

Chapter 4

Air Leakage Sealing – Materials and Techniques

Air leakage is a major problem for both new and existing homes and can:

- Contribute 30 percent or more to heating and cooling costs
- Create comfort and moisture problems
- Draw in pollutants such as radon and mold
- Occur in openings which also serve as a prime entry for insects and rodents

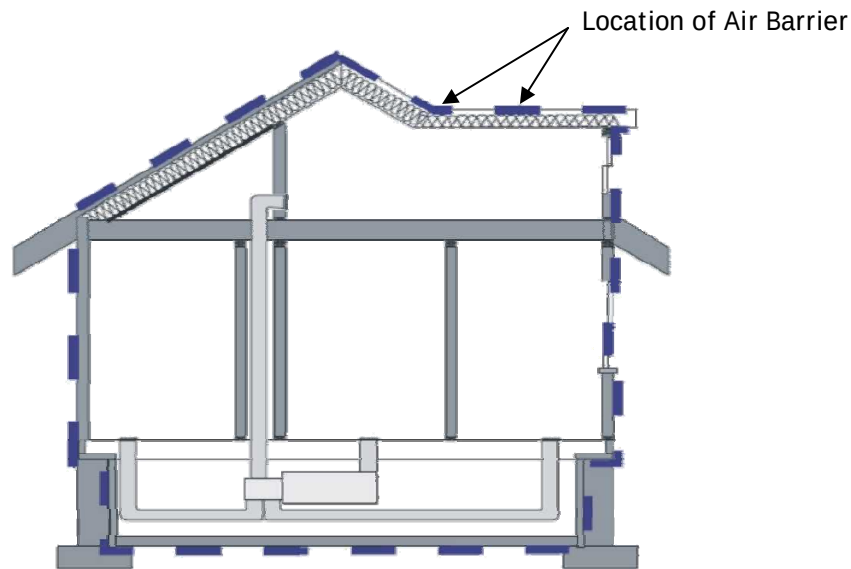
To reduce air leakage effectively requires a *continuous air barrier system* (sometimes called an *air retarder system*) — a combination of materials linked together to create a tight building envelope. An air barrier also minimizes air currents through insulation, helping maintain R-values. The air barrier should minimize air leakage through the building envelope - the boundary between the conditioned portion of the home and the unconditioned area.

Most standard insulation products are not effective at sealing air leakage. The R-value for these materials may drop if air leaks through the material. Some spray applied insulation materials, such as higher density fiberglass, rock wool, cellulose, and foam can seal against air leakage. However, these materials are often only applied in framing cavities; therefore, additional air sealing must be done between framing components.

The builder should work with his or her own crew and subcontractors to seal all holes through the envelope. Then, he or she should install a continuous air barrier material, such as drywall or housewrap, around the envelope. It is critical in the air sealing process to use durable materials and install them properly.

The air barrier constitutes the pressure boundary of the home as discussed in Chapter 3. The pressure, moisture, and thermal boundaries should coincide: otherwise, cold winter air may leak past the insulation, or water vapor may enter an uninsulated space where it encounters building materials below the dew point. Always draw sections of your home similar to Figure 4-1 in order to locate the pressure boundary distinctly.

Figure 4-1
Creating a Pressure Boundary



1. Install continuous Insulation
2. Seal penetrations and bypasses
3. Install and seal air-barrier material

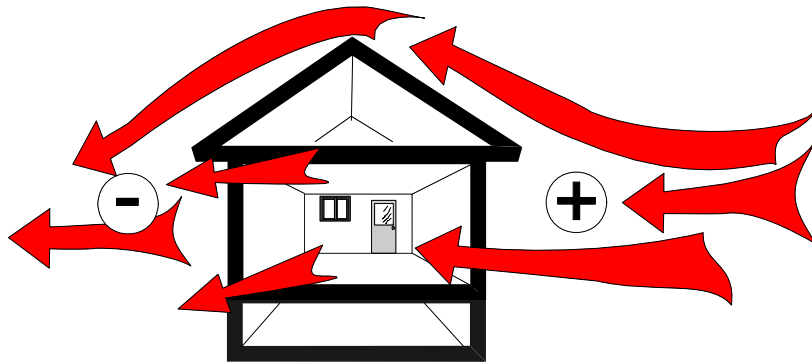
Air Leakage Driving Forces

Air leakage requires two main ingredients:

- Holes - the larger the hole, the greater the air leakage. Large holes have higher priority for air sealing efforts.
- Driving force - a pressure difference that forces air to flow through a hole. Holes that experience stronger and more continuous driving forces have higher priority. The common driving forces are:
 - *wind* - caused by weather conditions
 - *stack effect* - upward air movement of warmer air
 - *mechanical blowers* - induced pressure imbalances caused by operation of fans and blowers

Wind is usually considered to be the primary driving force for air leakage. When the wind blows against a building, it creates a high pressure zone on the windward areas. Outdoor air from the windward side infiltrates into the building while indoor air exits on the leeward side. Wind acts to create areas of differential pressure which causes both infiltration and exfiltration. The degree to which wind contributes to air leakage depends on its velocity and duration.

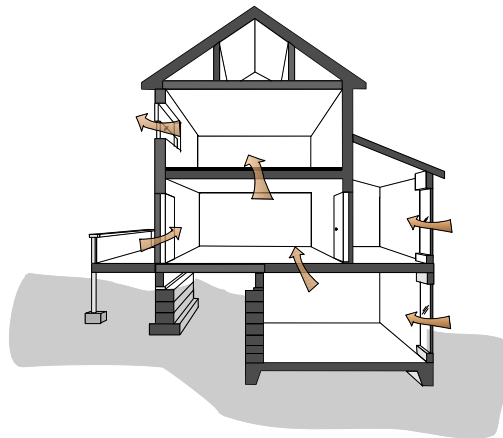
Figure 4-2
Wind Driven Infiltration



On average, wind may generate a pressure difference of 10 to 20 Pascals on the windward side. However; most homes have only small cracks on the exterior, and winds are variable.

Stack Effect: Heat transfer through the “envelope” causes warm air inside the home to rise and the heavier cool air to fall, creating a driving force known as the *stack effect*. The stack effect can vary from weak to strong, but is almost always present. Most homes have various sized holes leading into the attic and crawlspace or basement. Because the stack effect is so prevalent and the holes through which it drives air are often so large, it is usually a major contributor to air leakage, moisture, and air quality problems. Air may infiltrate at low elevations, and exfiltrate at upper elevations due to this effect. This brings in outside air at temperature and humidity level which is ambient. The HVAC may use far more energy. Air already heated or cooled may be forced to the outside in upper level holes or openings.

Figure 4-3
The Stack Effect

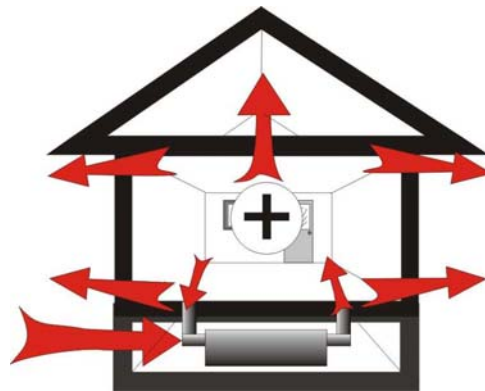


The stack effect can create pressure differences between 1 to 3 Pascals due to the power of rising warm air. Crawlspace and attic holes are often large.

