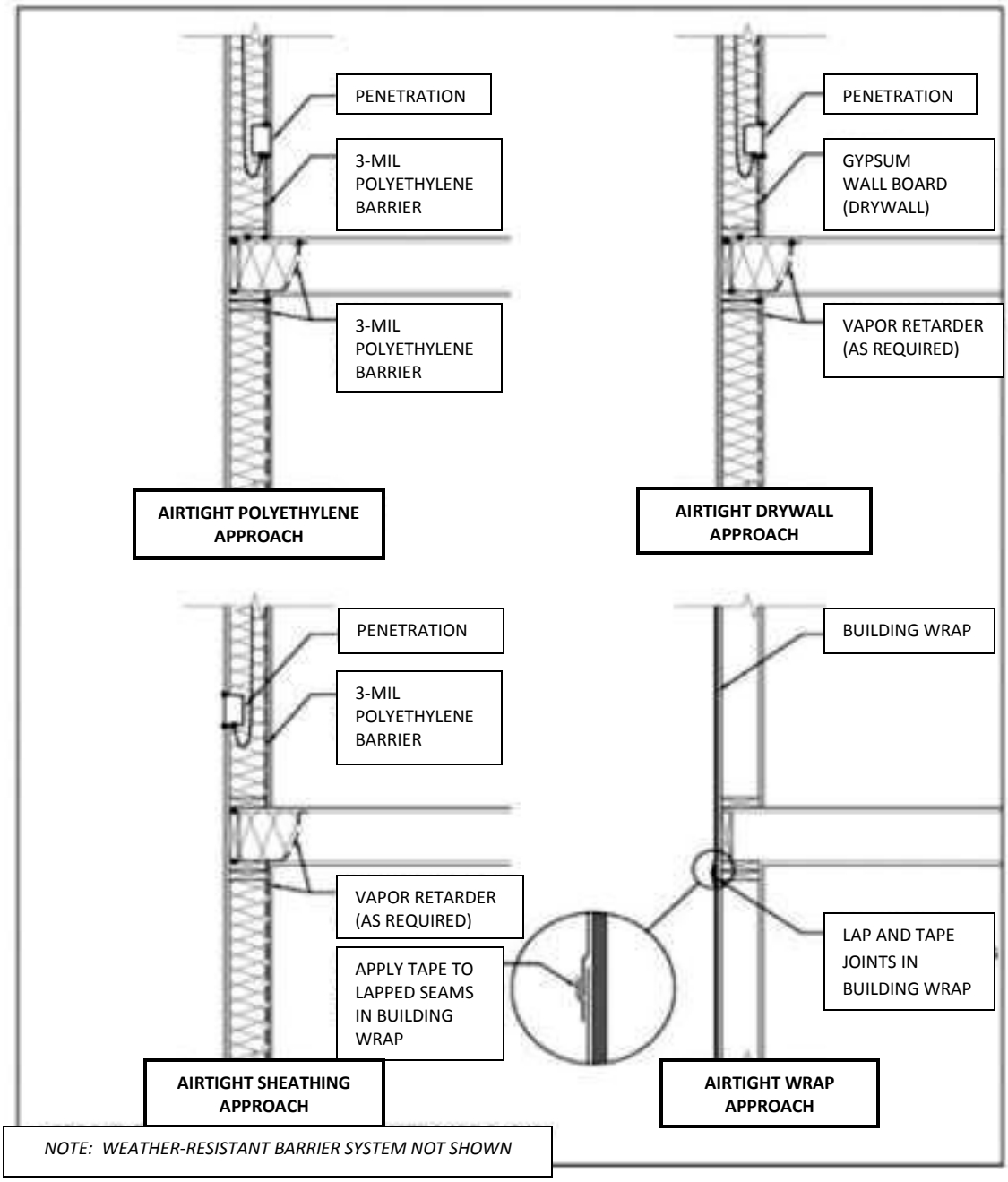
Here are the four types:

- **Interior Air Barrier Methods**
  - Airtight Drywall Approach (ADA)
  - Airtight Polyethylene Approach (APA)
- **Exterior Air Barrier Methods**
  - Airtight Sheathing Approach (ASA)
  - Airtight Wrap Approach (AWA)

In cold and very cold climates, moisture primarily tends to travel from the interior conditioned spaces to the exterior through the wall and ceiling assemblies. The primary concern is to prevent interior warm and humid air from flowing outward into the building's exterior envelope assemblies during winter months. This air flow can carry a large amount of moisture and cause condensation in the wall. Therefore, the use of an interior air-barrier system in cold and very cold climates is preferred and may be combined with a warm-in-winter vapor diffusion retarder. A viable approach in these climates is the ADA method used in conjunction with an interior vapor diffusion-retarder layer, such as kraft-faced batts or vapor diffusion-retarder paint on drywall. The APA method should be applied more cautiously, as some localities and building scientists are concerned that the poly layer is almost too airtight and vapor-impermeable and will not allow drying to the interior of the building at any time of the year. Conditioned interior spaces should be maintained at a low moisture level.

In hot-humid climates, moisture tends to go from the exterior to the cooled interior by passing through the walls and ceiling. The primary concern is preventing exterior warm, humid air from leaking inward through exterior surfaces into building envelope assemblies that will be cool from air conditioning. In humid climates, an air-barrier system is preferred for the outside of the wall. Many exterior sheathing products and wraps can provide this function and also serve the water-barrier function underneath siding materials -- particularly, the ASA and AWA methods.

In climates of mixed conditions, the most suitable air-barrier system can be selected based on other construction characteristics and then combined with these systems. For example, if building wrap is used as part of a drained-cavity, weather-resistant envelope, then the Airtight Wrap Approach (AWA) can be used with a little extra detailing of the building wrap, such as taping the overlapped seams. Similarly, sealing interior drywall joints and penetrations can make the Airtight Drywall Approach a reasonable strategy.


PENETRATION
3-MIL POLYETHYLENE BARRIER
3-MIL POLYETHYLENE BARRIER
AIRTIGHT POLYETHYLENE APPROACH
PENETRATION
GYPSUM WALL BOARD (DRYWALL)
VAPOR RETARDER (AS REQUIRED)
AIRTIGHT DRYWALL APPROACH
PENETRATION
3-MIL POLYETHYLENE BARRIER
VAPOR RETARDER (AS REQUIRED)
APPLY TAPE TO LAPPED SEAMS IN BUILDING WRAP
AIRTIGHT SHEATHING APPROACH
BUILDING WRAP
LAP AND TAPE JOINTS IN BUILDING WRAP
AIRTIGHT WRAP APPROACH
NOTE: WEATHER-RESISTANT BARRIER SYSTEM NOT SHOWN

QUIZ 10

1. T/F: Most types of insulation will not stop air leaks.

- True
- False

2. Because air leakage pathways exist due to the tendency for warm air to rise and cool air to fall, the ____ is often the best place to find air leaks and seal them up.

- utility room
- chimney
- basement
- attic

3. T/F: Leakage of humid indoor air into cold cathedral roof cavities is a major cause of condensation and moisture problems in this type of roof.

- True
- False

4. T/F: A good example of an air barrier is gypsum wallboard.

- True
- False

5. T/F: Without reasonable air-leakage control, the use of vapor diffusion retarders is of limited benefit.

- True
- False

6. T/F: Reducing air leakage through the building envelope is a good practice regardless of where in the envelope it takes place.

- True
- False

(continued)

7. The primary concern in _____ climates is preventing interior warm and humid air from flowing outward into the building's exterior envelope assemblies in winter months.

- hot
- warm
- cold
- humid

8. In hot-humid climates, moisture tends to go from the _____ to the cooled _____ by passing through the walls and ceiling.

- interior..... exterior
- walls..... ceiling
- exterior..... interior
- insulation..... exterior

Answer Key to Quiz 10

1. T/F: Most types of insulation will not stop air leaks.
   Answer: True

2. Because air leakage pathways exist due to the tendency for warm air to rise and cool air to fall, the attic is often the best place to find air leaks and seal them up.

3. T/F: Leakage of humid indoor air into cold cathedral roof cavities is a major cause of condensation and moisture problems in this type of roof.
   Answer: True

4. T/F: A good example of an air barrier is gypsum wallboard.
   Answer: True

5. T/F: Without reasonable air-leakage control, the use of vapor diffusion retarders is of limited benefit.
   Answer: True

6. T/F: Reducing air leakage through the building envelope is a good practice regardless of where in the envelope it takes place.
   Answer: True

7. The primary concern in cold climates is preventing interior warm and humid air from flowing outward into the building's exterior envelope assemblies in winter months.

8. In hot-humid climates, moisture tends to go from the exterior to the cooled interior by passing through the walls and ceiling.

SECTION 21: VAPOR DIFFUSION RETARDERS

Vapor Diffusion Retarders Defined

The movement of water vapor via vapor diffusion is a major factor of water vapor problems in houses, along with high indoor relative humidity (RH) and air leakage. A vapor diffusion retarder is intended to control the entry of water vapor into a building assembly by vapor diffusion. The vapor diffusion retarder may be needed to control the diffusion entry of water into a wall from the interior, or from the exterior, or both.

Vapor diffusion retarders should not be confused with air barriers. Air barriers control the movement of air through a building assembly, such as a wall.

Some Effective Air and Vapor Diffusion Retarders

- A continuous rubber membrane applied to the exterior-side of a foundation wall is both an air barrier and vapor diffusion retarder.
- A plastic sheet covering an exposed dirt floor in a crawlspace is an air barrier and vapor diffusion retarder.
- Building paper and housewrap are effective air barriers.
- Most building papers and housewraps are vapor-permeable because they breathe.

Vapor diffusion retarders are used to control and slow the diffusion of moisture vapor through building envelope materials. Vapor diffusion retarders, when installed properly, prevent high levels of humidity inside building envelope assemblies that can result in condensation. When installed improperly, vapor diffusion retarders can trap moisture, slow the normal drying process, and contribute to moisture damage.

Air leakage is a primary type of water vapor movement, but vapor diffusion retarders also play an important role in a strategy to control moisture. All materials exhibit some amount of vapor retardance -- that is, they have some impact on allowing moisture vapor to pass through them. Inspectors should understand that all materials play some role in the migration of water vapor.

Any material is either impermeable or permeable. Materials that retard the flow of water vapor are impermeable. Materials that allow water vapor to pass through them are considered permeable. But there are degrees of permeability, and materials can change from impermeable to permeable if their condition changes. For example, dry plywood is relatively impermeable until it gets wet. Plastic vapor diffusion retarders on crawlspace floors do not change their permeability. The unit of measurement of permeability is called a perm.

Perm Ratings of Some Different Building Materials	
Asphalt-coated paper backing on insulation	0.40
Polyethylene plastic (6 mil)	0.06
Plywood with exterior glue	0.70
Plastic-coated insulated foam sheathing	0.4 to 1.2
Aluminum foil (0.35 mil)	0.05
Vapor diffusion retarder paint or primer	0.45
Drywall (unpainted)	50
Drywall (painted – latex paint)	2-3

Some building materials that are considered impermeable to water vapor include:

- polyethylene plastic sheets;
- sheathing with foil facing;
- rubber membranes;
- aluminum foil;
- sheet metal; and
- glass.

Building materials considered semi-permeable to water vapor include:

- plywood;
- oriented strand board (OSB);
- heavy-weight (#30) building tar and felt paper; and
- bitumen-impregnated kraft paper (the facing on fiberglass batt insulation).

Housewraps, unpainted gypsum wallboard (or drywall), unfaced fiberglass insulation, and cellulose insulation are considered permeable to water vapor.

Vapor Diffusion Retarder vs. Vapor Barrier

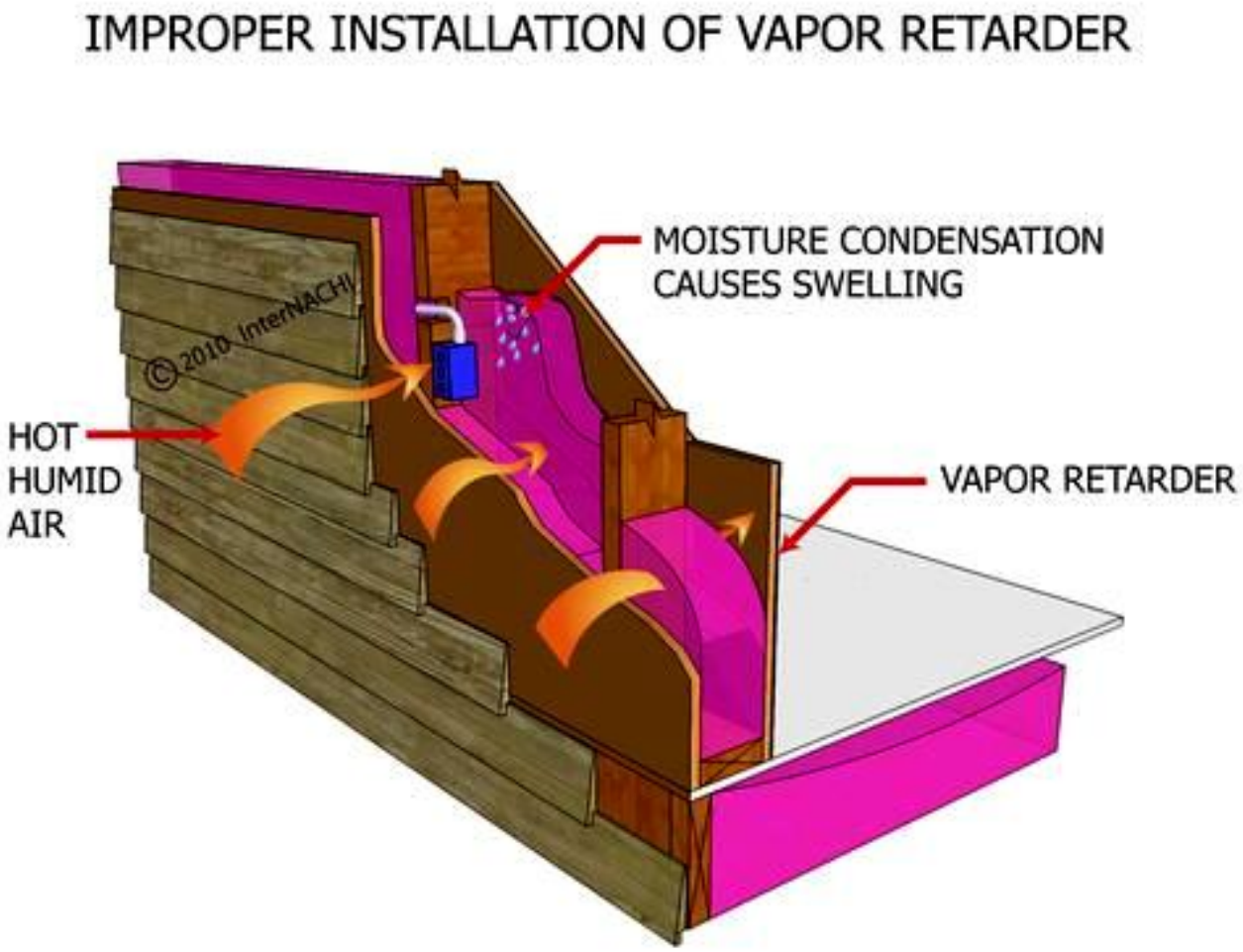
Using the correct term is important and can be difficult. "Vapor diffusion retarder" and "vapor barrier" are often used interchangeably, and that might cause some confusion because they are not exactly the same thing.

A vapor barrier, as defined by the International Building Code (IBC), is classified as 1 perm or less.

A vapor diffusion retarder is installed in a building assembly, such as an exterior wall of a house, and retards the movement of water by vapor diffusion through a material or wall assembly. And there are a few classes or categories of vapor diffusion retarders.

Four General Categories of Perm Ratings		
Class I vapor diffusion retarder	vapor-impermeable	≤ 0.1 perm
Class II vapor diffusion retarder	semi-impermeable	> 0.1 perm and ≤ 1 perm
Class III vapor diffusion retarder	semi-permeable	> 1 perm and ≤ 10 perms
Class VI vapor diffusion retarder	vapor-permeable	> 10 perms

The 2006 International Residential Code (IRC) defines a vapor diffusion retarder as a material, membrane or covering, such as foil, plastic sheeting or insulation facing, having a rating of 1 perm or less.



