TEXAS DEPARTMENT OF HOUSING AND COMMUNITY AFFAIRS

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September 28, 2012

Weatherization Assistance Program
Material Installation Standards Manual

About this Publication

This Weatherization Assistance Program Materials Installation Standards Manual (WAP Manual) is a compilation of TDHCA's June 1998 Materials Installation Standards Manual, TDHCA's Weatherization Field Guide & Mechanical Field Guide, excerpts from building science experts around the country, Weatherization Assistance Program Technical Assistance Center (WAPTAC), Code of Federal Regulations (CFRs), Best Practices, Texas Administrative Code (TAC), and general energy saving tips from the US Department of Energy (DOE).

Purpose

The purpose of this WAP Manual is to serve as a guide for TDHCA WAP contractors, crews, and installers.

Objective

The objective of this Manual is explain how to perform weatherization measures to properly obtain the best results. The Standards and Nonfeasible Criteria boxes provide an overall explanation of TDHCA's WAP expectations for weatherization contractors and crews. Additional information includes, but is not limited to, how the Texas climate impacts certain measures, how and why we perform certain measures, and health and safety issues.

Questions

For more information, please contact a TDHCA Community Affairs Team member. Please note that many Weatherization questions can be answered by reviewing TDHCA's "Weatherization Best Practices" page online at http://www.tdhca.state.tx.us/community-affairs/wap/wap-best-practices.htm.

We trust you will find this information useful for your weatherization visits.

Best Regards,

The TDHCA Community Affairs Division

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Chapter 1: Thermal Boundary

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Thermal Boundary

The **thermal boundary**, or thermal envelope, restricts or slows the flow of heat from conditioned and unconditioned spaces. **Conditioned spaces** are the indoor areas that are heated and cooled, such as the living room, kitchen, bedrooms, and bathrooms. **Unconditioned spaces** are the outdoors or any areas in a residence that are not heated or cooled, such as the attic, crawl space, unfinished basement, and garage.

Defining the thermal boundary may seem simple, but when you begin to look at the many points where the boundary may be breached, it can become a challenge. The thermal boundary consists of two components, an air barrier and insulation, when fully aligned.

Air barriers block random air movement through building cavities. As a result, they help prevent air leakage in your home, which can account for 30% or more of a home's heating and cooling costs. Air barriers also help control moisture in a home. While they stop most air movement, air barriers also allow any water vapor that does enter the home to diffuse back out again.

Types of Air Barriers

Air Barrier

Air travels into and out of homes through three main pathways:

1. Bypasses, which are significant flaws in the home’s air barrier;
2. Seams between building materials; and
3. The building materials themselves.

Material that is impermeable to airflow creates an air barrier. An air barrier is continuous and sealed at the seams.

Many of the materials used in a house for structural purposes and finished surfaces also act as air barriers. For many homes, these materials include sheet goods that form the ceilings, walls, and floors, such as drywall, foil faced foam board, sheathing, and decking. [1]

To create a *continuous air barrier* throughout a home for maximum energy efficiency, seal all holes and seams between sheet goods with durable caulk, gaskets, and/or foam sealants.

Insulation

Insulation reduces heat transmission by slowing conduction, convection, and radiation through the building shell. [2]

Properly insulating a home will not only help reduce heating and cooling costs but also make a home more comfortable. Insulation is, in most cases, not an air barrier; it is little more than a filter. Only spray in place foam, oriented strand board (OSB)/plywood, drywall, rigid foam boards, dense packed cellulose at 3.5 pounds/cubic foot, metal, and T-ply qualify as air barriers. [8]

Table 1.1 Building Components and Their Air Permeance

Good **Air Barriers** (<2 CFM_{50} per 100 ft²)	**Fair** **Air Barriers** (2-10 CFM_{50} per 100 ft²)	**Poor** **Air Barriers** (10-1000 CFM_{50} per 100 ft²)
▪ 5/8" oriented strand board ▪ 1/2" drywall ▪ 4-mil air barrier paper ▪ Asphalt shingles over perorated felt over 1/2" plywood ▪ 1/8" tempered hardboard ▪ Painted uncracked lath and plaster	▪ 15# perforated felt ▪ Concrete block ▪ Rubble masonry ▪ 7/16" asphalt-coated fiberboard ▪ 1" expanded polystyrene ▪ Brick veneer	▪ 5/8" tongue-and-groove wood sheathing ▪ 6" fiberglass batt ▪ 1.5" wet-spray cellulose ▪ Wood siding over plank sheathing ▪ Wood shingles over plank sheathing ▪ Blown fibrous insulation

Measurements taken at 50 Pascals pressure.