Forced-air heating and cooling systems that are either poorly designed or installed can create three types of driving forces for air leakage:

- Suction pressures that pull outside air into return duct leaks.
- HVAC blower forces heated or cooled air out of the supply ductwork which ends up leaking to the exterior.
- Duct-related problems can create pressure imbalances in the home that increases air leakage through holes in the pressure boundary.

Figure 4-4
Mechanical System Driven Infiltration



Leaks in supply and return ductwork can cause pressure differences of up to 30 Pascals. Exhaust equipment such as kitchen and bath fans and clothes dryers can also create pressure differences.

Measuring Air tightness with a Blower Door

While there are many well-known sources of air leakage, virtually all homes have unexpected air leakage sites called *bypasses*. These areas can be difficult to find and correct without the use of a *blower door*. This diagnostic device consists of a temporary door covering installed in an outside doorway and a fan which pressurizes (forces air into) or depressurizes (forces air out of) the building. When the fan operates, it is easy to feel air leaking through cracks in the building envelope. Blower doors have gauges which measure the building's air leakage rate.

One measure of a home's leakage rate is air changes per hour (ACH), which estimates how many times in one hour the entire volume of air inside the building leaks outside. To determine the number of air changes per hour, many experts use the blower door to create a negative pressure of 50 Pascals. A *Pascal* is a small unit of pressure — about 0.004 inches water gauge. A quarter resting on your hand exerts about 120 Pascals. Fifty Pascals is approximately equivalent to a 20 mile per hour wind. Energy efficient builders should strive for less than four air changes per hour when testing their home at 50 Pascals pressure (4ACH50). The rate of natural air changes per hour (NACH) can be estimated from the ACH50 and certain characteristics of the home.

Some building scientists use a different criterion — the air leakage rate per square foot of exterior envelope (CFM50/sq.ft.). The goal is often 0.30 CFM50/sq.ft. or less. An expert blower door technician can perform more advanced tests to find major sources of air leakage.

Table 4-1
Typical Infiltration Rates
(in air changes per hour – ach)

	ACH50	NACH
Description	(blower door test result)	(natural rate)
New home with special airtight construction and controlled ventilation	0.5 - 2.5	0.03 - 0.15
Home with air barrier	3.0 - 5.0	0.15 - 0.3
Standard new home	7.0 - 15.0	0.4 - 1.0
Standard existing home	10.0 - 25.0	0.5 - 1.3
Older, leaky home	20.0 - 50.0	1.0 - 3.0

Figure 4-5
Blower Door

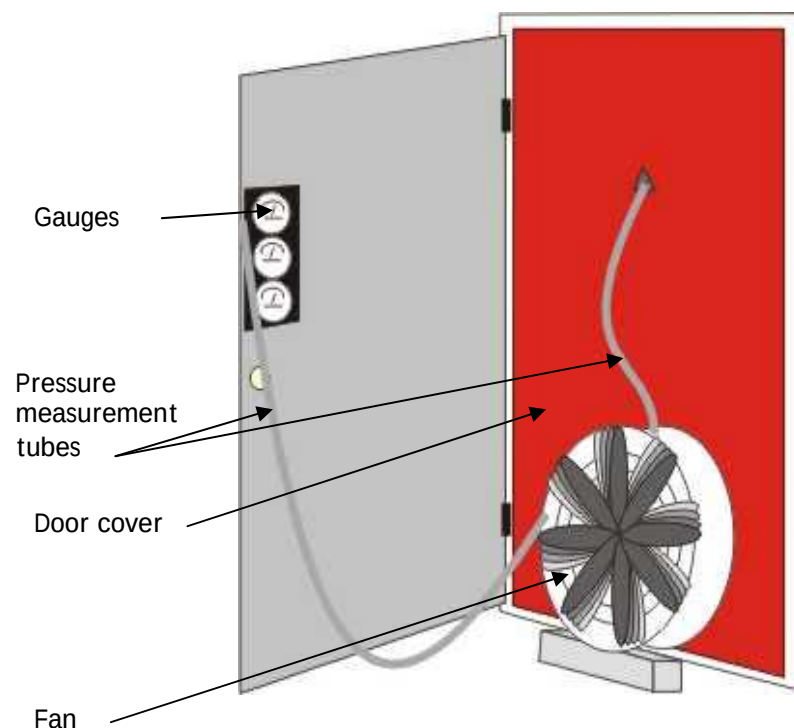
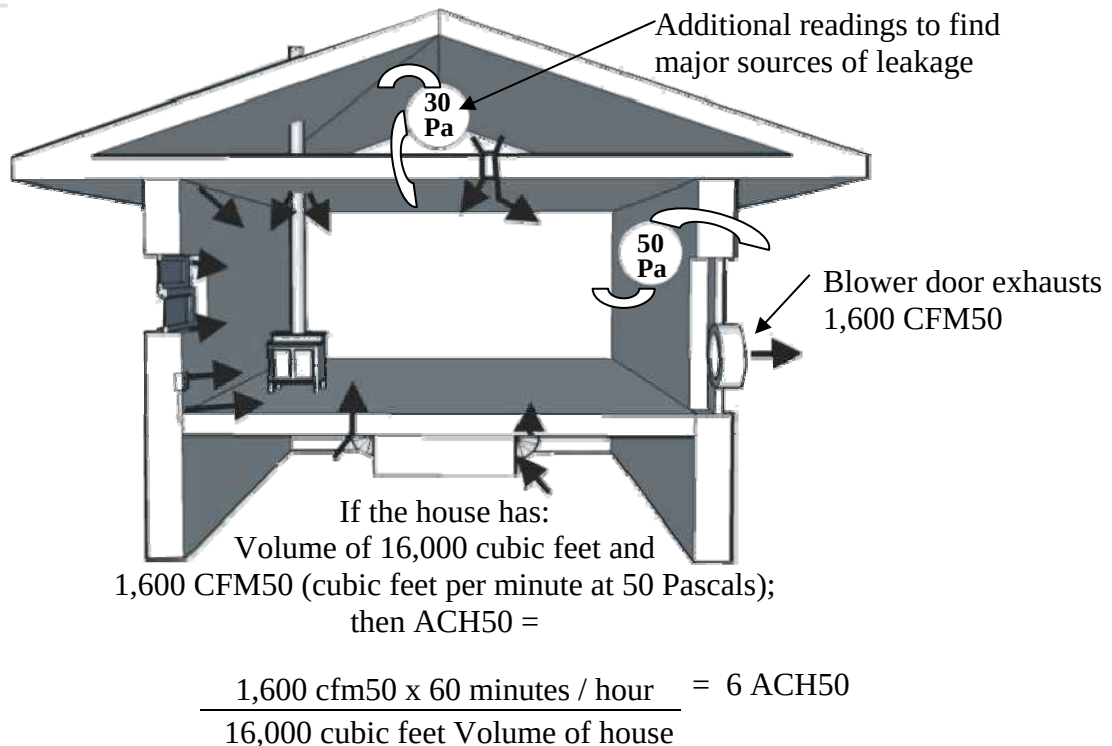