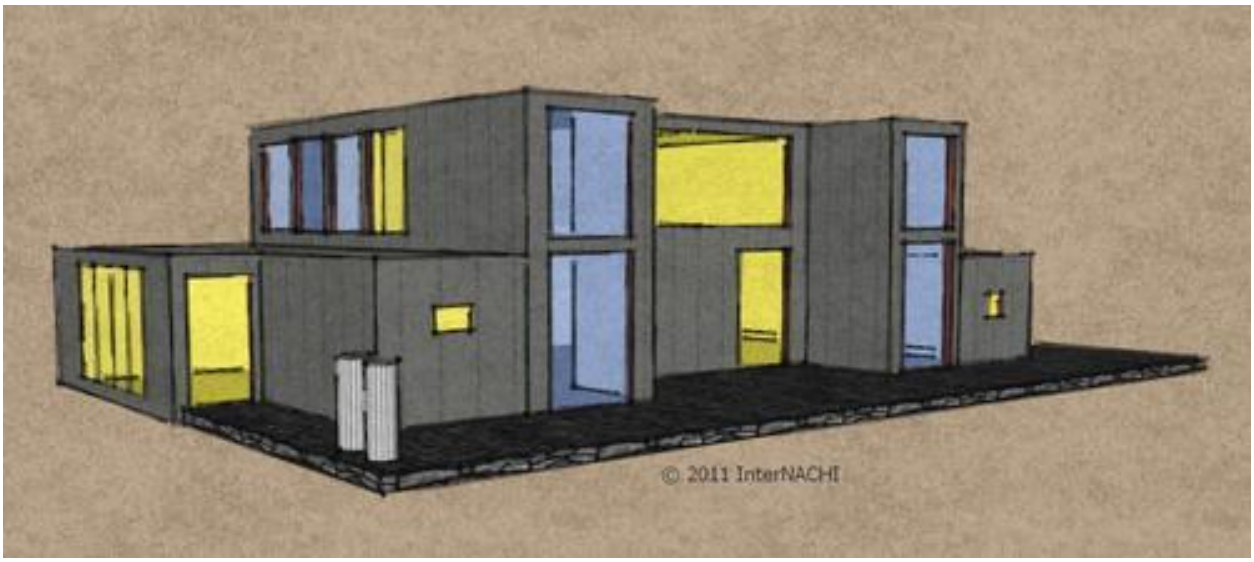
SECTION 22: WALLS IN HOT-HUMID CLIMATES

Inward Drying

In hot-humid climates, exterior wall systems should dry toward the interior by installing vapor retarding materials on the outside of the wall assembly and using vapor-permeable interior materials.

Providing some resistance to outdoor moisture vapor from diffusing into the wall assembly limits moisture problems during hot and humid periods of the year. And by keeping the interior-side of the wall assembly vapor-permeable, any moisture within the wall system can migrate to the cool and dry interior of the building.

If a vapor-retarding material, such as polyethylene or even vinyl wallpaper, is used toward the inside of the wall assembly, it could block vapor migration on its cool surface and cause condensation problems. Instead, materials toward the interior of the wall assembly should be semi-permeable or permeable, such as unfaced fiberglass batts with permeable interior paint on the gypsum board. Installation choices and practices related to vapor diffusion retarders and other wall-assembly materials are subject to local code requirements.



SECTION 23: WARM WALLS IN COLD CLIMATES

Inspection

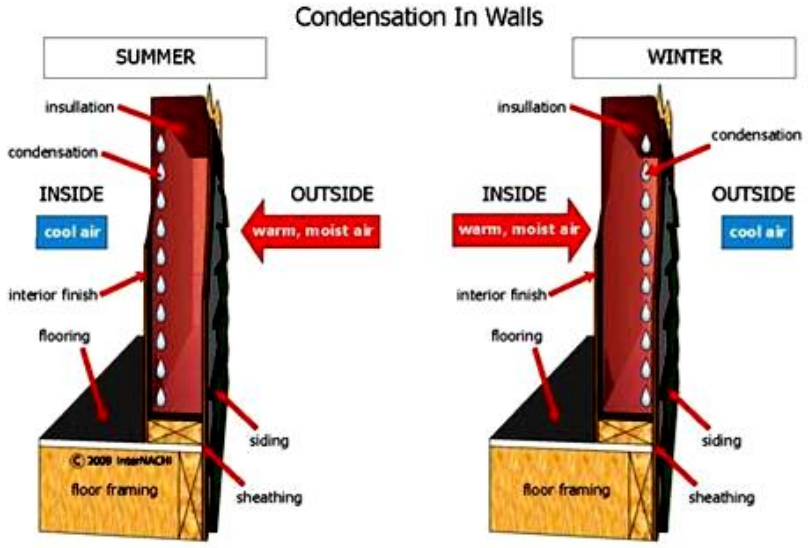
Some current research in building science recommends avoiding the use of sheathing materials that are low-perm and also of little insulating value in cold climates, such as wood structural panels and similar sheathings. The concern is that the inside face of these materials will create a cold surface during cold weather, and if humid indoor air enters the wall from air leakage or vapor diffusion, it will condense on this surface. Condensation that does form in this manner would be unable to dry outward through the sheathing, since the sheathing is low-perm.

Furthermore, when an exterior insulating sheathing is used that also happens to be a low-perm material, the available research and experience on such wall systems suggest that it should have an R-value high enough to keep its inside face from reaching a temperature low enough to cause condensation for any significant period of time. This type of design may be called a warm-wall approach. For this concept to work without creating condensation on a cold surface internal to the wall, the exterior insulating sheathing must be thick enough to minimize the potential for its inside face to reach dew-point temperature, given a reasonable winter-design condition (e.g., indoor and outdoor temperature and humidity).

Current building codes do not explicitly address this design approach for moisture-vapor control in walls. Building energy codes generally recommend an R-value for insulating sheathing of approximately one-third of the required overall wall insulation's R-value, including the cavity insulation.

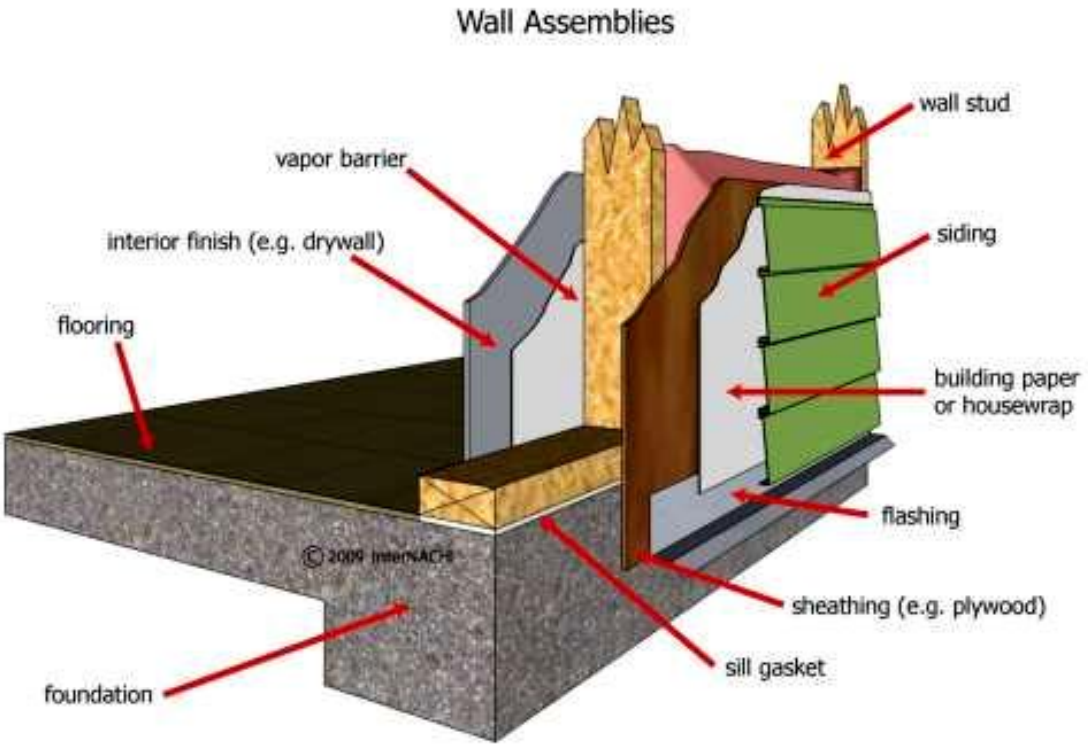
While this guide acknowledges current research in these areas, documentation of these issues and well-established best practices are lacking standardized rules for design and construction. Regardless, a properly executed warm-wall design is frequently used with success in colder climates because of the condensation control it provides.

In hot-humid regions, walls must be able to dry to the inside. Homeowners in these regions must be educated not to limit the ability of walls to dry toward the interior by adding non-breathable interior finishes on exterior walls. Finishes that could compromise the wall's ability to dry inward include vinyl wallpaper finishes and vapor diffusion-retarder paints.



SECTION 24: PROPER WALL ASSEMBLIES

Outwardly Dry



In cold climates, exterior wall systems should dry toward the outside by installing vapor-retarding materials on the inside of the wall assembly and keeping exterior materials vapor-permeable. Along with that, controlling the indoor humidity level and addressing air leakages are also very important issues.

To prevent moisture vapor from diffusing into the wall assembly from inside the house, common materials used for this purpose include kraft-faced or paper-faced insulation batts and semi-permeable interior paints. And while practices related to vapor diffusion retarders and other wall-assembly materials are subject to local code requirements, regions in northern climates have homes built with the wall assemblies designed to dry toward the exterior. As the climate becomes colder, this issue becomes even more important because longer and colder winter conditions require walls that can dry outward and assemblies that limit indoor moisture from entering the wall.

Along with vapor diffusion-retarder materials, such as kraft-faced batts, installed toward the inside of wall assemblies in cold regions, vapor-permeable materials installed toward the outside of the assembly will facilitate outward drying. This allows any moisture in the wall to dry outward toward the colder and drier outdoor environment. However, several common sheathing materials, such as wood structural panels and foam insulating panels, have fairly low-perm ratings which, in theory, could impede drying and possibly even create a cold surface for condensation. The building science community is still researching these issues.

Vapor Diffusion Retarder Location by Geographical Location

In most cold climates, the vapor diffusion retarder should be placed on the interior (warm-in-winter) side of walls.

In some southern climates, the vapor diffusion retarder should be omitted. However, in hot-humid climates, such as along the Gulf Coast and in Florida, the vapor diffusion retarder should be placed on the exterior of the wall.

SECTION 25: VENTILATION OF INTERIOR HOUSE AIR

Ventilation of House Air

Unless properly ventilated, an airtight home can seal in indoor air pollutants. Ventilation also helps control moisture -- another important consideration for a healthy, energy-efficient home. Historically, homes did not have requirements for ventilation because air leaks through the building envelope and natural ventilation were considered adequate. As envelope construction techniques and materials have improved, the need to control indoor air quality in the home has increased.

Today, many residential building codes require a home to have adequate mechanical ventilation systems installed with controls for the occupants to use. Each mechanical ventilation system (supply, exhaust or both) should have a readily accessible switch or other means for shutoff (or volume reduction and shutoff). Automatic or gravity dampers that close when the system is not operating should be installed at the exterior air hoods (intake and exhaust). Some terms to know:

- mechanical ventilation: the process of supplying or removing air by mechanical means to or from any space. Such air may or may not be conditioned.
- natural ventilation: the process of supplying or removing air by natural means to or from any space.
- CFM: stands for cubic feet per minute, which is a standard measurement of air flow.

The Purpose of Ventilation

All homes need ventilation — the exchange of indoor air with outdoor air — to reduce moisture, indoor pollutants and odors. Contaminants, such as formaldehyde, volatile organic compounds (VOCs) and radon, can accumulate in poorly ventilated homes and cause health problems.

Excess moisture in a home can generate high humidity. High humidity can lead to mold growth and structural damage to the home.

To ensure adequate ventilation, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) says that a home's living area should be ventilated at a rate of 0.35 air changes per hour, or 15 cubic feet per person per minute -- whichever is greater.

Three Ways to Ventilate

A home can be ventilated in the following three ways:

- Natural ventilation is uncontrolled air movement into a home through cracks, small holes and vents, such as through windows and doors. This method cannot be relied upon for tightly sealed and many new-construction homes.

- Whole-house ventilation is controlled air movement using one or more fans and duct systems.
- Spot ventilation is controlled air movement using localized exhaust fans to quickly remove pollutants and moisture at their source. It is typically used in conjunction with one of the other strategies.

NATURAL VENTILATION

Natural ventilation used to be the most common ventilation method for allowing fresh outdoor air to replace indoor air in a home. Today, it's usually not the best ventilation strategy, especially for homes that are properly air-sealed for energy efficiency. Natural ventilation also usually doesn't provide adequate moisture control.

Natural ventilation occurs when there is uncontrolled air movement or infiltration through cracks and small holes in a home — the same ones that homeowners want to seal to make their homes more energy-efficient. Opening windows and doors also provides natural ventilation. Because of central heating and cooling systems, however, most people don't open windows and doors as often for natural ventilation. Therefore, air infiltration has become the principal mode of natural ventilation in homes.

A home's natural ventilation rate is unpredictable and uncontrollable — it can’t be relied upon to ventilate a house's interior uniformly. Natural ventilation depends on a home's air-tightness, outdoor temperature, wind, and other factors. Therefore, during mild weather, some homes may lack sufficient natural ventilation for the removal of indoor air pollutants. Tightly sealed and/or tightly built homes may have insufficient natural ventilation most of the time, while homes with high air-infiltration rates may experience high energy costs.

Spot ventilation can be used to improve the effectiveness of natural ventilation. However, if both spot and natural ventilation together don't meet the home's ventilation needs, then the homeowner should consider a whole-house ventilation strategy.

WHOLE-HOUSE VENTILATION

The decision to use whole-house ventilation is typically motivated by concerns that natural ventilation won't provide adequate air quality, even with source control by spot ventilation.

Whole-house ventilation systems provide controlled, uniform ventilation throughout a house. These systems use one or more fans and duct systems to exhaust stale air and/or supply fresh air into the house.

There are four types of whole-house ventilation systems:

1. Exhaust ventilation systems force inside air out of a home. Spot ventilation is a form of exhaust ventilation.
2. Supply ventilation systems force outside air into the home.
3. Balanced ventilation systems force equal quantities of air into and out of the home.

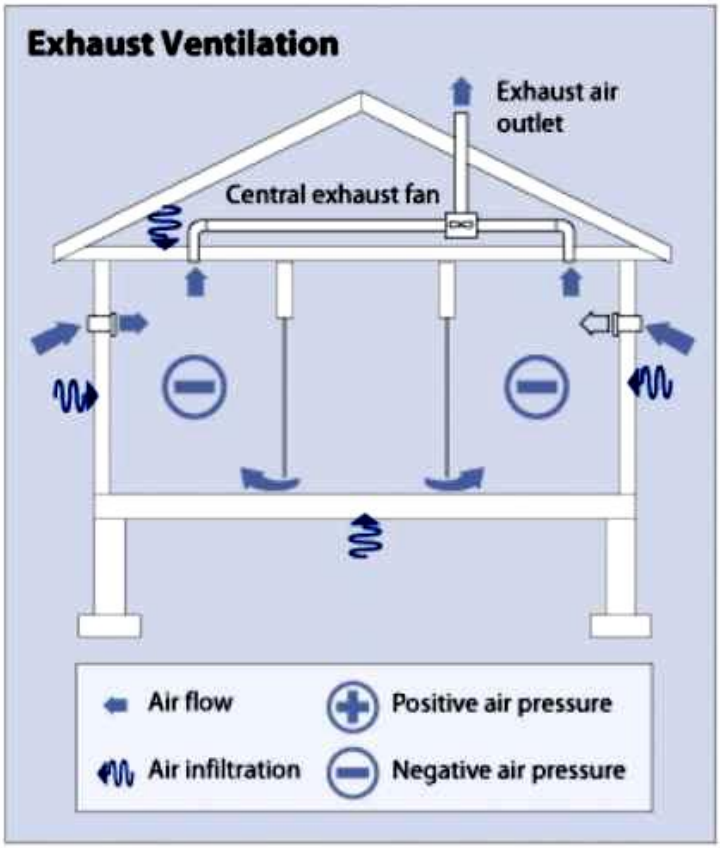
4. Energy-recovery ventilation (ERV) systems transfer heat from incoming or outgoing air to minimize energy loss.

EXHAUST VENTILATION SYSTEMS

Exhaust ventilation systems work by depressurizing the building. By reducing the air pressure indoors to a level below the air pressure outdoors, this type of system extracts indoor air from a house while make-up air infiltrates through leaks in the building's shell and through intentional, passive vents.

Exhaust ventilation systems are most effective in cold climates. In climates with warm, humid summers, depressurization can draw moist air into building wall cavities where it may condense and cause moisture damage.

An exhaust ventilation system is relatively simple and inexpensive to install. Typically, it's composed of a single fan connected to a centrally located, single exhaust point in the house. An ideal design option is to connect the fan to ducts from several rooms -- preferably, rooms where pollutants tend to be generated, such as bathrooms. Adjustable, passive vents through windows and/or walls can be installed in other rooms to introduce fresh air, rather than relying on leaks in the building envelope. However, passive vents may be ineffective because pressure differences larger than those induced by the ventilation fan may be needed for them to work properly.