Based on information from "Air Permeance of Building Materials", by Canada Mortgage Housing Corporation, and estimates of comparable assemblies by the author. [2]

Sealing air leaks improves the pressure boundary of a house - the building shell surface that limits air flow. Adding insulation improves the thermal boundary - the building shell surface that limits heat flow. For maximum energy efficiency and comfort, the pressure boundary should be aligned with the thermal boundary. The blower door exaggerates the pressure difference between the house and the outdoors - making it easier to locate and quantify air leakage. [18]

TDHCA

Perform air sealing work while running the blower door to find the leaks and assure reaching target CFMs.

Insulation and Air Sealing

A home's heating and cooling costs can be reduced through proper insulation and air sealing techniques. These techniques will also make a home more comfortable.

Any air sealing efforts will complement insulation efforts, and vice versa. Proper moisture control and ventilation strategies will improve the effectiveness of air sealing and insulation, and vice versa.

A home's energy efficiency depends on a balance between air sealing, insulation, moisture control, and ventilation. A proper balance between all of these elements will also result in a more comfortable, healthier home environment. [7]

✓ GOOD TO KNOW

HOT-HUMID CLIMATE

Hot and humid climates face several challenges for weatherization. The intense solar radiation in our southern climate imposes a large thermal load on houses that can increase cooling costs, affect comfort, and damage home furnishings.

Moisture, in the form of both high humidity and high rainfall, is a significant problem in our Texas climate. The ambient air has significant levels of moisture most of the year. Since air conditioning is often a necessity, cold surfaces are present where condensation can occur. Controlling the infiltration of this moisture-laden air into the building envelope and keeping moisture away from cold surfaces are major goals in our climate zone.

Air infiltration can contribute to problems with moisture, noise, dust, and the entry of pollutants, insects, and rodents. Controlling air movement through the building envelope requires sealing both the "big" holes and the "little" holes. The big holes occur behind bathtubs and showers on exterior walls, behind fireplaces, and where soffits or utility walls (double wall with chase) meet exterior walls or ceilings. Recessed lights collectively can be a really big hole in the ceiling assembly. These big holes are responsible for wasted energy (high utility bills) and condensation that can cause mold and wood decay. The little holes occur between framing members, such as band joist to sill plate, around electrical boxes, and where plumbing or wiring penetrate the envelope. All penetrations leading to unconditioned spaces should be sealed with foam or caulk. Another area needing special attention for occupant health and safety is sealing shared walls and ceilings between attached garages and living spaces. Carefully seal any penetrations, block air pathways through the attic, and weatherstrip any doors. [15]

The thermal boundary is the first step at reducing moisture and lowering cooling bills.