Figure 4-6
Home Blower Door Test



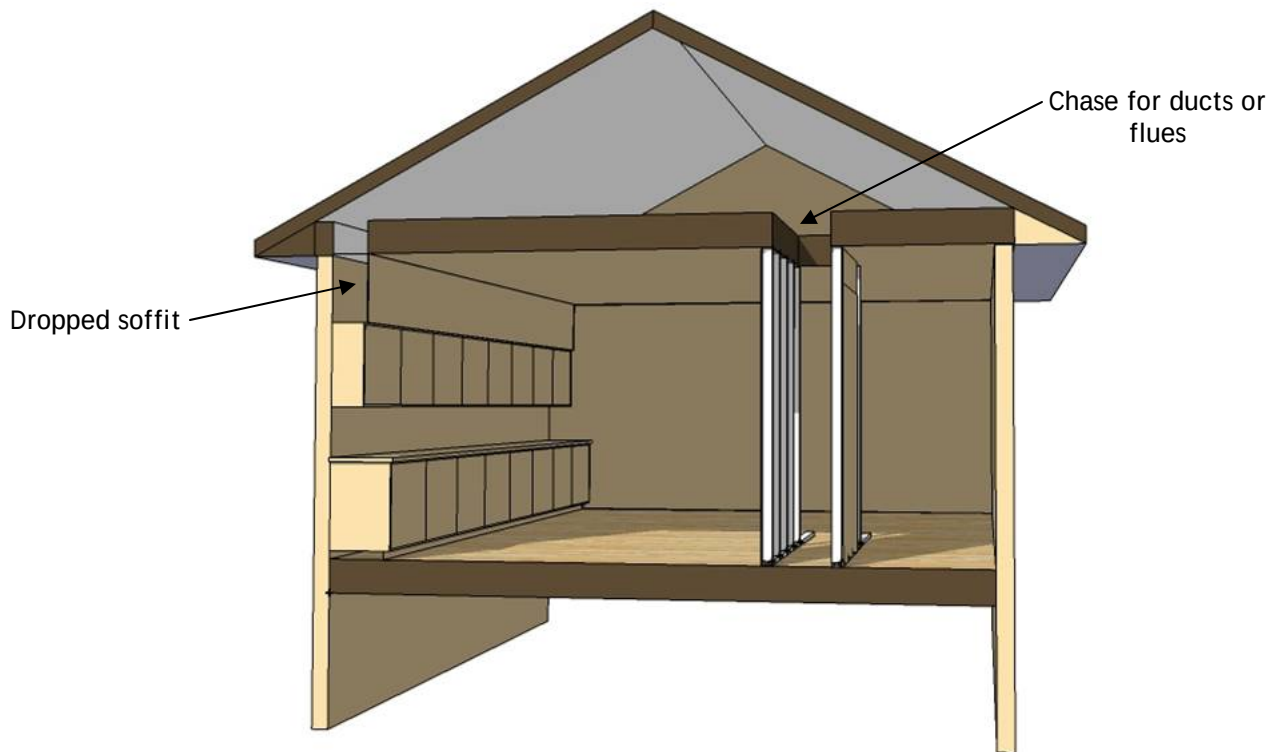
Materials

Most air barrier systems rely on a variety of caulks, gaskets, weatherstripping, and sheet materials, such as plywood, drywall, and housewrap. The extra cost of these materials is usually under \$500 for standard house designs. Polyethylene can serve as an air barrier in addition to a vapor barrier; however, vapor barriers are not recommended for homes in Louisiana.

Seal Penetrations and Bypasses

The first step for successfully creating an air barrier system is to seal all of the holes in the building envelope. Too often, builders concentrate on air leakage through windows and doors and ignore areas of much greater importance. Many of the key sources of leakage — called *bypasses* — are hidden from view behind soffits over cabinets, behind bath fixtures, dropped ceilings, as well as chases for flues and ductwork, as shown in Figure 4-7. Attic access openings and whole house fans are also common bypasses. Sealing these bypasses is critical to reduce air leakage and maintain the performance of insulation materials.

Figure 4-7
Air Leakage through Bypass

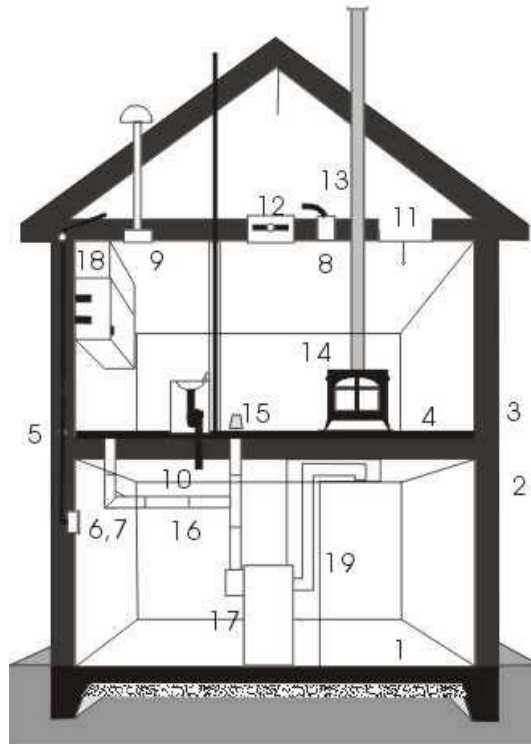


Figures 4-8, 4-9, and 4-10 show key areas that must be sealed to create an effective air barrier. The builder must clearly inform his or her subcontractors and workers of these details to ensure that the task is accomplished successfully. Make certain all sealants have at least 40-year service lives.

Table 4-2
Leaks and Sealants

Type of Leak	Commonly Used Sealants
Thin gaps between framing and wiring, pipes or ducts through floors or walls	40-year caulking; one part polyurethane is recommended
Leaks into attics, cathedral ceilings or wall cavities above first floor	Firestop caulking
Gaps, cracks or holes over 1/8 inch in width not requiring firestop sealant	Gasket, foam sealant, or stuffed with fiberglass or backer rod, and caulk on top
Open areas around flues, chases, plenums, plumbing traps, etc.	Attach and caulk a piece of plywood or foam sheathing material that covers the entire opening. Seal penetrations. If a flue requires a noncombustible clearance, use a noncombustible metal collar, sealed in place, to span the gap.
Final air barrier material	Use Airtight Drywall Method, continuous housewrap or other air barrier system.