At left: an exhaust ventilation system showing a side view of a simple house with an attic, living space and basement

In the attic is horizontal ductwork leading into a box labeled as the central exhaust fan. A duct extending vertically from the central exhaust fan and through the roof is labeled as the exhaust air outlet. Arrows show air flow going into the house through vents in the walls, moving through the living space, and moving into the central exhaust fan and out of the house through the exhaust air outlet. Minus symbols on the label show that the living space has negative air pressure. Air infiltration into the living space through the attic, basement, and the exterior walls is indicated by arrows.

SPOT VENTILATION

Spot-ventilation exhaust fans installed in the bathroom and operated continuously represent an exhaust ventilation system in its simplest form.

One concern with exhaust ventilation systems is that they may draw pollutants, along with fresh air, into the house. For example, in addition to drawing in fresh outdoor air, they may draw in the following:

- radon and mold spores from a crawlspace;
- dust from an attic;
- vapors from an attached garage; and
- flue gases from a fireplace or fossil-fuel-fired water heater and furnace.

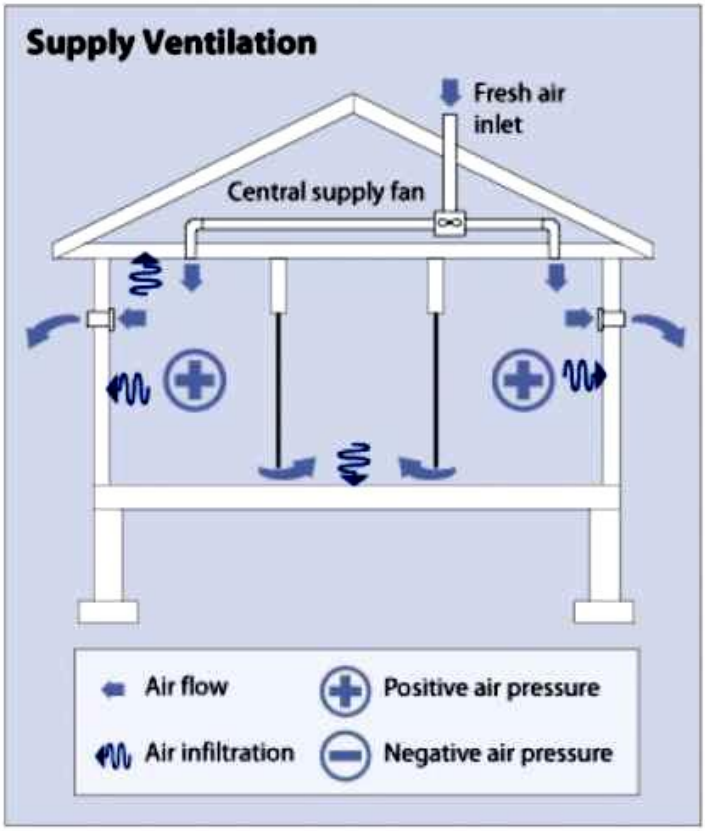
This can be of special concern when bathroom fans, range fans, and clothes dryers -- which also depressurize the home while they operate -- are run while an exhaust ventilation system is also operating.

Exhaust ventilation systems can also contribute to higher heating and cooling costs compared with energy-recovery ventilation systems because exhaust systems do not temper or remove moisture from the make-up air before it enters the house.

SUPPLY VENTILATION SYSTEMS

Supply ventilation systems work by pressurizing the building. They use a fan to force outside air into the building while air leaks out of the building through holes in the shell, bathroom and range fan ducts, and intentional vents (if any exist).

As with exhaust ventilation systems, supply ventilation systems are relatively simple and inexpensive to install. A typical supply ventilation system has a fan and duct system that introduces fresh air into usually one (but preferably several) rooms of the home that residents occupy most often, such as the bedrooms and living room. This system may include an adjustable window and/or wall vents in other rooms.



Above: a supply ventilation system showing a side view of a simple house with an attic, living space and basement

In the attic is horizontal ductwork labeled as the central supply fan. A duct extending vertically from the central supply fan and through the roof is labeled as the fresh-air inlet. Arrows show air flow going into the house through the fresh-air inlet, moving through the central supply fan into the living space, and out of the house through vents in the walls. Plus symbols on the label show that the living space has positive air pressure. Arrows on the label indicate air infiltration out of the living space through the ceiling, floor and exterior walls.

Supply ventilation systems allow better control of the air that enters the house than do exhaust ventilation systems. By pressurizing the house, supply ventilation systems discourage the entry of pollutants from outside the living space and prevent back-drafting of combustion gases from fireplaces and appliances. Supply ventilation also allows outdoor air that's introduced into the house to be filtered to remove pollen and dust, or it may be dehumidified to provide humidity control.

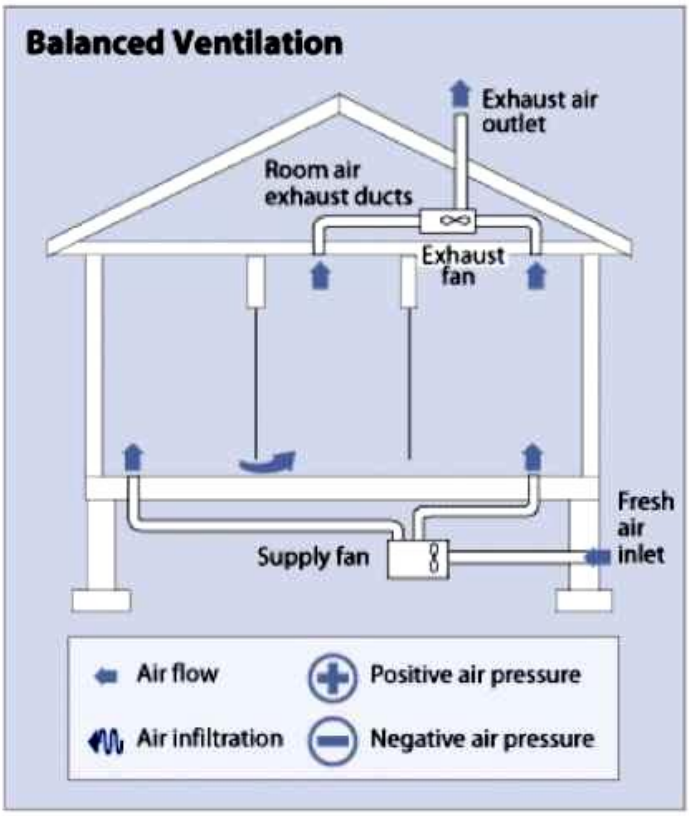
Supply ventilation systems work best in hot and mixed climates. Because they pressurize the house, supply ventilation systems have the potential to cause moisture problems in cold climates. In winter, the supply ventilation system causes warm interior air to leak through random openings in the exterior wall and ceiling. If the interior air is humid enough, some moisture may condense in the attic or the cold outer parts of the exterior wall, where it can promote mold, mildew and decay.

Like exhaust ventilation systems, supply ventilation systems do not temper or remove moisture from the make-up air before it enters the house. Thus, they may contribute to higher heating and cooling costs compared with energy-recovery ventilation systems. Because air is introduced into the house at discrete locations, outdoor air may need to be mixed with indoor air before delivery in order to avoid cold air drafts in the winter. An in-line duct heater is another option, but it will increase operating costs.

BALANCED VENTILATION SYSTEMS

Balanced ventilation systems, if properly designed and installed, neither pressurize nor depressurize a house. Rather, they introduce fresh outside air and exhaust polluted inside air in roughly equal quantities.

A balanced ventilation system usually has two fans and two duct systems. It facilitates effective distribution of fresh air by placing supply and exhaust vents in appropriate places. Fresh-air supply and exhaust vents can be installed in every room. But a typical balanced ventilation system is designed to supply fresh air to bedrooms and living rooms, where people spend the most time. It also exhausts air from rooms where moisture and pollutants are most often generated, such as the kitchen, bathrooms, and perhaps the laundry room. Some designs may use a single-point exhaust. Because they directly supply outside air, balanced systems allow the use of filters to remove dust and pollen from outside air before introducing it into the house.



At right: a balanced ventilation system showing a side view of a simple house with an attic, living space and basement

In the attic is horizontal ductwork that is labeled for the room air exhaust ducts leading from an exhaust fan into the living-space rooms. A pipe extending vertically from the exhaust fan and through the roof is labeled as the exhaust air outlet. A box in the basement labeled as the supply fan has two ducts leading into the living space and one duct leading to the outside, labeled as the fresh-air inlet. Arrows on the label show air flow into the house through the fresh-air inlet in the basement, moving through the supply fan and into the living space, through the room air exhaust ducts, into the exhaust fan in the attic, and out of the house through the exhaust air outlet in the roof.

Balanced ventilation systems are appropriate for all climates. However, because they require two duct-and-fan systems, balanced ventilation systems are usually more expensive to install and operate than supply or exhaust systems.

Like both supply and exhaust systems, balanced ventilation systems do not temper or remove moisture from the make-up air before it enters the house. Therefore, they may contribute to higher heating and cooling costs, unlike energy-recovery ventilation systems. Also, like supply ventilation systems, outdoor air may need to be mixed with indoor air before delivery to avoid cold air drafts in the winter.

ENERGY-RECOVERY VENTILATION SYSTEMS

Energy-recovery ventilation systems provide a controlled way of ventilating a home while minimizing energy loss. They reduce the costs of heating ventilated air in the winter by transferring heat from the warm inside air being exhausted to the fresh (but cold) supply air. In the summer, the inside air cools the warmer supply air to reduce ventilation cooling costs.

There are two types of energy-recovery systems: heat-recovery ventilators (HRVs) and energy-recovery (or enthalpy-recovery) ventilators (ERVs). Both types include a heat exchanger, one or more fans to push air through the machine, and some controls. There are some small wall- and window-mounted models, but most are central, whole-house ventilation systems with their own duct systems or shared ductwork.

The main difference between a heat-recovery and an energy-recovery ventilator is the way the heat exchanger works. With an energy-recovery ventilator, the heat exchanger transfers a certain amount of water vapor along with heat energy, while a heat-recovery ventilator transfers only heat.

Because an energy-recovery ventilator transfers some of the moisture from the exhaust air to the usually less humid incoming winter air, the humidity of the house's interior air stays more constant. This also keeps the heat exchanger core warmer, which minimizes problems with freezing.

In the summer, an energy-recovery ventilator may help to control humidity in the house by transferring some of the water vapor in the incoming air to the (theoretically) drier air that's leaving the house. In homes with an air conditioner, an energy-recovery ventilator generally offers better humidity control than a heat-recovery system. However, there's some controversy about using ventilation systems at all during humid (but not excessively hot) summer weather. Some experts suggest that it is better to turn the system off in very humid weather to keep indoor humidity low. A system can also be set up that runs only when the air-conditioning system is running, or by using pre-cooling coils.

Most energy-recovery ventilation systems can recover about 70% to 80% of the energy in the exiting air and deliver that energy to the incoming air. However, they are most cost-effective in climates with extreme winters and/or summers, and where fuel costs are high. In mild climates, the cost of the additional electricity consumed by the system's fans may exceed the energy savings from not having to condition the supply air.

Installation and Maintenance

Energy-recovery ventilation systems usually cost more to install than other ventilation systems. In general, simplicity is key to a cost-effective installation. To save on installation costs, many systems share existing ductwork. Complex systems are not only more expensive to install, but they are generally more maintenance-intensive and often consume more electrical power. For most houses, attempting to recover all of the energy in the exhaust air will probably not be worth the additional cost. Also, these types of ventilation systems are still not very common. Only a minority of HVAC contractors have enough technical expertise and experience to install them.

In general, there should be a supply and return duct for each bedroom and each common living area. Duct runs should be as short and straight as possible. The correct-size duct is necessary to minimize pressure drops in the system and thus improve performance. Insulate ducts located in unheated spaces, and seal all joints with duct mastic. Despite its name, never use ordinary duct tape on ducts.

Also, energy-recovery ventilation systems operating in cold climates must have devices to help prevent freezing and frost formation. Very cold supply air can cause frost formation in the heat exchanger, which can damage it. Frost buildup also reduces ventilation effectiveness. Energy-recovery ventilation systems require more maintenance than other ventilation systems. They need to be cleaned regularly to prevent deterioration of ventilation rates and heat recovery, and to prevent mold and bacteria from growing on the heat exchanger’s surfaces.

SPOT VENTILATION

Spot ventilation improves the effectiveness of natural and whole-house ventilation strategies by removing indoor air pollutants and/or moisture at their source.

Kitchens, bathrooms, lavatories, laundry rooms, utility rooms and toilet rooms all have specific functions in the home. These functions produce pollutants, such as moisture, odors, volatile organic compounds (VOCs), particles and combustion byproducts. The purpose of spot ventilation is to control the concentration of these pollutants in the room they were emitted into, and to minimize the spread of the pollutants into other parts of the house.

Spot ventilation includes the use of localized exhaust fans, such as those used above kitchen ranges and in bathrooms. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recommends intermittent or continuous ventilation rates for bathrooms and kitchens instead of using windows (natural ventilation): 50 or 20 cubic feet per minute for bathrooms, and 100 or 25 cubic feet per minute for kitchens, respectively.

BATHROOM VENTILATION

Bathroom ventilation systems are designed to exhaust odors and moist air to the home's exterior. Typical systems consist of a ceiling-fan unit connected to a duct that terminates at the roof.

Fan Function

The fan may be controlled in one of several ways:

- Most are controlled by a conventional wall switch.
- A timer switch may be mounted on the wall, which is recommended to prevent an accidental fire caused by a unit left running that may potentially overheat.
- A wall-mounted humidistat can be pre-set to turn the fan on and off based on different levels of relative humidity.

Newer fans may be very quiet but work just fine. Older fans may be very noisy or very quiet. If an older fan is quiet, it may not be working well. Inspectors can test for adequate air flow with a chemical smoke pencil or a powder puff bottle, but such tests exceed InterNACHI's Standards of Practice.

Bathroom ventilation fans should be inspected for dust buildup that can impede air flow. Particles of moisture-laden animal dander and lint are attracted to the fan because of its static charge. Inspectors should comment on dirty fan covers.

Ventilation systems should be installed in all bathrooms. This includes bathrooms with windows, since windows will not be opened during the winter in cold climates.

Defects

The following conditions indicate insufficient bathroom ventilation:

- moisture stains on walls and/or ceilings;
- corrosion of metal;
- visible mold on walls and/or ceilings;
- peeling paint or wallpaper;
- frost on windows; and
- high humidity.

The most common defect related to bathroom ventilation systems is improper termination of the duct. Vents must terminate at the home's exterior. The most common improper locations for terminations are:

- mid-level in the attic, which are easy to spot;
- beneath the insulation. You need to remember to look. The duct may terminate beneath the insulation, or there may be no duct installed; and
- beneath attic vents. The duct must terminate at the home's exterior -- not just above the ceiling or beneath the roof.

Improperly terminated ventilation systems may appear to work fine from inside the bathroom; you have to look in the attic or on the roof. Sometimes, poorly installed ducts will loosen or become disconnected at joints and connections.

Ducts that leak or terminate in attics can cause problems from condensation. Warm, moist air will condense on cold attic framing, insulation and other materials. This condition has the potential to cause health problems and structural decay from mold growth, as well as damage to building materials, such as drywall. Moisture also reduces the effectiveness of thermal insulation.

Mold

Perhaps the most serious consequence of an improper ventilation setup is the potential accumulation of mold in attics and crawlspaces. Mold may appear as a fuzzy, thread-like, cob-webby fungus, although it cannot be identified with certainty without being lab-tested. Health problems caused by mold are related to high concentrations of spores in indoor air.

Mold spores resemble microscopic seeds that are released by mold fungi when they reproduce. Nearly every home has mold. Moisture levels of about 20% in building materials will cause mold colonies to grow. Inhaling mold spores can cause health problems in those with asthma or allergies, as well as serious and even fatal fungal infections in those with lung disease and compromised immune systems.