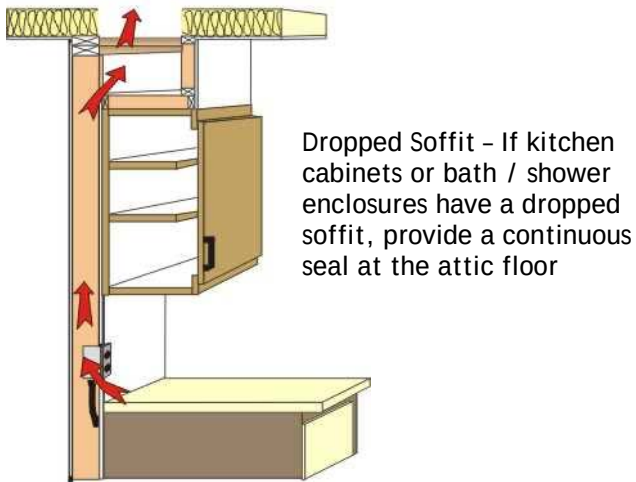
Figure 4-8
Typical Home Air Leakage Sites



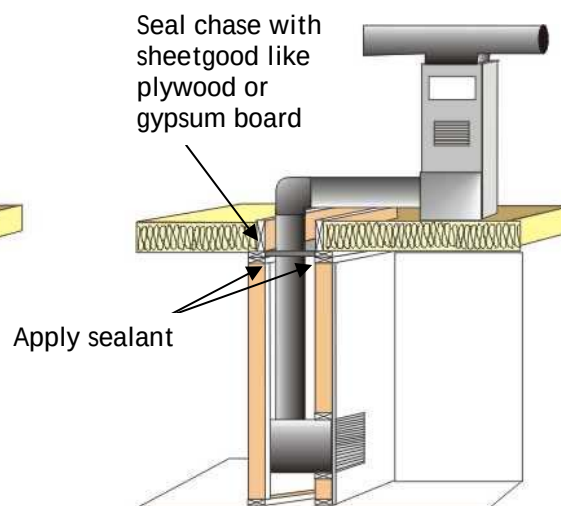
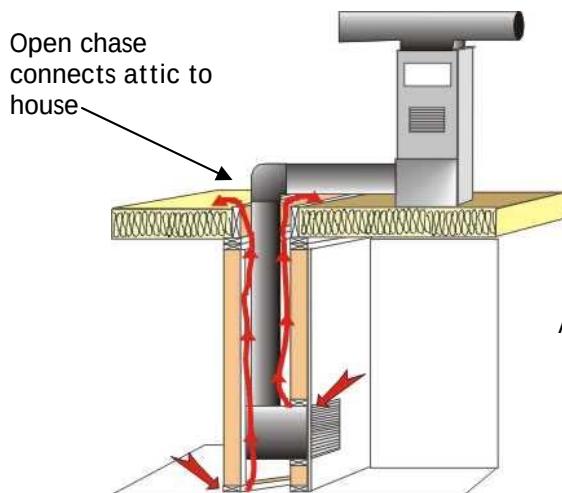
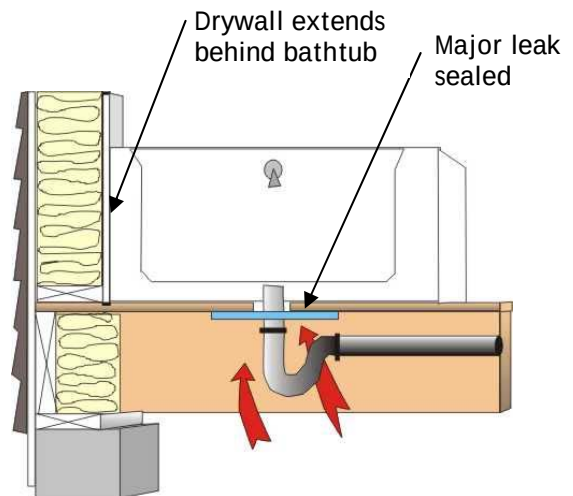
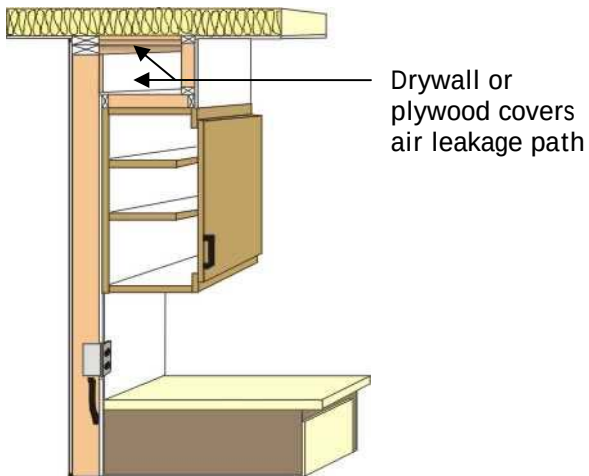
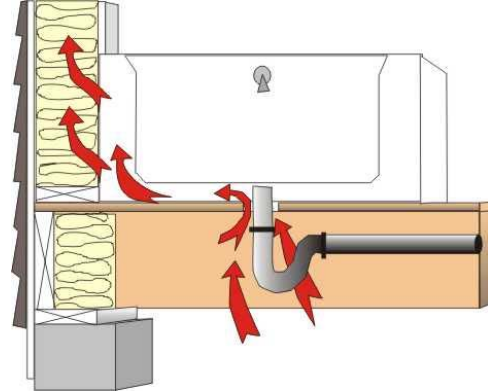
1. **Slab Floors** - seal all holes in the slab to prevent entry of water vapor and soil gas. A 4- to 6-inch layer of gravel under the slab is important to stop the seepage of water by capillary action.
2. **Sill Plate and Rim Joist** - seal all sill plates above basements and unvented crawlspaces. Seal rim or band joists between floors in multistory construction with caulking or gaskets.
3. **Bottom Plate** - use caulk or gasket between the plate and subflooring (or slab).
4. **Subfloor** - use an adhesive to seal the seams between pieces of subflooring.
5. **Electrical Wiring** - use wire-compatible caulk or spray foam to seal penetrations.
6. **Electrical Boxes** - use approved caulk or tape to seal around wiring holes of electrical boxes. Seal between the interior finish material and boxes.
7. **Electrical Box Gaskets** - caulk foam gaskets to all electrical boxes in exterior and interior walls before installing cover plates.
8. **Recessed Light Fixtures** - consider using surface-mounted light fixtures rather than recessed lights. When used, specify airtight models rated for insulation contact (IC).
9. **Exhaust Fans** - seal between the fan housing and the interior finish material. Choose products with tight-fitting backdraft dampers.

10. **Plumbing** - locate plumbing in interior walls, and minimize penetrations. Seal all penetrations with foam sealant or caulk.
11. **Attic Access** - weatherstrip attic access openings. For pull-down stairs, use latches to hold the door panel tightly against the weatherstripping. Cover the attic access opening with an insulated box.
12. **Whole House Fan** - use a panel made of rigid insulation or plastic to seal the interior cover or a box made from duct board to seal on top.
13. **Flue Stacks** - install a code-approved flue collar and seal with fire-rated caulk.
14. **Combustion Appliances** - closely follow local codes for fire stopping measures, which reduce air leakage as well as increase the safety of the appliance. Make certain all combustion appliances, such as stoves, inserts, and fireplaces, have an outside source of combustion air and tight-fitting dampers or doors.
15. **Return and Supply Registers** - seal all boots connected to registers or grilles to the interior finish material.
16. **Ductwork** - seal all joints in supply and return duct systems with mastic.
17. **Air Handling Unit** (for heating and cooling system) — seal all joints and holes with mastic. Seal service panels with tape.
18. **Dropped Soffit** - use sheet material such as drywall and sealant to stop leaks from attic into the soffit or wall framing; then insulate.
19. **Chases** (for ductwork, flues, etc.) - prevent air leakage through these bypasses with approved sheet materials and sealants.

Figure 4-9
Sealing Bypasses

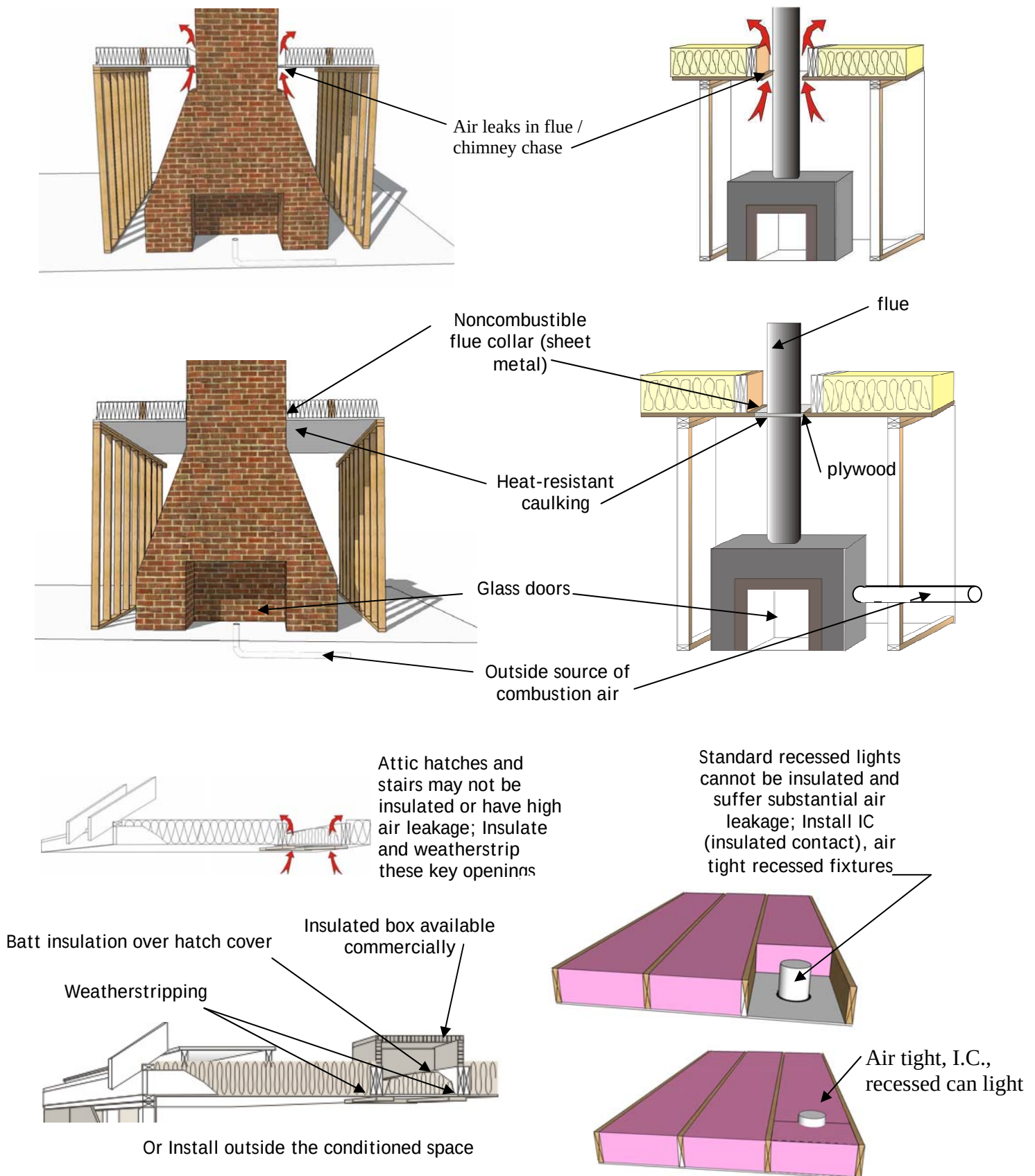


Plumbing - Seal penetrations, especially under bathtubs and other fixtures. Install drywall or housewrap behind bathtub to provide an air barrier.



Return and Supply Plenums - Seal framed areas for ductwork.