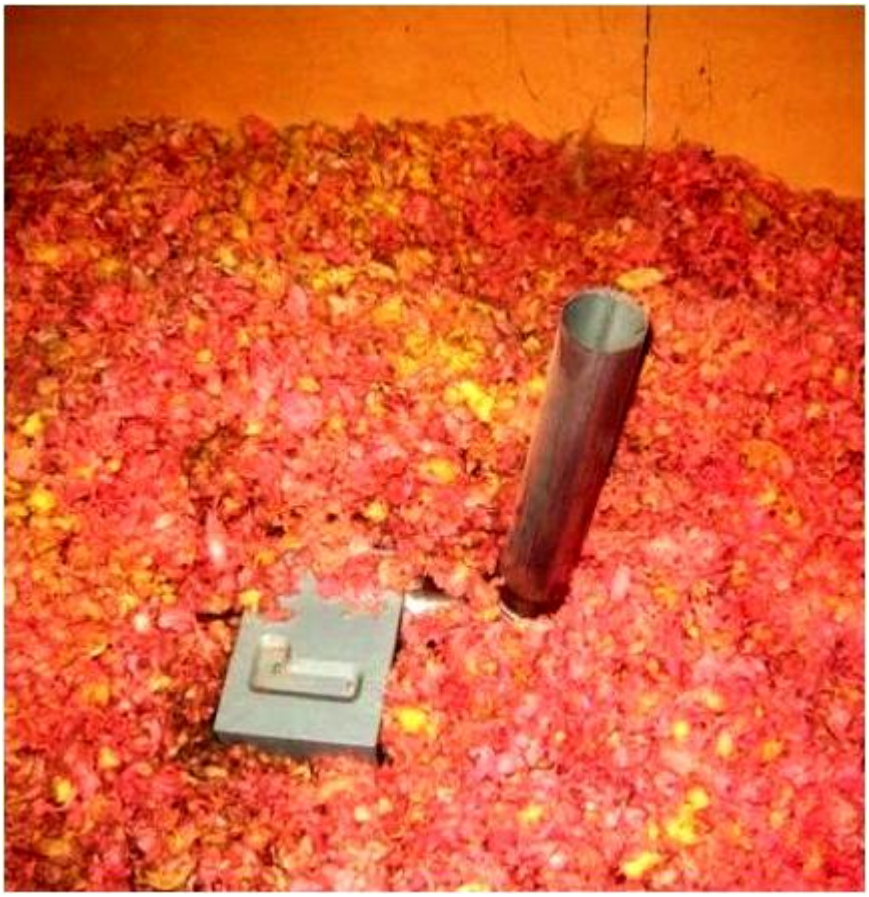
Mold is sometimes difficult to recognize visually and must be tested by a lab in order to be accurately identified. Inspectors should refrain from calling anything mold *per se*, but should refer to anything that appears to be mold as "a material that appears to be microbial growth." Inspectors should include in their report, as well as in the inspection agreement signed by the client, a disclaimer that explicitly states that a General Home Inspection is an inspection for safety and system defects, and not a mold inspection. Trained inspectors may wish to offer mold inspections as an ancillary service. Training is available through InterNACHI.

Decay, which is rot, is also caused by fungi. Incipient or early decay cannot be seen. By the time decay becomes visible, wood may have lost up to 50% of its strength.

In order to grow, mold fungi require that the following conditions are present:

- oxygen;
- a temperature between approximately 45° F and 85° F;
- food. This includes a wide variety of materials generally found in homes; and
- moisture.

If any of these requirements are of insufficient levels, all mold growth will stop and the fungi will go dormant. But most molds are difficult to actually kill.



Even though mold growth may take place in the attic, mold spores can be sucked into the living areas of a residence by low air pressure. Low air pressure is usually created by the expulsion of household air from exhaust fans in bathrooms and the kitchen, and from the clothes dryer and heating equipment.

Improper Ventilation

Ventilation ducts must be made of appropriate materials and oriented effectively in order to ensure that stale air is properly exhausted.

Ventilation ducts must:

- terminate outdoors. Ducts should never terminate within the building envelope;
- contain a screen or louvered (angled) slats at their termination to prevent bird, rodent and insect entry;
- be as short and straight as possible, and avoid turns. Longer ducts allow more time for vapor to condense and also force the exhaust fan to work harder;
- be insulated, especially in colder climates. Cold ducts encourage the formation of condensation;
- protrude at least several inches from the roof;
- be equipped with a roof termination cap that protects the duct from the elements; and
- be installed to manufacturer's recommendations.

The following tips are helpful, although not required. Ventilation ducts should:

- be made from inflexible metal, PVC, or other rigid material. Unlike dryer exhaust vents, they should not droop; and
- have a smooth interior. Ridges encourage vapor to condense, allowing water to back-flow into the exhaust fan or leak through joints onto vulnerable surfaces.

Above all else, a bathroom ventilation fan should be connected to a duct capable of venting water vapor and odors out to the exterior. Mold growth within the bathroom or attic is a clear indication of improper ventilation that must be corrected in order to avoid structural decay and respiratory health issues.

QUIZ 11

1. T/F: A balanced, whole-house ventilation system, if properly designed and installed, will neither pressurize nor depressurize a house.

- True
- False

2. Energy-recovery ventilation systems provide a controlled way of ventilating a home while minimizing _____ loss.

- air
- water
- energy
- humidity

3. The purpose of _____ ventilation is to control the concentration of pollutants in the room they were emitted into, and to minimize the spread of pollutants into other parts of the house.

- spot
- whole-house
- heat-recovery
- natural

4. T/F: Bathroom vents must terminate at the home's exterior.

- True
- False

Answer Key to Quiz 11

1. T/F: A balanced, whole-house ventilation system, if properly designed and installed, will neither pressurize nor depressurize a house.
   Answer: True

2. Energy-recovery ventilation systems provide a controlled way of ventilating a home while minimizing energy loss.

3. The purpose of spot ventilation is to control the concentration of pollutants in the room they were emitted into, and to minimize the spread of pollutants into other parts of the house.

4. T/F: Bathroom vents must terminate at the home's exterior.
   Answer: True

SECTION 26: WINDOWS

Types and Characteristics

This section deals with the common details and styles of windows that may be observed during an inspection of the interior.

At the end of this section, you should be able to:

- list the different types of the most common windows;
- describe how each type of window operates; and
- list the components of a typical double-hung window.

FIXED

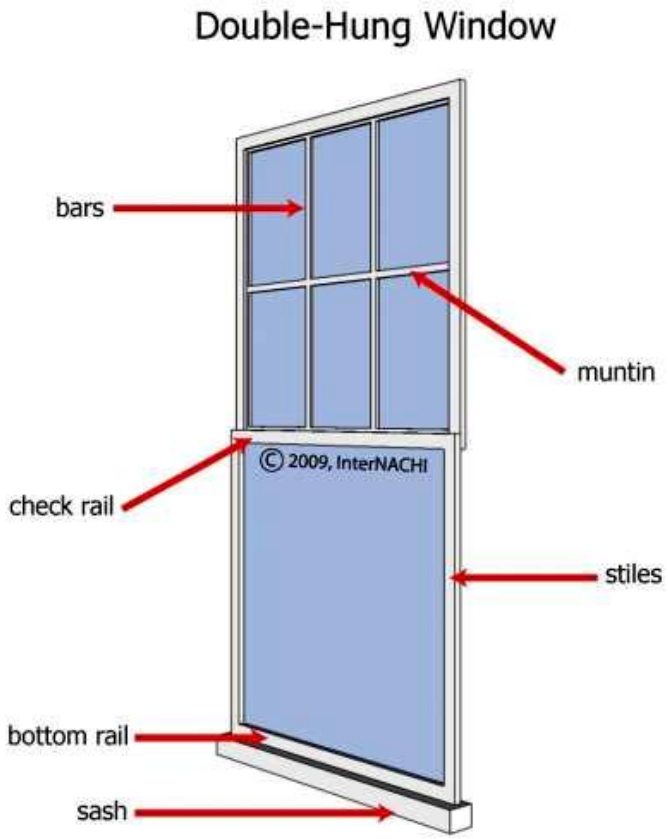
Fixed windows are sometimes referred to as picture windows. They do not open.

PICTURE WINDOW

A picture window is a very large fixed window in a wall. Picture windows are intended to provide an unimpeded view.

DOUBLE-HUNG

A double-hung window has two operable sashes that move. Many older and historic homes have double-hung windows. This window is a traditional style of window in the U.S. The window has two parts or sashes that overlap slightly and slide up and down inside the frame. Most new double-hung sash windows use spring balances to support the sashes. Traditionally, counterweights were used. The weights are attached to the sashes using pulleys of either a cord or chain.



HORIZONTAL SLIDING

A horizontal sliding-sash window has two or more sashes that overlap slightly but slide horizontally within the frame. In the U.K., these are sometimes called Yorkshire sash windows.

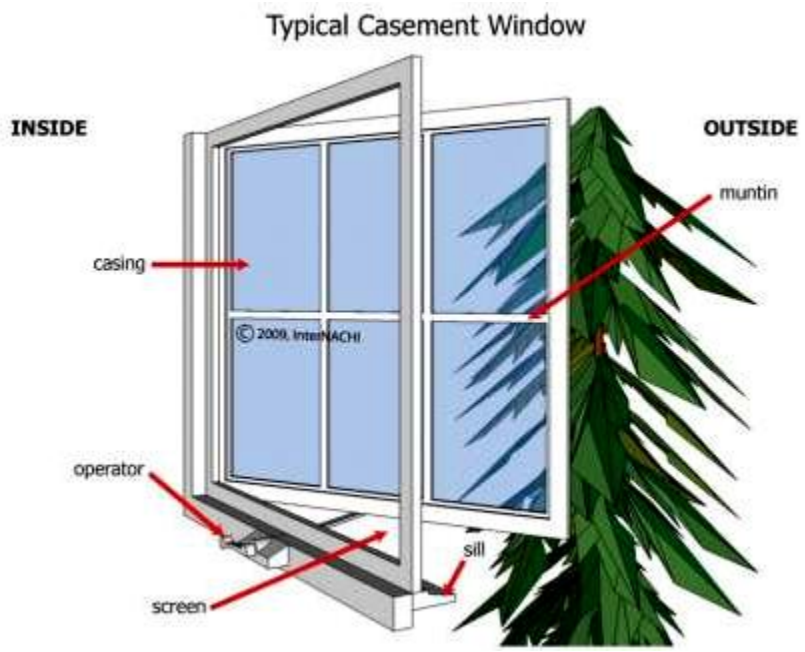
The entire window may have sliders, or, more typically, only one sash slides. These sliders are similar to patio door sliders, where one slider door is fixed and the other slides open and closed.

SINGLE-HUNG

Single-hung windows have a fixed and an operable sash. The operable sash is usually located on the bottom, and the fixed is located at the top of the window.

CASEMENT

A casement window is one that is hinged, usually at the side, and sometimes at the top or bottom. The sash swings in or out, much like a door, comprising either a side-hung, top-hung, or, occasionally, a bottom-hung sash, or a combination of these types. In the U.S., these windows are usually opened using a crank. In Europe, they tend to use friction mechanisms and espagnolette locking. If the window opens outward, a crank, stay or friction hinge is necessary in order to hold the window in position.



AWNING (CASEMENT) WINDOW

An awning window is a casement window that is hinged at the top. The window hangs horizontally by the hinges. It swings outward like an awning. It usually opens outward and operates with a crank.

HOPPER (CASEMENT) WINDOW

A hopper window is a casement window that has hinges on the bottom. Usually, the window opens inward toward the living space, rather than outward.

JALOUSIE OR LOUVER

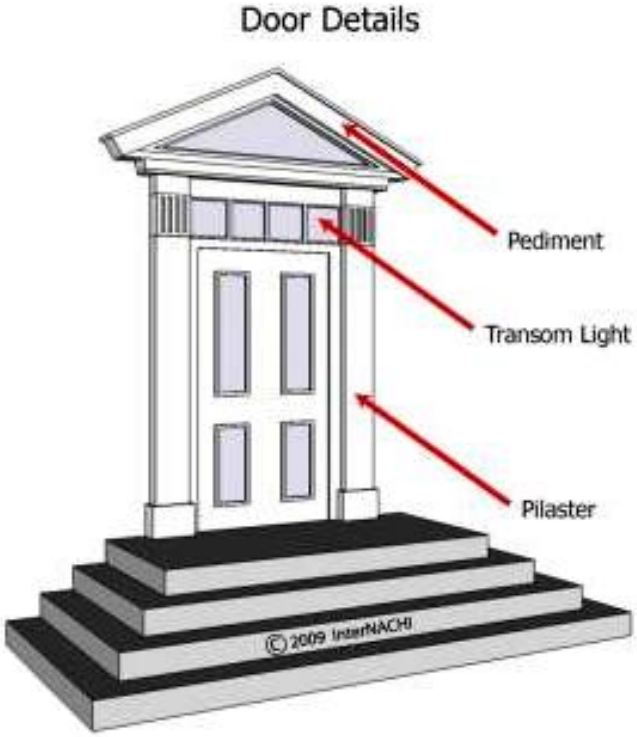
A jalousie window consists of parallel glass, acrylic or wooden louvers set in a frame. The louvers are locked together onto a track so that they may be tilted open and shut in unison to control air flow through the window. When the window is closed, the louvers overlap each other in a shingle pattern.

Jalousie windows are best-suited for porches that are not climate-controlled and are in mild-winter climates. They are common on mid-20th-century homes in Florida and other southern states of the U.S. They are also common in Hawaii.

They are good for providing ventilation. They are not weathertight. They are not good insulators in northern climates if energy efficiency is a concern. They can remain open during rain and yet keep most of the rain from entering because of the shingle orientation.

TRANSOM

A transom window is located above a door. In an exterior door, the transom window is typically fixed. In an interior door, it may open. In an older house, the function of an interior transom window that opens was to provide ventilation before the forced-air HVAC system was introduced.



BAY WINDOW

A bay window is a multi-panel window with at least two panels set at different angles to create a projection from the wall.

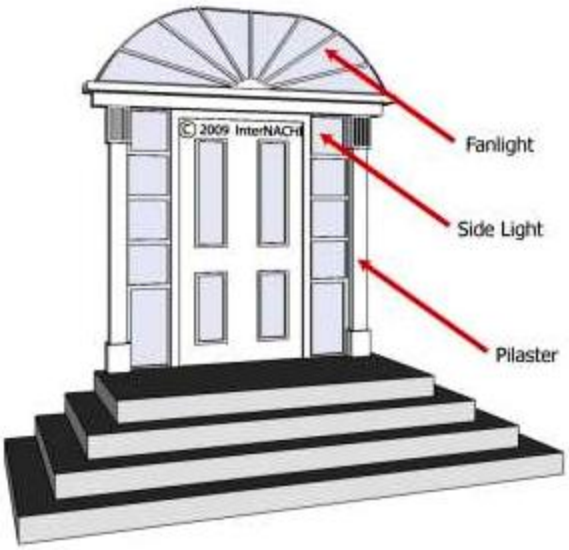
EMERGENCY ESCAPE AND EGRESS

This is a window designed to allow occupants to escape through the opening in an emergency, such as a fire. In the United States, specifications for emergency windows in bedrooms are provided in many building codes.

WINDOW COMPONENTS

Lite or Light

The terms "lite" and "light" are used interchangeably and refer to a glass pane. Several lites may be installed in a window. For example, a fixed window has one lite. A single-light can refer to one piece of glass in a sash. A horizontal slider has two lites, with one sash fixed and the other a slider. A double-light refers to two lites of a window.



Muntins

The lites in a window sash are divided horizontally and vertically by narrow strips of wood or metal called muntins. Muntins divide a sash into smaller lites or panes.

In many modern windows, the muntins are not true muntins but are decorative only. Fake muntins are mounted either on the interior-side of the glass, or they are installed between two panes of a double-glazed window. They may be made of wood, metal or plastic.

Mullion

A mullion is a structural element that divides adjacent window units. "Mullion" is often confused with "muntin" (or "glazing bar" in the U.K.), which is the term for the small strips of wood or metal that divide a sash into smaller glass panes or lites.

A mullion acts as a structural member, and it carries the dead load of the weight above the opening.

CONDENSATION IN DOUBLE-PANED WINDOWS

Condensation is the accumulation of liquid water on relatively cold surfaces.

Almost all air contains water vapor, which is the gas phase of water and is composed of tiny water droplets. The molecules in warm air are far apart from one another and allow the containment of a relatively large quantity of water vapor. As air cools, its molecules get closer together and squeeze the tiny vapor droplets closer together, as well. A critical temperature, known as the dew point, exists where these water droplets will be forced so close together that they merge into visible liquid in the process called condensation.

Household air is humidified from high levels of water vapor in human and animal exhalation, plant transpiration, and household appliances and fixtures, such as showers and dryers. This humidity can rise significantly higher than exterior air because of the insulation design of the house. Cold indoor surfaces can cool the surrounding air enough to force vapor to condense. This often happens on single-paned windows because they lack the necessary thermal insulation available in higher-quality windows. Double-paned windows have a layer of gas -- usually, argon or air -- trapped between the two panes of glass and should be insulated enough to prevent the accumulation of condensation. If this type of window appears misty or foggy, it means that its seal has failed and the window may need to be replaced.

Silica Desiccant

A desiccant is an absorptive material designed to maintain dryness within its vicinity. A common type of desiccant is silica gel, a porous plastic used to prevent spoilage in various food products, as well as supplied in the pockets of new clothing and within new shoes and leather goods to prevent the accumulation of moisture during temperature extremes that are typical when such goods are shipped from their manufacturers to their distributors in distant locations.

In a window, a tightly packed assortment of silica pellets is contained inside the aluminum perimeter strip to dehumidify incoming household air that is not stopped by the window's seal. If not for this substance, incoming air could condense on the glass.

Silica gel has an immense surface area -- approximately 800 m^2/g -- which allows it to absorb water vapor for years. Eventually, the silica pellets will become saturated and will no longer be able to prevent condensation from forming. A double-paned window that appears foggy has failed and needs to be repaired or replaced.