Figure 4-10
Sealing More Bypasses



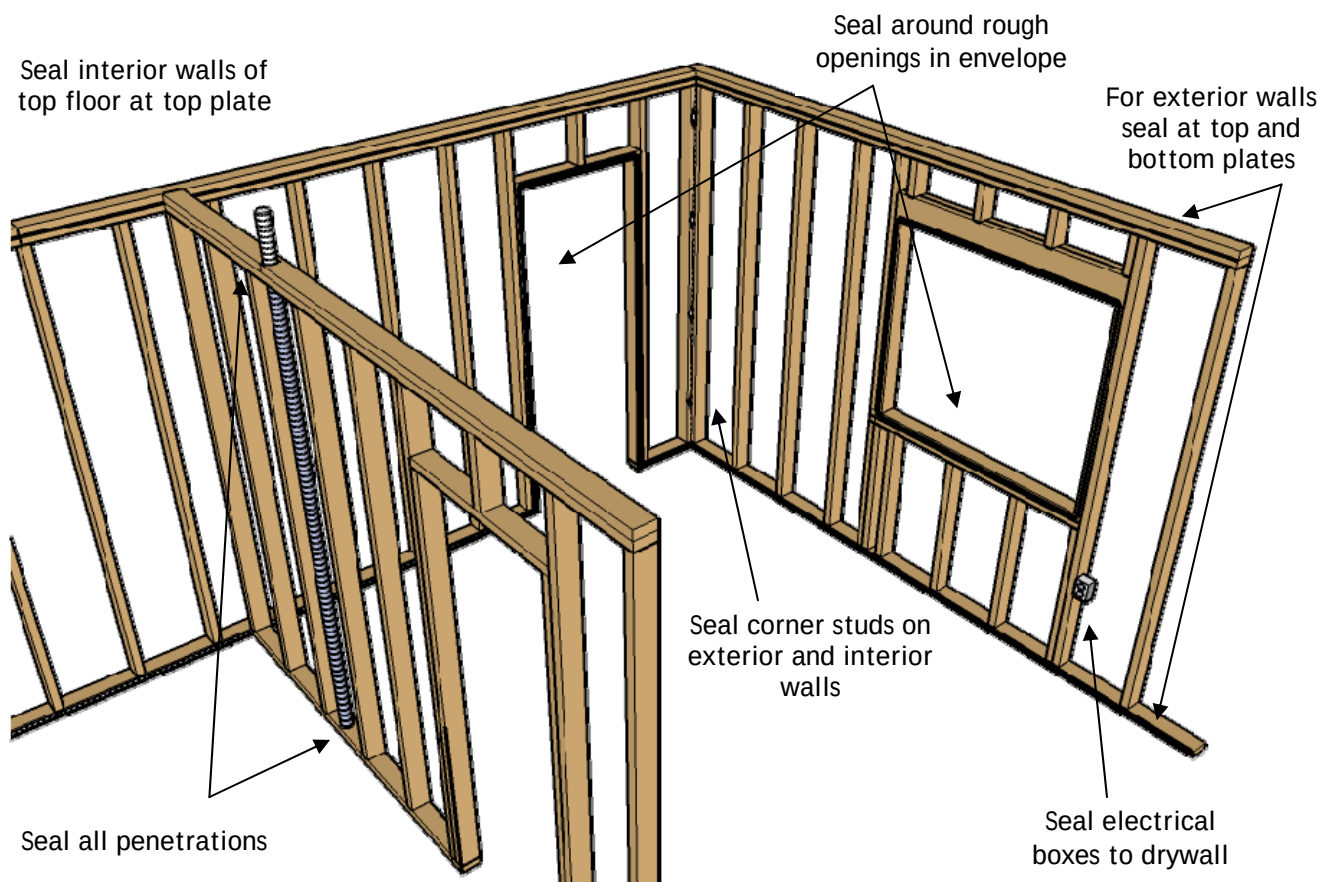
Airtight Drywall Method

The Airtight Drywall Method (ADM) is an air sealing system that connects the interior finish of drywall and other building materials together to form a continuous barrier. ADM has been used on hundreds of houses and has proven to be an effective technique to reduce air leakage as well as keep moisture, dust, and insects from entering the home.

In a typical drywall installation, most of the seams are sealed by tape and joint compound. However, air can leak in or out of the home in the following locations:

- Between the edges of the drywall and the top and bottom plates of exterior walls
- From the attic down between the framing and drywall of partition walls.
- Between the window, door frames and drywall
- Through openings in the drywall for utilities and other services

Figure 4-11
Airtight Drywall Method Air Barrier



ADM uses either caulk or gaskets to seal these areas and make the drywall a continuous air barrier system. ADM gaskets are pliable materials with “memory” – when compressed and then released by drywall that is shrinking or expanding. They quickly return to their previous shape and position. The gaskets can be applied long before the drywall crew arrives – just make sure they do not remove the gaskets.

ADM Advantages

Effective - ADM is a reliable air barrier.

Simple - does not require specialized subcontractors or unusual construction techniques. If gasket materials are not available locally, they can be shipped easily.

Does not cover framing - the use of ADM does not prevent the drywall from being glued to the framing.

Scheduling - gaskets can be installed anytime between when the house is “dried-in” and the drywall is attached to framing.

Adaptable - builders can adapt ADM principles to suit any design and varying constructions schedules.

Cost - materials and labor for standard designs should only cost \$100 - \$300.

Not a vapor barrier - Vapor barriers are not recommended in climate zones 2 and 3; such as in Louisiana.

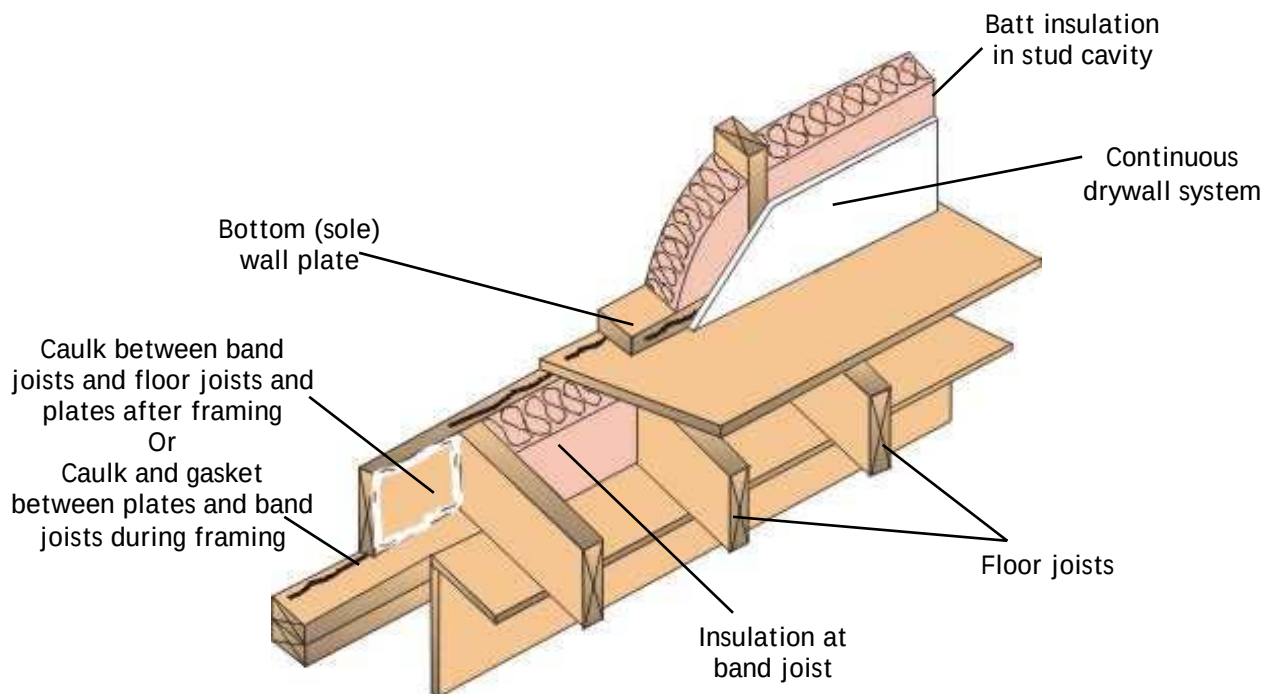
ADM Disadvantages

New - although ADM is a proven technique, many building professionals and code officials are not familiar with its use.

Requires thought - while ADM is simple, new construction techniques require careful planning to ensure that the air barrier remains continuous. However, ADM is often the most error-free and reliable air barrier for unique designs.

Requires care - gaskets and caulking can be damaged or removed by subcontractors when installing the drywall or utilities.

Figure 4-12
Creating an Air Barrier Between Floors



ADM Installation Techniques

Wood Framed Floors

- Seal seams in and around the band joist to minimize air leakage.
- For unvented crawlspaces or basements, seal or gasket beneath the sole plate.
- Seal the seams between pieces of subflooring with good quality adhesive.

Slab Floors

- Seal expansion joints and penetrations with a sealant such as one-part urethane caulk.

Windows and Doors

- Seal drywall edges to either framing or jambs for windows and doors.
- Fill rough opening with dry foam gasket or nonexpanding caulk, spray foam sealant, or suitable substitute.
- Caulk window and door trim to drywall with clear or paintable sealant.

Exterior Framed Walls

- Seal between the bottom plate and subflooring with caulk or gaskets.

- Install ADM gaskets or caulk along the face of the bottom and top plate so that when drywall is installed it compresses the sealant to form an airtight seal against the framing.
- Use drywall joint compound or caulk to seal the gap between drywall and electrical boxes; install foam gaskets behind cover plates and caulk holes in boxes.
- Homes in Louisiana do ***not*** need a vapor barrier. Sealing air leaks is more effective as moisture control.
- Seal penetrations through the top and bottom plates for plumbing, wiring, and ducts; local fire codes may require fire stopping for penetrations through top plates.

Partition Walls

- Seal the drywall to the top plate of partition walls where attics and other unconditioned spaces are above.
- Install gaskets or caulk on the face of the first stud in the partition wall. Sealant should extend from the bottom to the top of the stud to keep from leaking inside or outside.
- Seal around ductwork where it projects through partition walls.
- Seal penetrations through the top and bottom plates for plumbing, wiring, and ducts.

Ceiling

- Seal openings above or into chases and dropped soffits.
- Follow standard finishing techniques to seal the junction between the ceiling and walls.
- When installing ceiling drywall, do not damage ADM gaskets on wall studs, especially in tight areas such as closets and hallways.
- Seal all penetrations in the ceiling for wiring, plumbing, ducts, attic access openings, and whole house fans.
- Avoid recessed lights; where used, install airtight, IC-rated fixtures and caulk or gasket between fixtures and drywall.

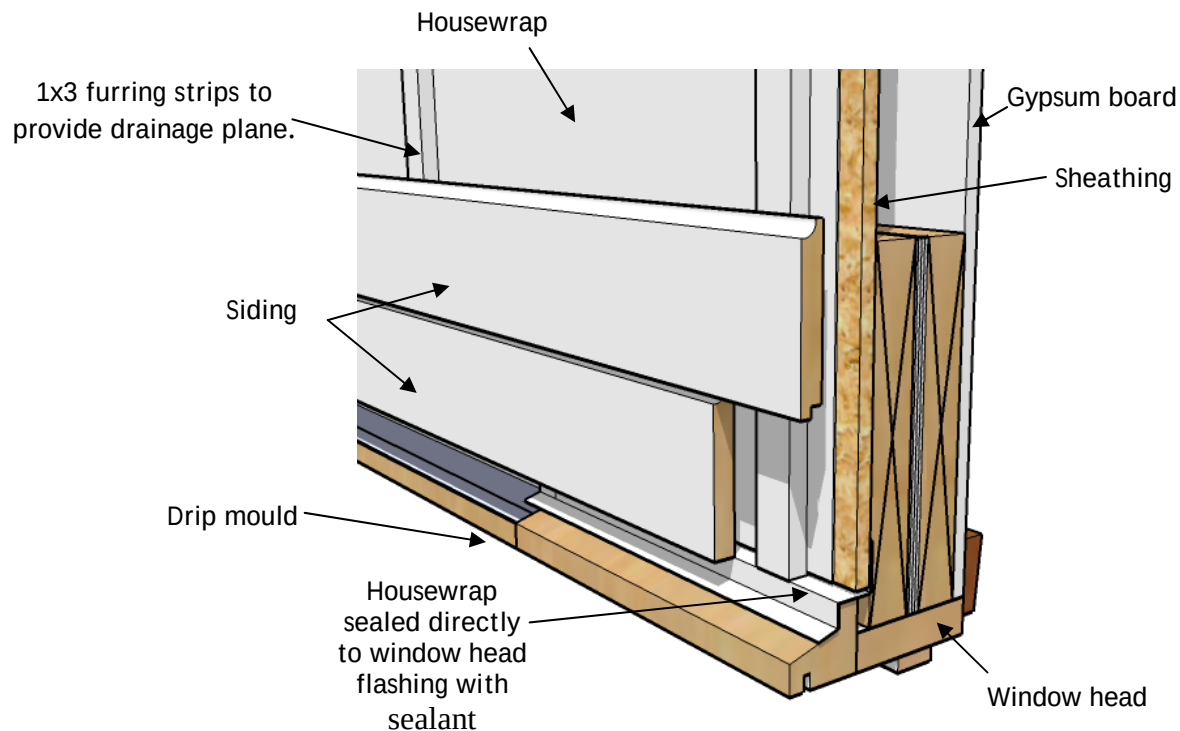
Housewrap Air Barriers

Housewrap materials can reduce air leaks through exterior walls if installed properly. They are advantageous in Louisiana because they are permeable to water vapor, thus helping prevent moisture buildup in walls.

One of the major problems with housewraps has been poor field installation. In fact, many homes with exterior housewraps do not reap the full energy savings because of sub-par installation. To stop air leakage, the housewrap material must be sealed to the sheathing at framing openings, all

penetrations and seams. Follow manufactures recommendations. Check perm rating to ensure that the material is not a vapor barrier (< 1 perm).

Figure 4-13
Housewrap – Window Connection



Housewrap Advantages

Air barrier - housewraps allow water vapor to pass through.

Availability - housewraps have been used for years on homes and are usually available in local building supply houses.

Installation - housewraps require no special tools and can be installed in large sheets with relatively few joints. Tears can be repaired with approved tapes.

Cost - materials and labor for completely air sealing standard home designs should only cost a few hundred dollars.

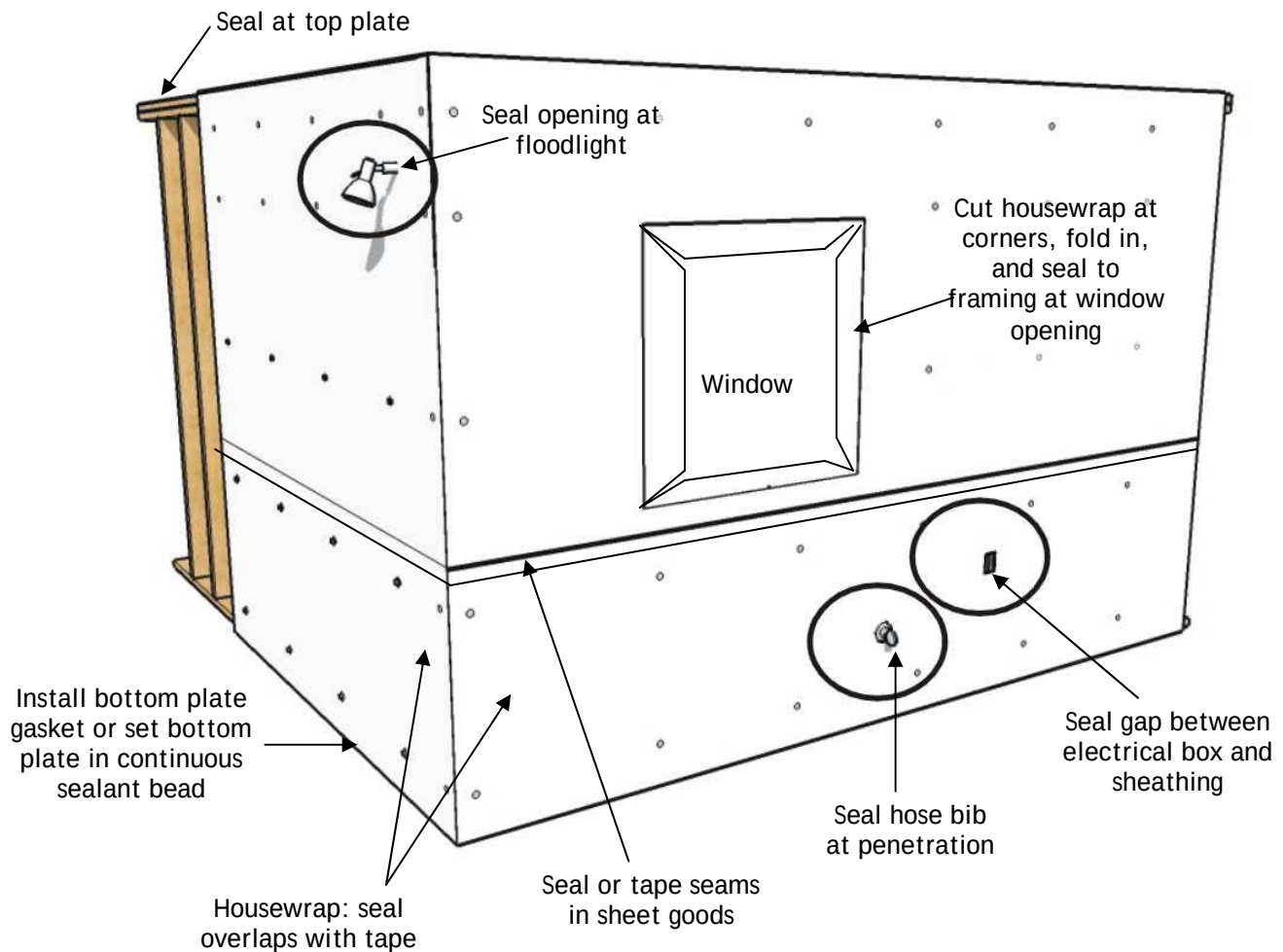
Marketing - the visibility of housewraps help advertise the home as "energy efficient".