Why Double-Paned Windows Fail: Solar (Thermal) Pumping

Although double-paned windows appear to be stable, they actually experience a daily cycle of expansion and contraction caused by thermal pumping. This process occurs when sunlight heats the air space between the panes and causes the gas there to heat up and pressurize. Expanding gas cannot leave the chamber between the panes, and this causes the glass to bulge outward during the day and contract at night to accommodate the changing pressures. This motion acts like the bellows of a forge, pumping minute amounts of air in and out of the air space between the panes. Over time, the constant pressure fluctuations caused by thermal pumping will stress the seal and challenge its ability to prevent the flow of gas in and out of the window chamber. If it is cold enough, incoming humid air has the potential to condense on the window's surface.

Can failed windows be repaired?

Inspectors should be aware that there are companies that claim to be able to repair misty windows through a process known as de-fogging.

This repair method proceeds in the following order:

1. A hole is drilled into the window, usually from the outside, and a cleaning solution is sprayed into the air chamber.
2. The solution and any other moisture are sucked out through a vacuum.
3. A de-fogger device is permanently inserted into the hole that will allow the release of moisture during thermal pumping.

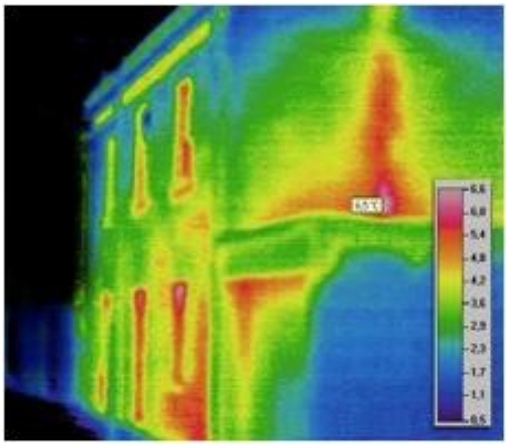
Inspectors should know that there is currently a debate as to whether this process is a suitable repair for windows that have failed, or if it merely removes the symptom of this failure. Condensation appears between double-paned windows when the seal is compromised, and removal of this water will not fix the seal itself. A window "repaired" in this manner, although absent of condensation, might not provide any additional insulation. This method is still fairly new and opinions about its effectiveness range widely.

Regardless, de-fogging certainly allows for cosmetic improvement, which is of some value to homeowners. It also removes any potential damage caused by condensation in the form of mold or rot.

Window condensation will inevitably lead to irreversible physical damage to the window. This damage can appear in the following two ways:

- riverbedding: Condensed vapor between the glass panes will form droplets that run down the length of the window. Water that descends in this fashion has the tendency to follow narrow paths and carve grooves into the glass surface. These grooves are formed in a process similar to canyon formation; and
- silica haze: Once the silica gel has been saturated, it will be eroded by passing air currents and accumulate as white "snowflakes" on the window's surface. It is believed that if this damage is present, the window must be replaced.

Thermal Imaging as a Detection Tool



The presence of condensation in double-paned windows means that they have failed, but the absence of condensation does not mean that the window is fully functional. This latter fact is especially true in hot, dry environments, and when the temperature inside a house is the same as the temperature outside. A method has recently developed that uses infrared (IR or thermal) imaging to provide a better determinant of faulty windows.

Home inspectors can become trained to use thermal imaging cameras to test for heat transfer through windowpanes (and other interior locations). In NACHI.TV's *Introduction to Infrared Thermography,* InterNACHI member John McKenna explains how an IR camera can be used to identify failed windows by imaging any unusual temperature gradients. Even the slightest entry of cold exterior air into the home that would ordinarily go unnoticed will stand out as a dark blue haze in an IR image. A trained inspector can stand outside or inside the house and watch for the escape of warm air or the entrance of cool air, respectively. A trained inspector can compare images of individual windows in a residence and look for anomalies.

In summary, condensation in double-paned windows indicates that the window has failed and needs to be replaced. Condensation, while it can damage windows, is itself a symptom of a lack of integrity of the window's seal. A failing seal will allow air to transfer in and out of the window even if it is firmly closed. Inspectors should be aware of this process and know when to recommend that clients' windows be replaced.

Safety Glass

Safety glass is a stronger, safer version of ordinary glass. It is often used in locations where human harm due to breakage is likely, such as in vehicles and low windows. It is manufactured in the following two forms:

- Laminated safety glass is typically found in car windshields. It is produced by bonding a resin or a thin, transparent plastic film, known as PVB, between multiple sheets of ordinary glass. The effect of this process is that when shattered, the glass will adhere to the plastic sheet and be held in place. Laminated safety glass blocks most ultraviolet radiation, as well as sound, and is used in cutting boards, thermometers, and bullet-resistant windows in banks.

- Tempered safety glass fractures parallel to its edge, rather than perpendicular, and when it shatters, it breaks into small, rounded, generally safe pieces. It is created by heating glass to a high temperature and then rapidly cooling it to produce compression stress fractures on the surface, while retaining tension in the center. The glass is several times stronger as a result of this process, and it can withstand significantly higher temperatures. Tempered safety glass is commonly found in rear and side windows of vehicles, computer monitors and storm doors. Unlike laminated safety glass, it cannot be custom-cut once it is formed.

Where in a home might you find it?

Laminated glass may sometimes be found in shower enclosures, but it is generally uncommon in homes. Tempered glass appears more often and can be found in storm doors, skylights, sliding glass doors, and unsafe locations. Safety glass should be found in locations considered to be, according to the 2006 International Residential Code (IRC), "subject to human impact." It describes these locations, as well as their exceptions, in R308.4: Hazardous Locations, under Section R308, Glazing, as the following:

R308.4: The following shall be considered specifically hazardous:

Locations for the Purposes of Glazing:

- *glazing in swinging doors except jalousies;*
- *glazing in fixed and sliding panels of sliding door assemblies, and panels in sliding and bifold closet door assemblies;*
- *glazing in storm doors;*
- *glazing in all unframed swinging doors;*
- *glazing in doors and enclosures for hot tubs, whirlpools, saunas, steam rooms, bathtubs and showers;*
- *glazing in any part of a building wall enclosing these compartments where the bottom exposed edge of the glazing is less than 60 inches (1,524 mm) measured vertically above any standing or walking surface;*

- *glazing in an individual fixed or operable panel adjacent to a door where the nearest vertical edge is within a 24-inch (610-mm) arc of the door in a closed position, and whose bottom edge is less than 60 inches (1,524 mm) above the floor or walking surface;*
- *glazing in an individual fixed or operable panel, other than those locations described in Items 5 and 6 above, that meets all of the following conditions:*
    - *exposed area of an individual pane larger than 9 square feet (0.836 mm);*
    - *bottom edge less than 18 inches (457 mm) above the floor;*
    - *top edge more than 36 inches (914 mm) above the floor;*
    - *one or more walking surfaces within 36 inches (914 mm) horizontally of the glazing.*
- *all glazing in railings, regardless of an area or height above a walking surface; included are structural baluster panels and non-structural infill panels;*
- *glazing in walls and fences enclosing indoor and outdoor swimming pools, hot tubs and spas where the bottom edge of the glazing is less than 60 inches (1,524 mm) above a walking surface and within 60 inches (1,524 mm) horizontally of the water's edge. This shall apply to single glazing and all panes in multiple glazing;*
- *glazing adjacent to stairways, landings and ramps within 36 inches (914 mm) horizontally of a walking surface when the exposed surface of the glass is less than 60 inches (1,524 mm) above the plane of the adjacent walking surface;*
- *glazing adjacent to stairways within 60 inches (1,524 mm) horizontally of the bottom tread of a stairway in any direction when the exposed surface of the glass is less than 60 inches (1,524 mm) above the nose of the tread.*

Exception: The following products, materials and uses are exempt from the above hazardous locations:

- *openings in doors through which a 3-inch (76-mm) sphere is unable to pass;*
- *glazing in Section R308.4, Items 1, 6 or 7, in decorative glass;*
- *glazing in Section R308.4, Item 6, when there is an intervening wall or other permanent barrier between the door and the glazing;*
- *glazing in Section R308.4, Item 6, in walls perpendicular to the plane of the door in a closed position, other than the wall toward which the door swings when opened, or where access through the door is to a closet or storage area 3 feet (914 mm) or less in depth. Glazing in these applications shall comply with Section R308.4, Item 7;*

- *glazing in Section R308.4, Items 7 and 10, when a protective bar is installed on the accessible side(s) of the glazing 36 inches ± 2 inches (914 mm ± 51 mm) above the floor. The bar shall be capable of withstanding a horizontal load of 50 pounds per linear foot (730 N/m) without contacting the glass, and be a minimum of 1-1/2 inches (38 mm) in height;*
- *outboard panes in insulating glass units and other multiple glazed panels in Section R308.4, Item 7, when the bottom edge of the glass is 25 feet (7,620 mm) or more above grade, a roof, walking surfaces, or other horizontal [within 45 degrees (0.79 rad) of horizontal] surface adjacent to the glass exterior;*
- *louvered windows and jalousies complying with the requirements of Section R308.2;*
- *mirrors and other glass panels mounted or hung on a surface that provides a continuous backing support;*
- *safety glazing in Section R308.4, Items 10 and 11, is not required where:*
    - *the side of a stairway, landing or ramp has a guardrail or handrail, including balusters or infill panels, complying with the provisions of the handrail and guardrail requirements; and*
    - *the plane of the glass is more than 18 inches (457 mm) from the railing; or*
    - *when a solid wall or panel extends from the plane of the adjacent walking surface to 34 inches (863 mm) to 36 inches (914 mm) above the floor, and the construction at the top of that wall or panel is capable of withstanding the same horizontal load as the protective bar.*
- *glass block panels complying with Section R610.*

How do you identify safety glass?

If safety glass is not specifically labeled as such, there are often signs that aid in its identification. Unfortunately, it may be impossible to identify ordinary glass with certainty without breaking it.

According to the IRC, tempered glass must contain an identifying label. It states that a label must be "acid-etched, sand-blasted, ceramic-fired, laser-etched, embossed, or be of a type which, once applied, cannot be removed without being destroyed." Tempered spandrel glass, an opaque glass found in commercial curtain walls, is exempt from this rule because an etched label can cause the entire panel to fracture. Of multi-pane assemblies containing safety glass, the IRC states the following:

> *R308.1.1 Identification of multi-pane assemblies: Multi-pane assemblies having individual panes not exceeding 1 square foot (0.09 m^2) in exposed area shall have at least one pane in the assembly identified in accordance with Section R308.1. All other panes in the assembly shall be labeled "16CFR1201."*

Section R308.1 details identification as follows:

> *R308.1 Identification: Except as indicated in Section R308.1.1, each pane of glazing installed in hazardous locations as defined in Section R308.4 shall be provided with a manufacturer's or installer's label, designating the type and thickness of glass and the safety glazing standard with which it complies, which is visible in the final installation. The label shall be acid-etched, sand-blasted, ceramic-fired, embossed-mark, or shall be of a type which, once applied, cannot be removed without being destroyed.*

Country-specific laws similarly require a permanent label on most or all safety glass. In the U.K., for instance, tempered glass must include a "T," and laminated glass must include an "L."

New Zealand requires, according to Clause 303.7 of NZS 4223: Part 3: 1999, that all safety glass include a label at the bottom that includes the following information:

- the name, registered trademark or code of the manufacturer or supplier;
- the type of safety glazing material. This may be in the form of a code, such as "T" for toughened glass, or "L" for laminated glass, as indicated by the relevant test Standard (refer to AS/NZS 2208);
- the Standard to which the safety glazing material has been tested, e.g. AS/NZS 2208;
- if applicable, the classification relating to impact-test behavior, i.e., A for Grade A, B for Grade B, C for Grade C.

Laminated safety glass is often labeled, although codes do not always require it to be. An easy way to tell if unlabeled glass is laminated is by examining the reflection of your hand or some other object. As there are two pieces of glass, you should see two different images, but you must be careful not to confuse them with the inner and outer surfaces of a single sheet of ordinary glass. Laminated glass is also slightly thicker than ordinary glass, although this difference is difficult to discern without the aid of very precise measuring instruments.

Tempered glass can also be identified through polarized glasses when viewed from an angle. Black lines, a result of the heating and cooling process, should appear as you approach the glass's side and your angle from the glass surface increases.

When uncertain, property inspectors should always assume that glass is not safety glass.

SECTION 27: DOORS

DETAILS AND STYLES

This section deals with the common details and styles of doors that may be observed during an inspection of the interior. At the end of this section, the inspector should be able to:

- list the different types of the most common doors;
- describe how each type of door operates; and
- list the components of a typical panel door.

A door is a movable barrier used to cover an opening. A door can be opened to provide egress. It can be closed and secured using a lock. When a door is open, it brings in light and ventilation. Doors assist in preventing the spread of fire. Doors can reduce noise. There are all kinds of doors. There are many names for different doors, depending upon their purpose.

The most common type of door consists of a single rigid panel that fills the doorway.

TYPES

- A Dutch door is divided in half horizontally.
- Saloon doors consist of a pair of swinging doors that are typically found in public bars, pubs and taverns, as well as some residential kitchens.
- A blind door is one designed to blend in with the adjacent wall finish.
- A French door has windows (sometimes several pairs) going the full length of the door.
- A louvered door has fixed or movable wooden fins.
- A flush door is completely smooth with a hollow-core interior and is used primarily as an interior door.
- A moulded door has a structure similar to a flush door, but the skin surface is of moulded skin.
- A brace door is made from vertical planks secured together by two horizontal planks and kept square by a diagonal plank.
- A bifold door has several sections that fold in pairs.
- A sliding glass door is made of glass, slides open, and sometimes has a screen.

Hinged

Most doors are hinged along one side. The door swings or pivots away from the opening in one direction. A swinging door has hinges that allow it to swing either outward or inward. Typical French doors have two swinging door panels that swing in or out.

Sliding

Sliding doors move along a horizontal track. The bottom of the slider door has wheels with grooves that keep the bottom of the door steady on the track. Slider doors are commonly found as the door in the rear of a house that leads to the patio, deck or backyard. Interior doors that slide inside a pocket cavity installed inside a wall are called pocket doors.

DOOR COMPONENTS

Exterior doors are typically panel doors or moulded doors that appear to be panel doors. Panel doors are also called stile and rail doors. Panel doors are built with frame and panel construction components.

Stiles

Stiles are vertical boards that run the full height of a door and compose its right and left edges. The hinges are mounted to the fixed side (known as the hanging stile) and the handle, lock, bolt and/or latch are mounted on the swinging side (known as the latch stile).

Rails

Rails are horizontal boards at the top, bottom, and sometimes also in the middle of a door that join the two stiles. The top rail and bottom rail are named for their positions. The bottom rail is also known as the kick rail. A middle rail at the height of the bolt is known as the lock rail.

Mullions

Mullions are smaller, (optional) vertical boards that run between two rails that split the door into two or more columns of panels.

Muntins

Muntins are vertical members that divide the door into smaller panels.

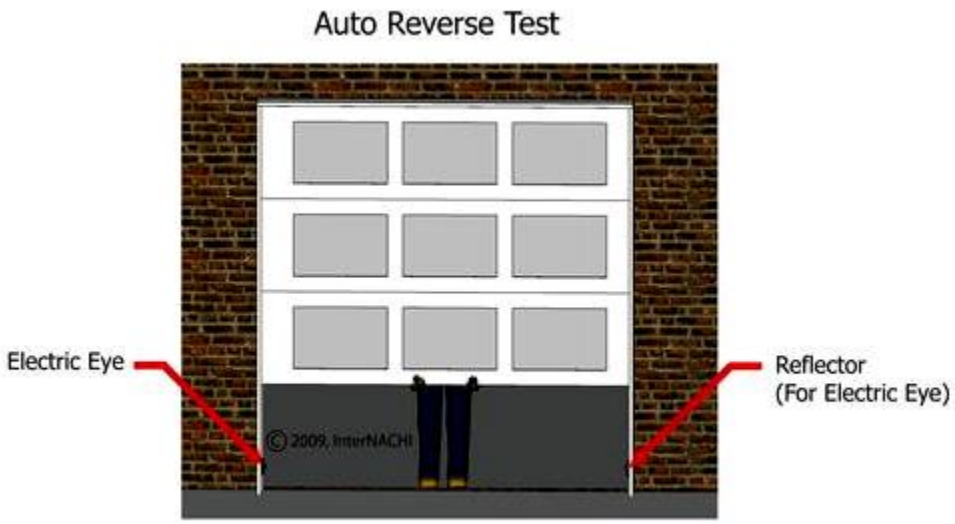
Panels

Panels are large, wide boards that fill the space between the stiles, rails and mullions. The panels typically fit into grooves in the other pieces and help to keep the door rigid. Panels may be flat, or in raised-panel designs.

Lites

Lites are pieces of glass used in place of a panel, essentially giving the door a window.

SECTION 28: GARAGE DOOR INSPECTION IN 10 STEPS



This section covers the most important parts of a basic inspection of a residential sectional garage door that is connected to an automatic garage door opener. This inspection of the garage door does not apply to tilt-up, one-piece doors -- only to sectional garage doors.