Housewrap Disadvantages

Sealing penetrations and seams - it can be difficult to seal housewraps to plumbing, wiring, and ducts; between overlapped seams; and at the junctions between floors, walls and ceilings. Many standard caulks do not provide an effective, long-term seal, so select products with 30 to 50-year guarantees.

Connection to floor and ceiling - housewraps can seal air leaks through exterior walls easily, but the builder must take care to connect the seal membrane over sheathing at ceiling and floor assembly areas.

Figure 4-14
Recommended Housewrap
Installation Process & Procedures

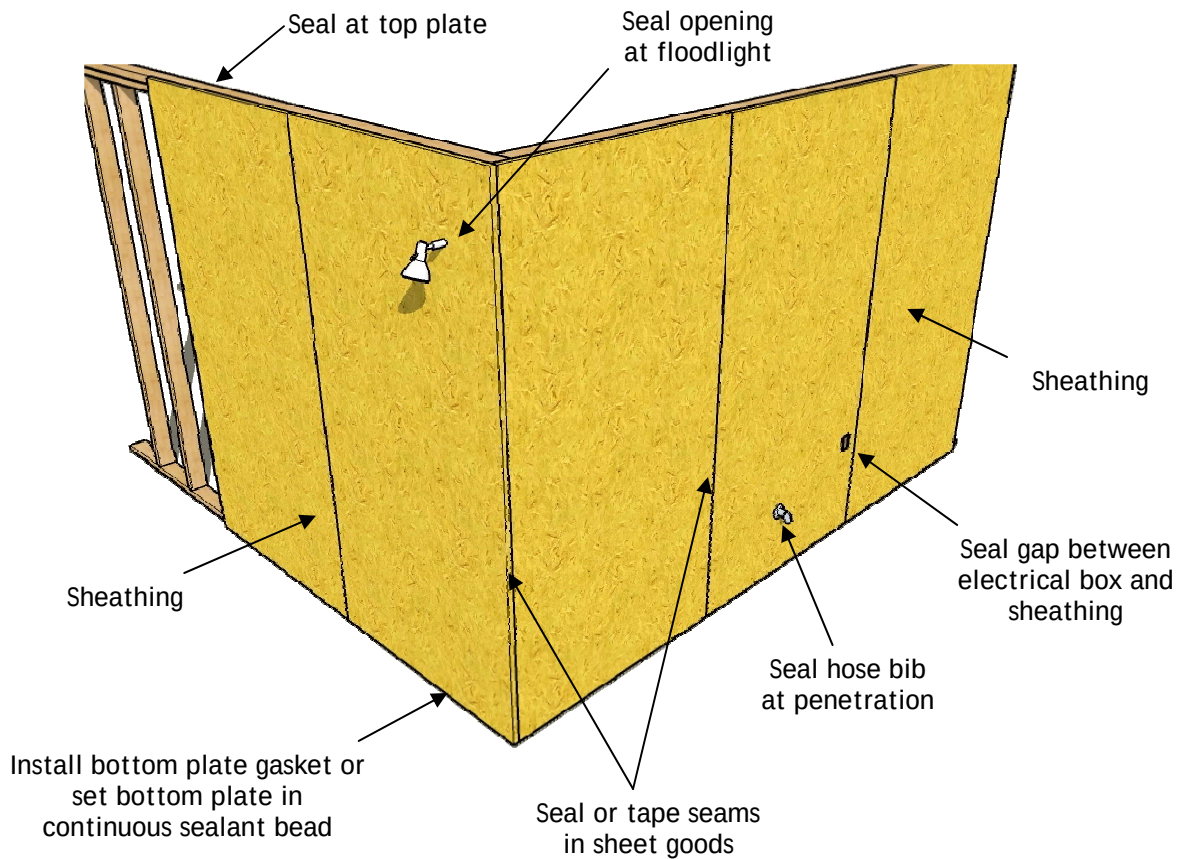


Foam Sheathing Barrier

Foam exterior sheathing can serve as both insulation and an exterior drainage plane. Detailing is, of course, critical especially at joints and penetrations. All seams should be sealed, as shown in Figure 4-15. Horizontal seams must be flashed with Z-flashing or comparable sealants.

The exterior sheathing material can either serve as a moisture shedding / air sealing membrane or as a moisture absorbing surface that may contribute to the degradation of the building envelope.

Figure 4-15
Sealing Sheathing as Exterior Air Barrier



The keys to having a beneficial sheathing surface are:

- Protect sheathing materials, such as OSB, plywood, and exterior dry wall that will degrade with exposure to sun, water, or other environmental hazards.
- Always lap protective materials such as housewrap and exterior felt higher over lower courses (shingle style) to shed water.
- Do not use tape to seal horizontal seams, install flashing instead.

Provide moisture and vapor a place from which to escape—a drain for moisture at the bottom and a vent for removing vapor at the top of the wall.

It is important in Louisiana to allow the wall to dry—usually by eliminating the interior vapor barrier and allowing water vapor to move through the wall cavity, into the home to be removed from the home (in liquid form) through the condensate pan drain in the air handler. Avoid applying vinyl wall coverings and other interior vapor barrier materials on exterior walls in this hot–humid climate. High humidity areas like baths and kitchens need special treatment, like exhausting vapor laden air.