The garage door is typically the largest moving object in the house, and many of its components are under high tension. Improper installation or maintenance of a garage door can create a hazardous condition that can cause serious injury or even death.

This 10-step inspection procedure covers the safest procedures that are supported by DASMA, the Door and Access Systems Manufacturers Association. If you come across a problem with the garage door, recommend that a professional inspect it to make suggestions regarding any necessary corrections.

1. Manual Release

Begin inside the garage. Have the door closed. Check for a manual release handle, i.e., a means of manually detaching the door from the door opener. The handle should be colored red so that it can be seen easily. The handle should be easily accessible and no more than 6 feet above the garage floor.

2. Door Panels

From inside the garage with the door fully closed, check the condition of the door panels. Check for damage, cracking, denting, bulging and separation of the panels.

3. Warning Labels

The garage doors should have the following warning labels:

- a spring warning label attached to the spring assembly;
- a general warning label attached to the back of the door panel;
- a warning label near the wall control button; and
- two warning labels attached to the door in the vicinity of the bottom corner brackets. Some newer doors have tamper-resistant bottom corner brackets that do not require these warning labels.

4. Spring and Hardware

Close the door and check the springs for damage. If a spring is broken, operating the door can cause serious injury or death. Do not operate the door if there is damage. Visually check the door's hinges, brackets and fasteners. If the door has an opener, the door must have an opener-reinforcement bracket that is securely attached to the door's top section. The header bracket of the opener rail must be securely attached to the wall or header using lag bolts or concrete anchors.

5. Door Operation

Close the door. If the door has an opener, pull the manual release to disconnect the door from the opener. Lift and operate the door. If the door is hard to lift, then it is clearly out of balance. This is an unsafe condition. Raise the door to the fully-open position, then close the door. The door should move freely, and it should open and close without difficulty. As the door operates, make sure that the rollers stay in the track.

Reconnect the door to the opener, if present. This is generally done by activating the opener until it reconnects itself to the door.

6. Spring Containment

The counter-balance system is usually comprised of torsion springs mounted above the door header, or extension springs, which are usually found next to the horizontal track. When springs break, containment helps to prevent broken parts from flying around dangerously in the garage. Torsion springs are already mounted on a shaft, which inherently provides containment.

If the door has extension springs, verify that spring containment is present. Extension springs should be contained by a secure cable that runs through the center of the springs.

7. Wall Push Button

The wall button should be at least 5 feet above the standing surface, and high enough to be out of reach of small children. Press the push button to see if it successfully operates the door.

8. Location of the Photo-Electric Eyes

Federal law states that residential garage door openers manufactured after 1992 must be equipped with photo-electric eyes or some other safety-reverse feature that meets UL-325 standards.

Check to see if photo-electric eyes are installed. The vertical distance between the photo-eye beam and the floor should be no more than 6 inches.

9. Non-Contact Reversal Test

Standing inside the garage but safely away from the path of the door, use the remote control or wall button to close the door. As the door is closing, wave an object in the path of the photo-electric eye beam, such as a 2x4. The door should automatically reverse.

10. Contact Reversal Test

UL-325 requires this test, but in some rare cases, this test has damaged the door system when the opener's force setting has been improperly set, or when the opener reinforcement bracket is not securely or appropriately attached to the top section. If you have any concerns that this test may cause damage, a trained door systems technician should check the entire system and conduct the test.

Open the door. Under the center of the door, place a 2x4 flat on the floor in the path of the door. Standing inside the garage but safely away from the path of the door, use the remote control or wall button to close the door. When the door contacts the wood, the door should automatically reverse direction and return to the fully-open position.

GARAGE DOOR LABELS

The labels provide helpful safety information. Three labels were created using the guidelines of the ANSI-Z535 series of standards regarding the content and format of product safety labels.

The descriptions of the labels created by DASMA are as follows.

- CRGD-100, Garage Door Safety Instructions Safety Label:

  This label warns of hazards associated with a garage door. A list of instructions is also given pertaining to safe operation of a garage door. This label should be placed at a readable height on the door. (See Figure 1.)

- CRGD-101, Garage Door Bottom Bracket Safety Label:

  This label warns that a garage door's bottom bracket is under extreme spring tension. This label should be placed adjacent to a garage door's bottom bracket. (See Figure 2.)

- CRGD-102, Garage Door Springs Safety Tag:

  This two-sided tag warns that garage door springs are under extreme tension. This tag should be affixed directly to a garage door spring assembly such that it does not interfere with spring function. (See Figure 3.)

Figure 1

Figure 2

Figure 3

SECTION 29: EGRESS, STEPS, HANDRAILS AND ILLUMINATION

DOORS, EGRESS AND LANDINGS

EGRESS DOOR INSPECTION

Regardless of the size of the house, at least one egress door should be provided. The required door should provide access from the habitable area of the home to the outside without going through a garage.

Measure the door.

The required door must be a side-hinged door, and it must be at least 3 feet wide, and 6 feet and 8 inches tall. Other doors do not need to meet these minimum dimensions. They can be of any size and need not be a swinging type.

All egress doors shall be readily openable from the inside without the use of a tool or key, or special knowledge or effort. This standard permits a wide variety of hardware options.

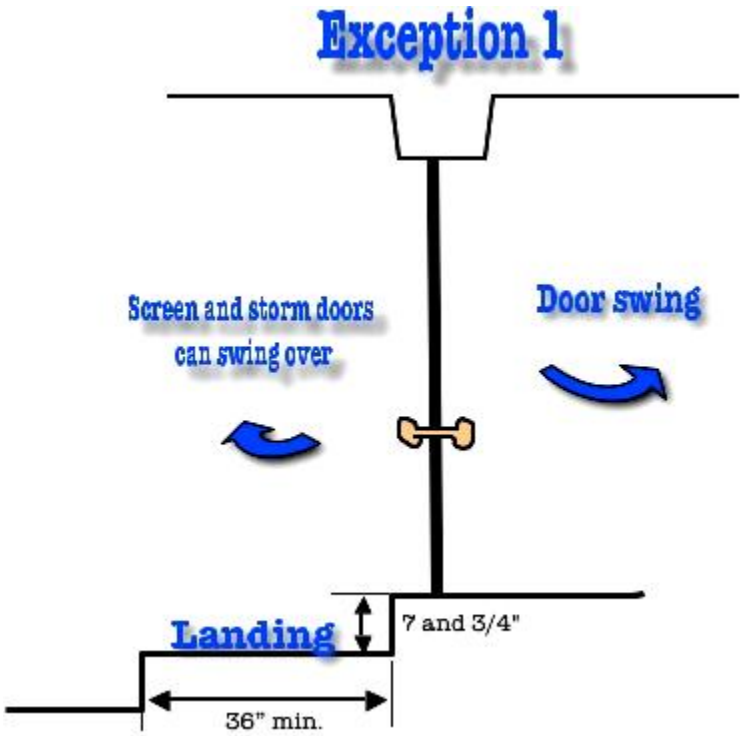
Measure the landing's width.

The width of a landing should not be less than the door's width. The minimum dimension of every landing is 36 inches measured in the direction of travel.

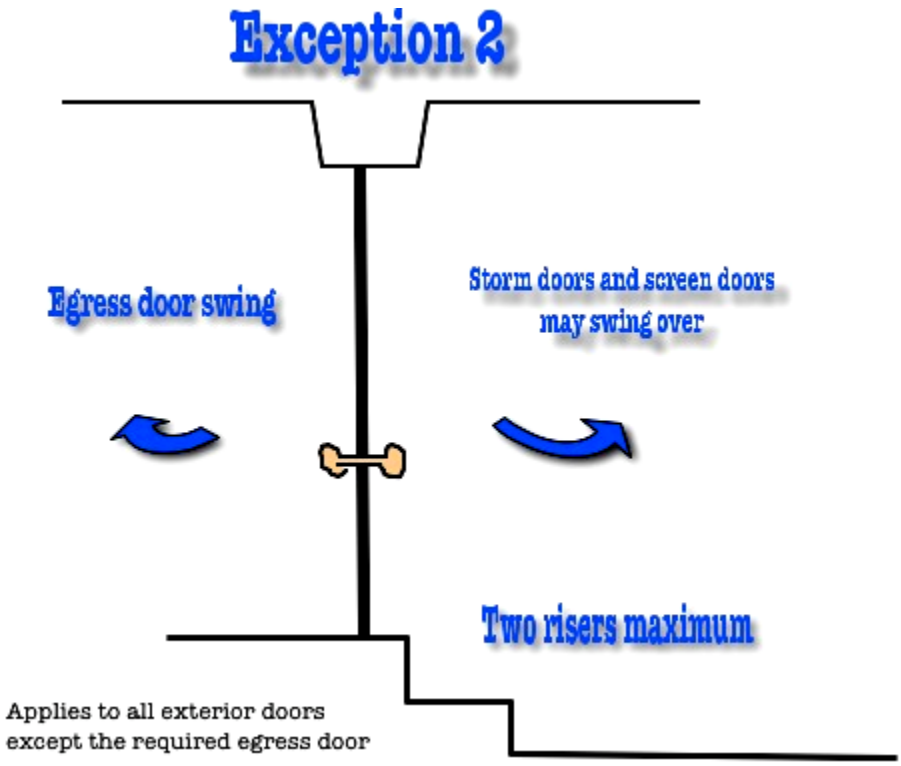
Check the floors or landings at the doors.

On each side of each exterior door, there should be a floor or landing. The floor or landing should not be more than 1-1/2 inches below the top of the threshold. There are three exceptions:

- If the door does not swing over the landing, then the exterior landing can be, at most, 7-3/4 inches below the top of the threshold. This is applicable to all exterior doors, including the required egress door. The screen and storm doors are allowed to swing over the landing. This is the most commonly used exception.
- If a stairway with, at most, two risers is at the exterior-side of a door, other than the required egress door, a landing on the outside is not required, provided the door does not swing over the stairway. Again, the screen or storm door is allowed to swing over the stairway.
- A floor at all exterior doors, other than the required egress door, should not be more than 7-3/4 inches lower than the top of the threshold. It is also acceptable to raise the threshold of an exterior door, other than the egress door, up to 7-3/4 inches above the floor on the interior-side.



The exception to the rule for a landing at an exterior door is illustrated in the graphic on the previous page. If the door does not swing over the landing, then the exterior landing can be, at most, 7-3/4 inches below the top of the threshold. This is applicable to all exterior doors, including the required egress door. The screen and storm doors are allowed to swing over the landing. This is the most commonly used exception.



Another exception to the rule for a landing at an exterior door is illustrated in the graphic above. If a stairway with, at most, two risers is at the exterior-side of a door, other than the required egress door, a landing on the outside is not required, provided the door does not swing over the stairway. Again, the screen or storm door is allowed to swing over the stairway.

HALLWAY INSPECTION

Measure the hallway's width.

The minimum width of a hallway is 36 inches.

RAMP INSPECTION

There are three main points to check while inspecting a ramp. They are the ramp's:

1. slope;
2. landings; and
3. handrails.

Check the ramp's slope.

Ramps should not have a slope greater than 1 unit vertical in 12 units horizontal, or an 8.3% slope.

EXCEPTION: In areas where it is not possible to comply with the 1:12 slope, ramps may have a maximum slope of 1:8, or a 12.3% slope.

Check the landing.

A minimum 3-foot by 3-foot landing should be installed in the following four locations:

1. at the top of the ramp;
2. at the bottom of the ramp;
3. where doors open onto the ramp; and
4. where the ramp changes direction.

Check the handrails, including their height.

There should be a handrail on at least one side of all ramps that have a slope greater than the 1:12 slope maximum. Typically, most installers install a handrail on all ramps regardless of the slope.

The height of the ramp's handrail is measured from the finished surface of the ramp. The minimum is 34 inches and the maximum is 38 inches.

Check for continuity.

Handrails should be continuous for the full length of the ramp.

Check the termination.

Handrails should end at a newel post, wall or safety terminal.

Measure the space.

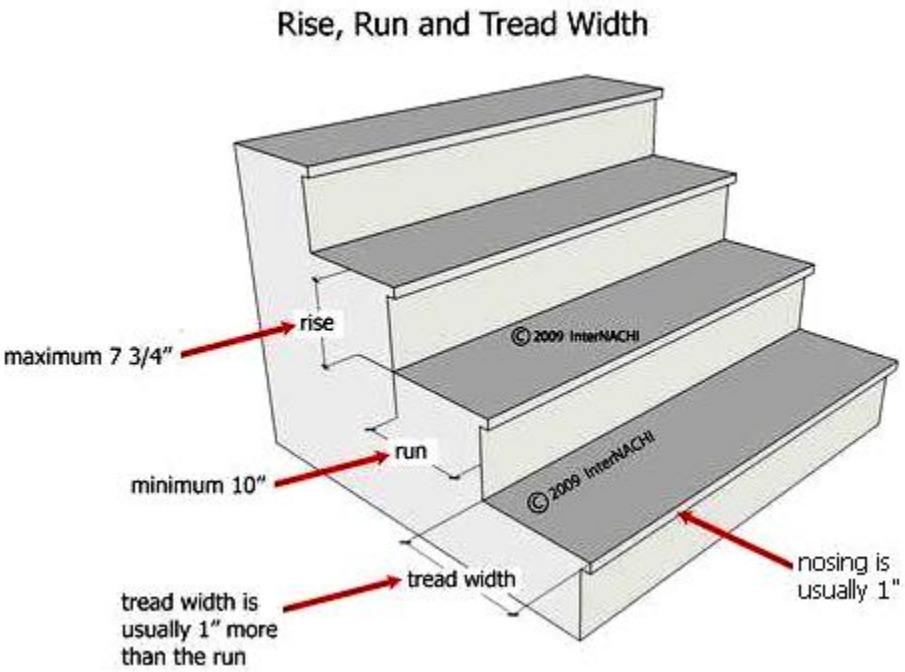
The space between a handrail at a ramp and the wall should be at least 1-1/2 inches.

Measure the length.

The maximum rise for any run shall be 30 inches.

If the slope of a ramp is between 1:12 and 1:16, the maximum rise shall be 30 inches and the maximum horizontal run shall be 30 feet. If the slope of the ramp is between 1:16 and 1:20, the maximum rise shall be 30 inches and the maximum horizontal run shall be 40 feet.

STAIRWAYS



Stairways are one of the most hazardous areas of a home, and stair falls are often fatal. Let's go over the standards and requirements of a stairway and ramp in detail so that when you are on an inspection, you will be able to recognize defects quickly and report them concisely.

HANDRAILS

First, determine whether the stairway should have a handrail.

For the U.S. and Canada: Any stairway with four or more risers should have a handrail on at least one side.

Measure the handrail's height.

The height of a handrail is measured vertically from the sloped plane adjoining the tread nosing or leading edge.

For the U.S.: The handrail height should be at least 34 inches and not more than 38 inches. (EXCEPTION: If there is a continuous handrail transition between flights, the handrail height at the transition can be greater than the maximum.)

For Canada: The handrail height should be at least 800 mm, and not more than 965 mm.

Inspect its continuity.

The handrail should be continuous for the full length of the flight of stairs, measured from a point directly above the top riser to a point directly above the bottom riser of the flight. Continuity can be interrupted by a newel post at a turn.

For the U.S.: A volute, starting easing or turnout can be installed over the lowest tread.

For Canada: A doorway or landing can interrupt continuity.

Check the handrail's termination.

For the U.S.: Handrails should end at a newel post or a wall.

For Canada: Handrails shall terminate in a manner that will not obstruct travel or create a hazard.

Check the handrail clearance.

For the U.S.: Handrails adjacent to a wall should have a space of not less than 1-1/2 inches between the wall and the handrails.

For Canada: Handrails adjacent to a wall should have a space of not less than 50 mm between the wall and the handrails, or 60 mm if the surface behind the handrail is rough or abrasive.

Check the handrail attachment to the wall.

For the U.S.: The handrail should have attachment devices to transfer to the structural wall a concentrated load of 200 pounds applied at any point in any direction.

For Canada: The handrail should have attachment devices to transfer to the structural wall a concentrated load of 0.9 kN applied at any point in any direction. The attachment points shall not be spaced more than 1.2 m apart. The first attachment point should be no more than 300 mm from the end of the handrail. If attached to wooden structural components, the fasteners shall consist of at least two wood screws at each point, penetrating at least 32 mm into solid wood.

STAIRWAY WIDTH

For the U.S.: When a handrail is installed on only one side, the minimum clear width of the stairway at and below the handrail height is at least 31-1/2 inches. When handrails are installed on both sides, the minimum clear width of the stairway at and below the handrail height is at least 27 inches.

For Canada: A handrail shall be provided on at least one side of stairs less than 1,100 mm in width. A handrail shall be provided on both sides 1,100 mm in width or greater.

A handrail shall be provided on both sides of curved stairs of any width, except those within a dwelling unit.

Measure the width of the stairway.

For the U.S.: Stairways should be at least 36 inches wide. This is measured at all points above the handrail height and below the required headroom height. For spiral stairways, there should be a width of at least 26 inches measured at and below the handrail.

For Canada: Required exit stairs shall have a width of not less than 900 mm. At least one stair between each floor level within a dwelling unit, and exterior stairs serving a single dwelling unit except required exit stairs, shall have a width of not less than 860 mm.

Measure handrail projections.

For the U.S.: Handrails should not project more than 4-1/2 inches on either side of the stairway.

For Canada: Handrails should not project more than 100 mm on either side of the stairway.

Be sure to measure projections other than the handrail.

Typically, when a building standard requires a minimum width, it is expected that the width be the clear, net, usable, unobstructed width. However, the standard described here is not concerned with components such as trim, stringers, or other items that may be found below the handrail, as long as they do not exceed the projection of the handrail. The stairway width limitations are based on the body's movements as a person walks on a stairway.

For the U.S.: Projections of 4-1/2 inches or less located below the handrail, including treads, trim, stringers or other items, are permitted.

For Canada: Projections of 100 mm or less below the handrail into the required width of the stairway are permitted.

RISERS AND TREADS

Measure the riser height, including any differences.

For the U.S.: The minimum riser height is 4 inches, and the maximum is 7-3/4 inches. For spiral stairs, the maximum rise is 9-1/2 inches.

For Canada: The minimum riser height is 125 mm, and the maximum is 200 mm. For curved or spiral stairs, the rise shall be between 125 mm and 180 mm.

Any significant variation that would interfere with the rhythm of a person's natural stride should be avoided.

For the U.S.: The greatest riser height within any flight of stairs should not exceed the smallest by more than 3/8-inch.

For Canada: The greatest riser height within any flight of stairs should not exceed the smallest by more than 6 mm.

Measure the tread depth.

For the U.S.: The minimum tread depth is 10 inches. For winders, this is measured at the 12-inch walk line.

For Canada: The minimum tread depth is 235 mm, and the maximum tread depth is 355 mm. The minimum run is 210 mm, and the maximum is 355 mm.

Measure the difference between the treads' depths.

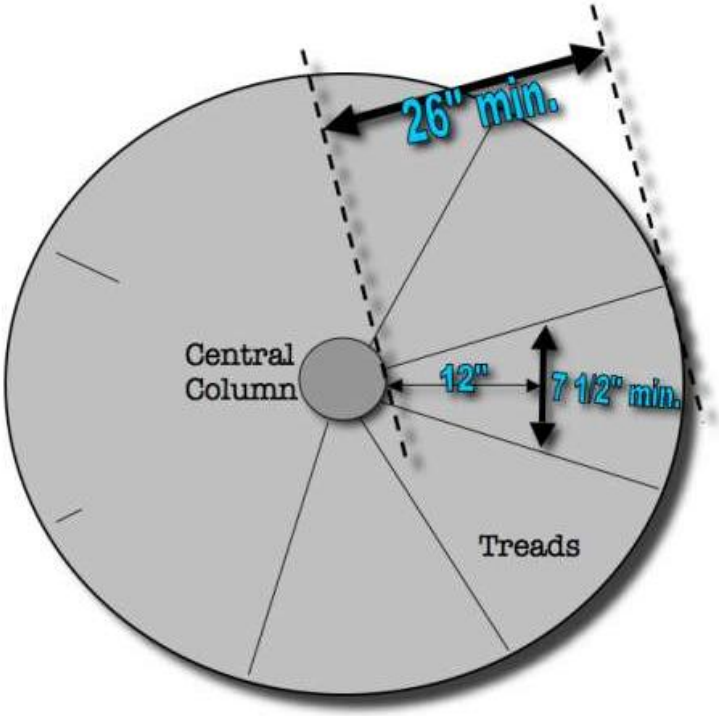
For the U.S.: The greatest tread depth within any flight of stairs should not exceed the smallest by more than 3/8-inch.

For Canada: The greatest tread depth within any flight of stairs should not exceed the smallest by more than 6 mm.

The tolerance for differences allowed for risers and treads is because construction practices make it difficult to create identical riser heights and tread dimensions in the field.

Inspect the treads in spiral staircases.

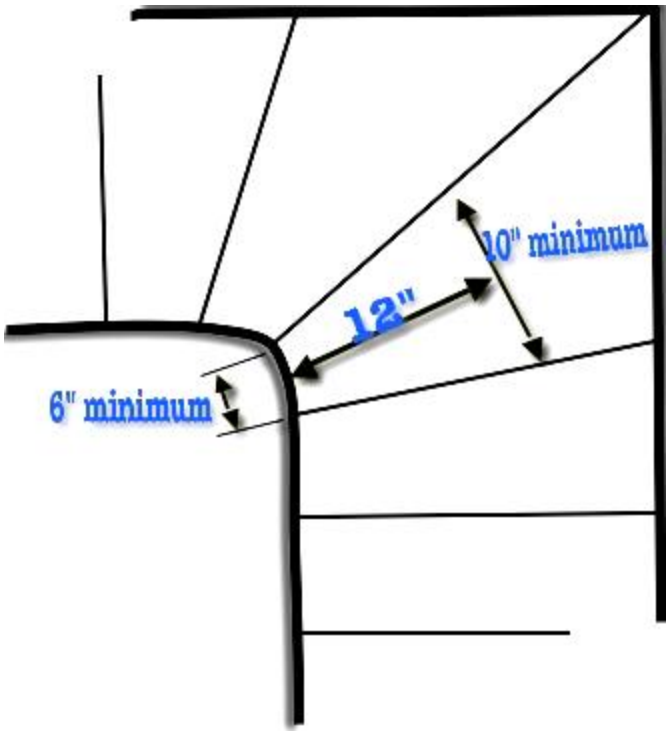
For the U.S.: For spiral stairs, all treads should be identical. Each tread should have a depth of at least 7-1/2 inches at 12 inches from the narrower edge.



For Canada: For spiral stairs, all treads should have a minimum run of not less than 150 mm, and an average run of not less than 200 mm.

Inspect the winder stair treads.

For the U.S.: For winder stairs, treads should have a depth of at least 10 inches measured at a point 12 inches from the side where the treads are narrowest. Winder treads should have a depth of at least 6 inches at any point.



For Canada: Where angled treads or winders are incorporated into a stair, the treads in sets of angled treads or winders within a flight shall turn in the same direction. A set of winders shall not turn through more than 90 degrees. Winder-type turns in stairs are limited to 30 or 45 degrees only. The run should be at least 280 mm measured 230 mm away from the handrail at the narrow end of the tread.

Check the slope.

For the U.S.: The walking surface of the stairway treads and landings should be sloped no steeper than 1 unit vertical in 48 units horizontal, which is a 1/4:12 ratio (or a 2% slope).

For Canada: The cross-slope of treads and landings shall not exceed 1 in 100, which is a 1:100 ratio (or a 1% slope).

Check the loads.

For the U.S.: The minimum concentrated load on stair treads on an area of 4 square inches is 300 pounds.

For Canada: The load on the stair shall be designed for strength and rigidity under uniform loading criteria to support 1.9 kPa (kiloPascal) for stairs serving a dwelling unit.

For both the U.S. and Canada: Check for cracked, damaged and loose treads.

NOSING AND LEADING EDGE

Inspect the nose or leading edge.

For the U.S.: On stairways with solid risers, there should be a nosing at least 3/4-inch and not more than 1-1/4 inches. The radius of a nosing curve should be no greater than 9/16-inch. A nosing is not required when the tread depth is 11 inches or more.

For Canada: The nose of treads that are beveled or rounded shall not exceed 25 mm horizontally. The leading edge of the stair tread shall have a radius or bevel between 6 mm and 10 mm in the horizontal direction.

GUARDS

Inspect the guards.

Guards should be constructed so as to prevent adults from falling over them and children from crawling through them. The height of a guard is measured vertically from the sloped plane adjoining the tread nosing or leading edge.

Check the guard's strength.

For the U.S.: The design strength of a guard should resist a 200-pound concentrated load applied at any point in any direction along the handrail or the top of the guard.

For Canada: The design strength for a guard should resist a horizontal load of 0.5 kN/m (kiloNewton) or concentrated load of 1 kN applied inward or outward at any point at the top of the guard. The top of the guard shall resist an evenly distributed vertical load of 1.5 kN/m.

Check the strength of rails and balusters.

For the U.S.: Intermediate rails and balusters should be able to withstand a horizontal load of 50 pounds on an area equal to 1 square foot.

For Canada: The guard shall resist a horizontal load applied inward or outward on the elements within the guard, including solid panels and pickets, of 0.5 kN applied over a maximum width of 300 mm and a height of 300 mm imposed, engaging at least three balusters.

Measure the height of the elevated floor level.

All decks and porches, including those with insect screening, landings, balconies, mezzanines, galleries, ramps or raised floor surfaces located more than 30 inches (U.S.) or 1.2 m (Canada) above the floor or ground should have guards. A guard is necessary at those elevated floor areas because a fall from that height can result in injury.

For Canada:

- Where an interior stair has more than two risers, the sides of the stair and the landing or floor level around the stairwell shall be protected by a guard on each side that is not protected by a wall.
- A guard is required where there is a difference in elevation of more than 600 mm between the walking surface or adjacent surface, or where the adjacent surface within 1.2 m of the walking surface has a slope of more than 1:2.
- In dwelling units, openable windows over stairs, landings and ramps that extend to less than 900 mm above the surface of the treads, ramp or landing shall be protected by a guard.

Measure the guard height.

For the U.S.: The minimum height of the horizontal guard is 36 inches. Open sides of stairways with a total rise of more than 30 inches above the floor or ground should have guards not less than 34 inches in height.

For Canada: The minimum height for interior guards is 900 mm. Where the walking surface served by a guard is not more than 1,800 mm above the finished ground level, the minimum height of an exterior guard is 900 mm; otherwise, the minimum height for all exterior guards is 1,070 mm. The maximum height of a required guard at a landing shall not exceed 1,070 mm.

Check for damage.

For the U.S. and Canada: Inspect for cracked, loose and missing intermediate rails.

Check for a ladder effect.

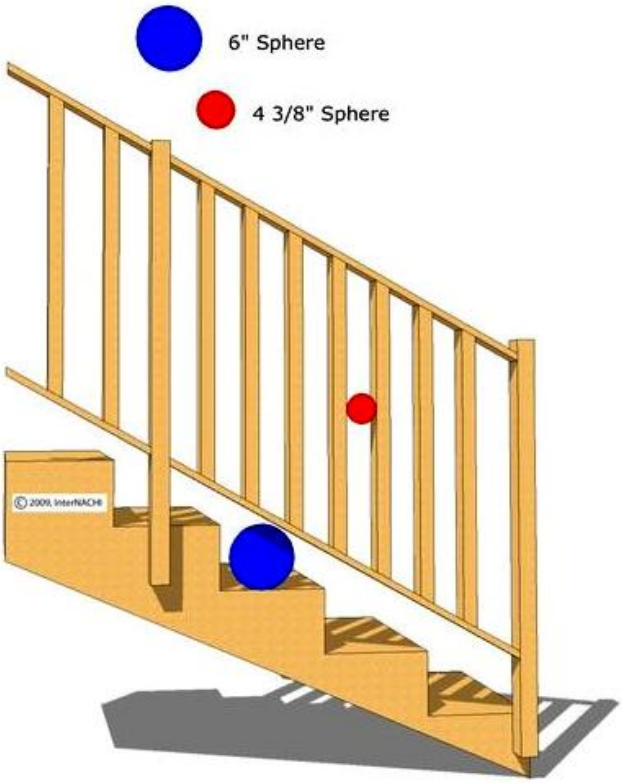
For the U.S. and Canada: Guards should not have horizontal or ornamental patterns, members, attachments or openings that would facilitate climbing.

Inspect the glass in guards.

For the U.S.: Glass used as a handrail assembly or a guard section should be constructed of single, fully-tempered glass, laminated fully-tempered glass, or laminated heat-strengthened glass. The minimal nominal thickness is 1/4-inch. Each pane of safety glazing installed shall be identified by a manufacturer's designation, which shall be acid-etched, sand-blasted, ceramic-fired, laser-etched, embossed, or of a type that, once applied, cannot be removed without being destroyed.

For Canada: Glass in guards shall be wired glass or safety glass of the laminated or tempered type.

SPHERES



For the U.S.: Horizontal guards at raised floor areas, balconies and porches should have intermediate rails or ornamental enclosures that do not allow the passage of a 4-inch-diameter sphere.

For Canada: Openings through any guard shall be of a size that will prevent the passage of a spherical object having a diameter of 100 mm, unless it can be shown that it will not represent a hazard.

For the U.S.:

- Open risers should not allow the passage of a sphere 4 inches in diameter. On stairs with a total rise of 30 inches or less, the size of the open riser is not limited.
- The triangular area formed by a tread, riser and guard should not allow passage of a sphere 6 inches in diameter.
- The opening at guards on the sides of stair treads should not allow the passage of a sphere 4-3/8 inches in diameter.

HANDGRIPS

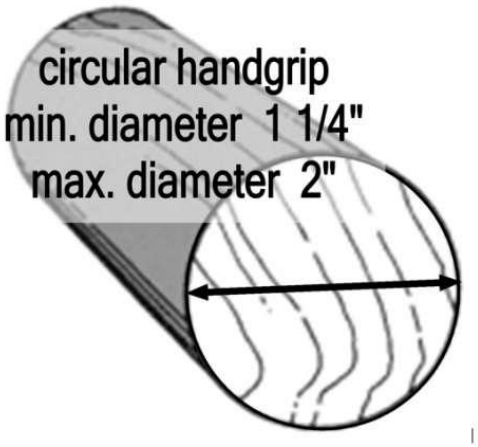
Inspect the handgrip of the handrail.

A handgrip should be graspable along the entire length of the handrail. The handgrip's shape should provide a graspable surface. It should allow the user to maintain a consistently secure and natural grasp on the handrail without twisting the fingers or requiring release. The handgrip can be circular or non-circular.

Inspect the circular handgrip.

For the U.S.: A circular handgrip should have a cross-section a minimum of 1-1/4 inches and a maximum of 2 inches. All handrails should be equivalently graspable to the 2-inch circular handgrip.

For Canada: A circular handgrip should have a cross-section a minimum of 30 mm and a maximum of 43 mm.

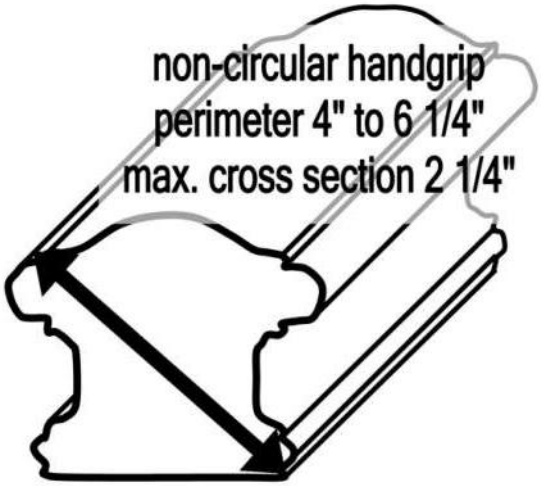


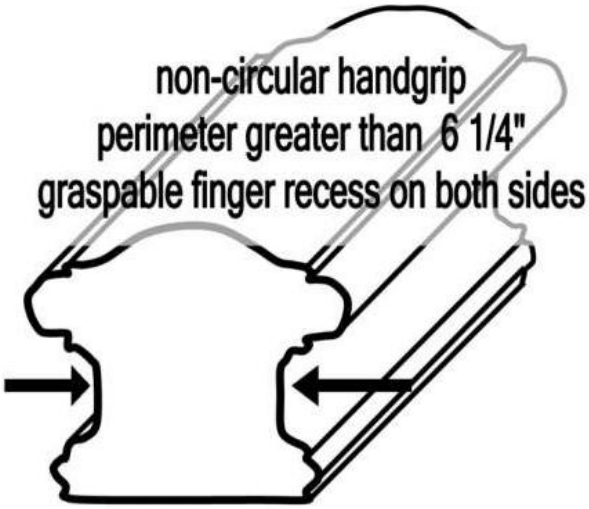
Inspect the non-circular handgrip.

For the U.S.: A non-circular handgrip with a perimeter a minimum of 4 inches and a maximum of 6-1/4 inches should have a maximum cross-section of 2-1/4 inches.

A non-circular handgrip with a perimeter greater than 6-1/4 inches should have a graspable finger recess on both sides.

For Canada: A non-circular handgrip with a perimeter a minimum of 100 mm and a maximum of 125 mm should have a maximum cross-section of 45 mm.





ABOVE AND BELOW THE STAIRS

Measure the headroom above the stairs.

Headroom is measured vertically from the sloped plane adjoining the tread nosing or from the floor surface of the landing or platform.

For the U.S.: The headroom in all parts of a stairway should not be less than 6 feet and 8 inches. Spiral stairways should have headroom of at least 6 feet and 6 inches.

For Canada: The headroom shall not be less than 1,950 mm for stairs within dwelling units, and 2,050 mm for stairs not within dwelling units.

Inspect below the stairs.

For the U.S.: An enclosed, accessible space under stairs should be protected on the enclosed side with 1/2-inch gypsum board.

For the U.S. and Canada:

- Check for water damage at the bottom of the stair stringer boards.
- Inspect below the stairs for mold and damage caused by insect infestation.

Check for ground contact.

For the U.S.: Wooden stair components in contact with the ground or in contact with concrete exposed to the weather shall be of approved pressure-preservative-treated wood suitable for ground-contact use.

For Canada: Exterior wood steps shall not be in direct contact with the ground unless suitably treated with a wood preservative.

LANDINGS, ILLUMINATION AND ATTACHMENT

LANDINGS

Inspect the landings.

For the U.S. and Canada: A floor or landing is required at both the top and bottom of a stairway. There is an exception: A floor or landing is not required at the top of an interior flight of stairs, including stairs in an enclosed garage, provided that a door does not swing out over the stairs.

For Canada: A landing may be omitted at the top of an interior flight of stairs serving a secondary entrance, not including from an attached garage, provided that the stairway does not contain more than three risers.

Inspect the total rise of the stairway.

For the U.S.: A stairway should not have a vertical rise greater than 12 feet between floor levels or landings.

For Canada: A stairway shall not exceed 3.7 m.

Inspect the width of the landing.

For the U.S.: Every landing should be at least 36 inches measured in the direction of travel. The width of the landing should not be less than the width of the stairway.

For Canada: The landing should be at least the width of the stairway. The landing length should be not less than 860 mm for a landing turn of less than 30 degrees within the dwelling unit, and not less than 900 mm for a landing turn of less than 30 degrees outside the dwelling unit. The length of the landing with a turn of 30 to 90 degrees should be not less than 230 mm measured at the inside edge of the landing, and not less than 370 mm measured 230 mm from the inside edge of the landing or handrail.

Also for Canada: A landing may be omitted at the bottom of an exterior stair, provided that there is no obstruction, such as a gate or door, within the 900 mm-width for stairs serving the dwelling unit, or within the 1,100 mm-width for stairs not serving the dwelling unit.

ILLUMINATION

Check for lighting at the stairs.

For the U.S. and Canada: All interior and exterior stairways should have a means to illuminate the stairs, including landings and treads.

For the U.S.: Interior stairways should have a light located at each landing, except when a light is installed directly over each stairway section.

Check the controls.

For the U.S. and Canada: Lights at an exterior stairway should be controlled from inside the property.

Interior Stairways

For the U.S.: Interior stairways with at least six risers require wall switches at each floor level, unless the lights are continuously illuminated or automatically controlled.

For Canada: Interior stairways with four or more risers shall have three-way wall switches located at the head and foot of every stairway to control at least one light fixture.

Exterior Stairways

For the U.S.: Exterior stairways should have a light located at the top of the stairway.

Also for the U.S.: Exterior stairways from the outside ground level to a basement should have a light at the bottom of the stairway.

ATTACHMENT

Check the attachment to the structure.

Required egress stairways, decks, balconies, and similar means of egress should be anchored to the primary structure to resist both vertical and lateral forces. The use of toenails or nails subject to withdrawal is not permitted.

SECTION 30: EMERGENCY ESCAPE AND RESCUE OPENINGS

An emergency egress is an exterior window, egress door or similar component that can serve as a means of escape and access for rescue in case of an emergency.

Deck Obstructing Emergency Egress

OPENING

Check for the required opening.

Basements and every sleeping room should have at least one emergency escape and rescue opening. Such openings should open directly onto a public street, public alley, yard or court.

Check sleeping rooms.

Where basements contain one or more sleeping rooms, these openings should be installed in each sleeping room but are not required in adjoining areas of the basement.

Exception: Basements used for mechanical equipment only and not larger than 200 square feet need not have an emergency escape and rescue opening.

Measure the sill height.

The sill height of the opening should not be more than 44 inches above the floor.

Measure the opening.

The minimum net-clear opening required is 5.7 square feet.

Exception: Grade/floor openings shall have a minimum net-clear opening of 5 square feet.

Measure the height and width of the opening.

The minimum net-clear height of the opening is 24 inches.

The minimum net-clear width of the opening is 20 inches.

Check the window's operability.

The emergency escape and rescue opening should be operational from the inside without the use of tools, keys or special knowledge.

WINDOW WELL

Measure the window well.

The horizontal area of the window well should be at least 9 square feet. It should have a horizontal projection and width of at least 36 inches each way.

Exception: Ladders or steps may project into the space 6 inches.

Measure the vertical depth and the ladder or steps.

Wells with a vertical depth of at least 44 inches should have a permanent ladder or steps, with an inside width of 12 inches minimum, and at least 3 inches from the wall, and should be spaced no greater than 18 inches apart vertically.

Open the bulkhead.

Bulkheads should open to a fully-open position, and they should meet the minimum net-clear opening requirements.

Check the covers.

A set of bars, a grille, a cover or a screen is permitted over an egress opening, provided that the minimum net-clear opening requirements are met. Such devices should be removable from the inside without the use of a key, tool, special knowledge, or force greater than that which is needed for normal operation of the emergency escape and rescue opening.

Check the decks and porches.

Emergency escape and rescue openings are allowed to be under decks and porches, provided that the opening can still be fully opened, and there is an egress path at least 36 inches high leading to a yard or court.

QUIZ 12

1. T/F: The lites in a window sash are divided horizontally and vertically by narrow strips of wood or metal called muntins.

- True
- False

2. T/F: The required egress door is a side-hinged door at least 3 feet wide, and 6 feet and 8 inches tall.

- True
- False

3. T/F: The minimum height for a riser is 4 inches and the maximum height is 7-3/4 inches.

- True
- False

4. The minimum tread depth for a standard stair is ___ inches.

- 10
- 11
- 12
- 14

5. Intermediate rails or balusters should be able to withstand a horizontal load of ____ pounds on an area equal to 1 square foot.

- 15
- 20
- 30
- 50

6. The greatest tread depth within any flight of stairs should not exceed the smallest by more than ____.

- 1/4-inch
- 1/2-inch
- 3/8-inch
- 5/8-inch

(continued)

7. The design strength of a guard should resist a _____-pound concentrated load applied at any point in any direction along the handrail or the top of the guard.

- 100
- 150
- 200
- 300

8. The minimum height of a horizontal guard is ___ inches.

- 30
- 32
- 34
- 36

9. Horizontal guards at raised floor areas, balconies and porches should have intermediate rails or ornamental enclosures that do not allow the passage of a ___-inch diameter sphere.

- 3
- 4
- 4-1/2
- 6

10. T/F: A handrail should allow the user to maintain a consistently secure and natural grasp on without twisting the fingers or requiring release.

- True
- False

11. T/F: An enclosed accessible space under stairs should be protected on the enclosed side with 1/2-inch gypsum board.

- True
- False

12. Every landing should be at least ____ inches measured in the direction of travel.

- 24
- 30
- 36
- 42

(***continued)***

13. T/F: Basements and every sleeping room should have at least one emergency escape and rescue opening.

- True
- False

14. In relation to emergency escape and rescue openings, the sill height of the window opening should not be more than ___ inches above the floor.

- 24
- 44
- 48
- 52

15. In relation to emergency escape and rescue openings, the horizontal area of a window well should be at least ___ square feet.

- 3
- 6
- 9
- 12

Answer Key is on the next page.

Answer Key to Quiz 12

1. T/F: The lites in a window sash are divided horizontally and vertically by narrow strips of wood or metal called muntins.
   Answer: True

2. T/F: The required egress door is a side-hinged door at least 3 feet wide, and 6 feet and 8 inches tall.
   Answer: True

3. T/F: The minimum height for a riser is 4 inches and the maximum height is 7-3/4 inches.
   Answer: True

4. The minimum tread depth for a standard stair is 10 inches.

5. Intermediate rails or balusters should be able to withstand a horizontal load of 50 pounds on an area equal to 1 square foot.

6. The greatest tread depth within any flight of stairs should not exceed the smallest by more than 3/8-inch.

7. The design strength of a guard should resist a 200-pound concentrated load applied at any point in any direction along the handrail or the top of the guard.

8. The minimum height of a horizontal guard is 36 inches.

9. Horizontal guards at raised floor areas, balconies and porches should have intermediate rails or ornamental enclosures that do not allow the passage of a 4-inch diameter sphere.

10. T/F: A handrail should allow the user to maintain a consistently secure and natural grasp without twisting the fingers or requiring release.
    Answer: True

11. T/F: An enclosed accessible space under stairs should be protected on the enclosed side with 1/2-inch gypsum board.
    Answer: True

12. Every landing should be at least 36 inches measured in the direction of travel.

13. T/F: Basements and every sleeping room should have at least one emergency escape and rescue opening.
    Answer: True

14. In relation to emergency escape and rescue openings, the sill height of the window opening should not be more than 44 inches above the floor.

15. In relation to emergency escape and rescue openings, the horizontal area of a window well should be at least 9 square feet.

SECTION 31: FLOORS, WALLS AND CEILINGS

Inspection Tips

Floors in a home are designed as walking surfaces that support people and furniture. Floors should be level, smooth and durable. Some common flooring materials include wood, concrete, carpet and tile.

Water damage is one of the major conditions to look for when inspecting the interior. Water damage can often be found around areas where there is water, such as at the toilet or sink. More than any other fixture, toilets leak water and cause major structural damage. Check around the bathroom toilets, especially when the flooring is made of wood. Make sure the toilet is securely attached to the floor and not leaking water from a bad seal.

If you are not able to determine what material the floor is made of, you could find a floor register (if one exists in the house) and remove it. You will be able to see the edges of the flooring materials, from the sub-floor decking to the top-floor covering, and make a determination of the floor's materials. Be sure to replace the register securely.

There are many things to look for in relation to inspecting the interior floors. Some conditions include:

- trip hazards;
- water damage;
- loose or cracked tiles or grout;
- wet areas;
- cracked, heaving or improperly sloped concrete;
- wood rot, buckled boards or squeaks; and
- stained carpeting.

Walls

Common materials that make up the walls of a home include:

- plaster;
- drywall;
- wood boards;
- wood paneling; and
- plywood.

There are many things to look for in relation to inspecting the interior walls. Some conditions include:

- water damage;
- cracking;
- nail pops;
- bulging;

- thermal bridging; and
- wood rot.

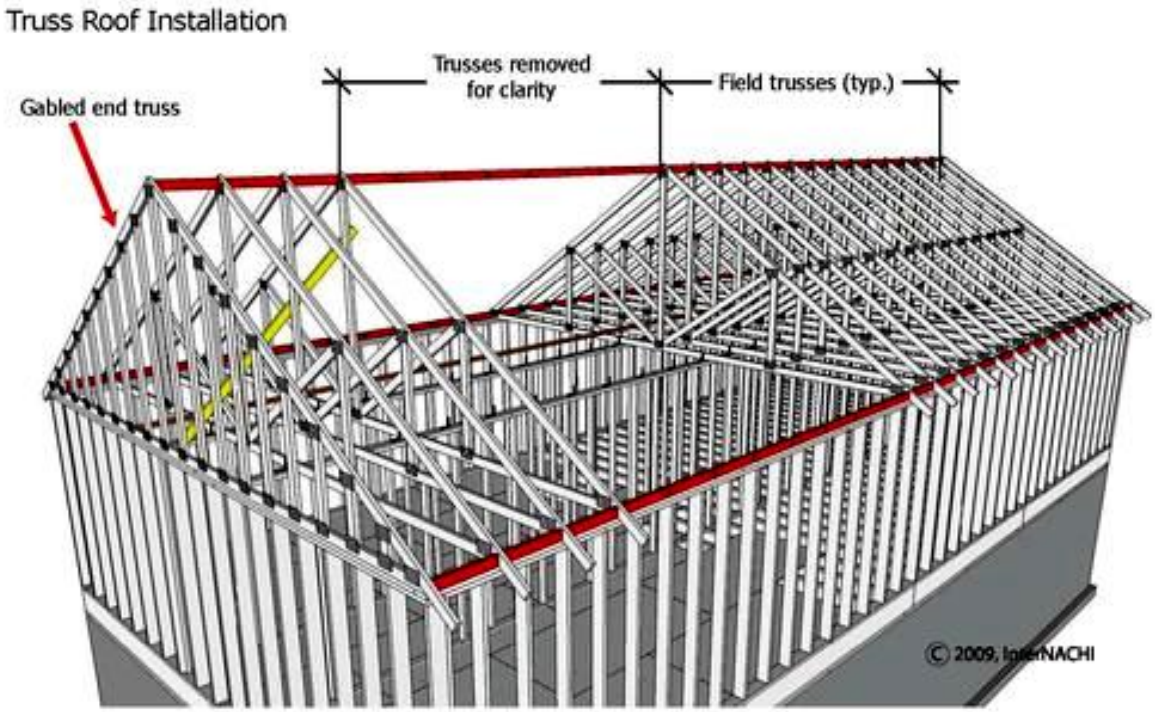
Ceilings

The ceiling materials are similar to those of the walls. The things to look for at the ceilings include:

- water damage;
- cracks;
- bulges hanging down;
- nail pops; and
- poor drywall joints.

Drywall Truss Uplift

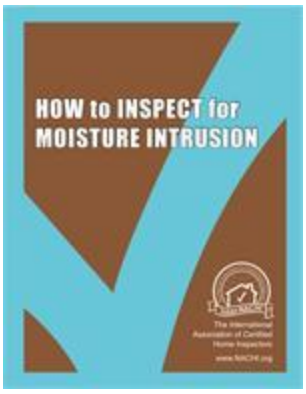
Truss uplift may be discovered when inspecting the ceiling. It occurs when the roof's structural system is made up of trusses. The bottom chord of the truss arches up and cracks the drywall ceiling below. If the bottom of the chord is securely attached to the top of the interior wall, the entire wall might lift up with the truss. This uplift condition of the truss may be cyclical. It may lift in the winter and drop in the summer. One correction is to not attach the drywall to the ceiling within 18 inches of the intersection of the wall and ceiling. This will allow some play for the truss to lift and the drywall in the ceiling corner to move and not crack.

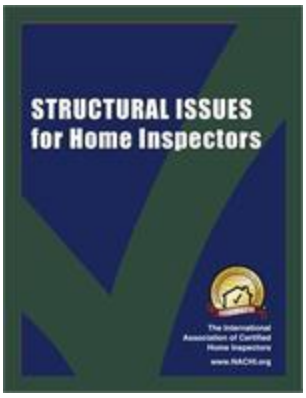


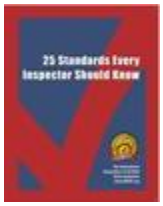
RESOURCES

Additional information about insulation is available from the sources listed below. Your local public utility company may also provide information about home energy-conservation practices and materials.

- ENERGY STAR Programs supported by the U.S. Environmental Protection Agency: www.energystar.gov
- U.S. Department of Energy, Energy Efficiency and Renewable Energy Program Office: www.eere.energy.gov
- Consumer's Guide to Energy Efficiency and Renewable Energy in the Home: www.eere.energy.gov/consumer/your_home/
- ZIP Code Computer Program: www.ornl.gov/~roofs/Zip/ZipHome.html
- International Association of Certified Home Inspectors (InterNACHI): www.nachi.org







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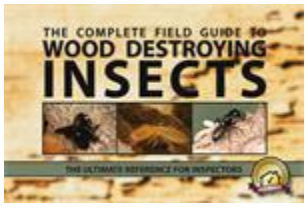

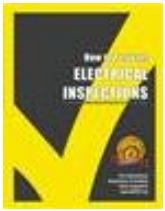

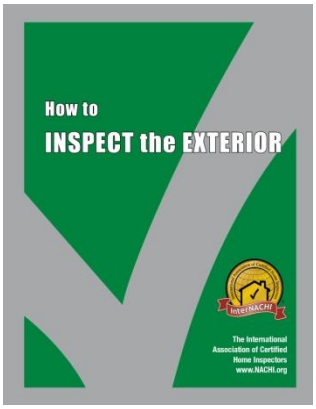

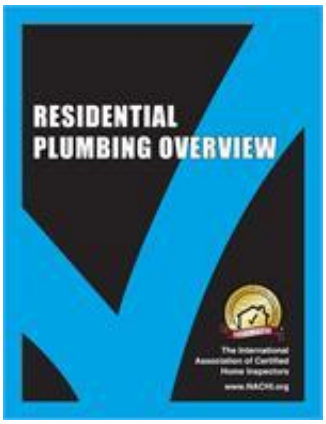

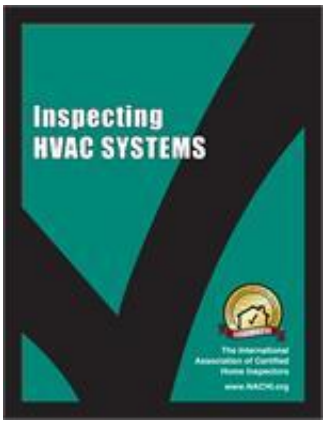

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