Diagram 1.1 House as a System Supply Leaks

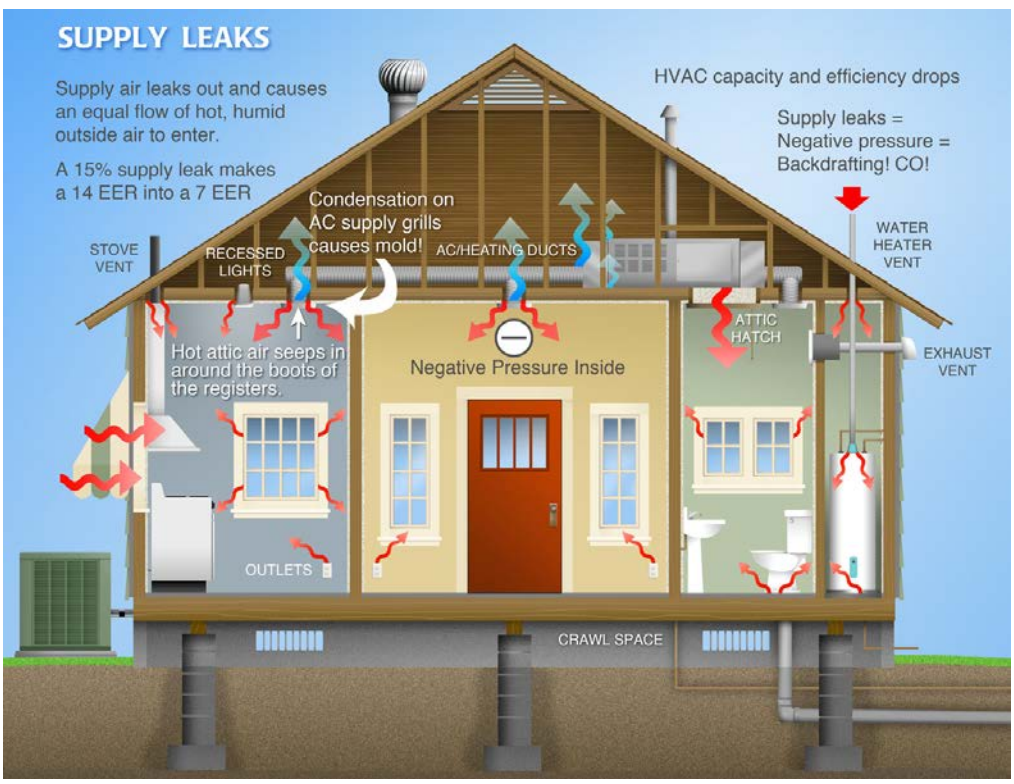
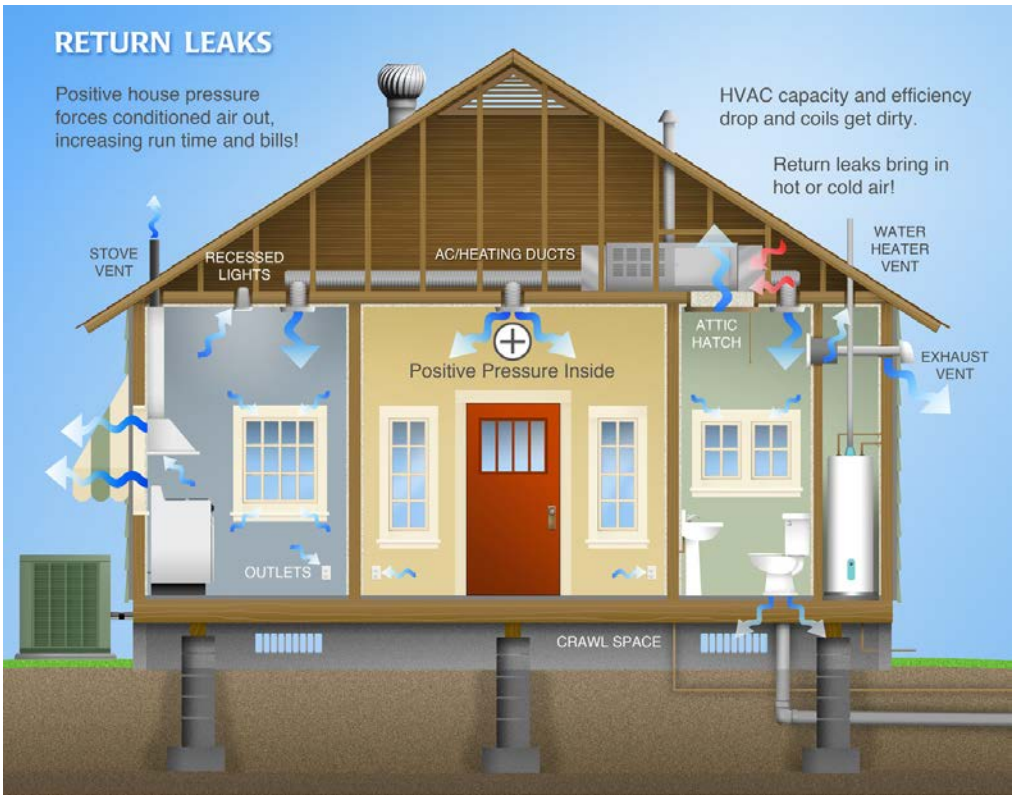


Diagram 1.2 House as a System Return Leaks



Air and duct sealing are crucial measures in weatherization. They affect the energy use, the comfort, and the durability of a home. For these reasons, the blower door is used at the initial assessment, during air-sealing activities, and at the final inspection. The blower door data sheet records the initial CFM at 50 Pascals reading, the minimum reduction value, and the building tightness limit.

Weatherization crews are to attempt to reach the building tightness limit. The minimum reduction value is a guide toward that goal; it is not the goal. The final blower door reading is to verify that we achieved adequate CFM reduction and that the home has not become too tight.

A house is a system, as the prior illustrations demonstrate. One weatherization measure can positively or negatively affect another. For example, air sealing may result in an appliance not receiving sufficient combustion air causing carbon monoxide to be produced. This is why we conduct final tests to verify that we are leaving our clients in a safe and healthy home.

Air sealing is the first step to defining the thermal boundary.

Chapter 2: Air Sealing

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Sealing Major Air Leaks and Bypasses

Air travels into and out of the building by three main pathways:

1. Major air leaks, or bypasses, which are significant flaws in the home's air barrier
2. Minor air leaks, which are often seams between building materials
3. Through the building materials themselves [2]

Major air sealing involves finding and sealing large openings that admit outdoor air into the conditioned space. Sealing major air leaks is a key energy saving measure.

Major air sealing activities are generally completed prior to other shell measure activities, and should result in a significant drop in the blower door reading and/or changes in pressure diagnostics readings.

Bypasses are conduits for air travel within building cavities. Bypasses don't always allow outdoor air into the home, but may allow outdoor air to circulate within building cavities. They can contribute to significant energy loss when they are adjacent to interior surfaces of the home that can conduct heat into or out of the home. Bypasses and major air leaks are often found in combination with one another; with some air leaking through the air barrier and some staying within the building cavities.

Bypasses that do not penetrate the air barrier won't have an impact on pressure diagnostic tests, but they should still be sealed to reduce conductive losses (through interior surfaces) and to limit the condensation that can take place on cold interior surfaces.

✓ GOOD TO KNOW

HOT, HUMID CLIMATE

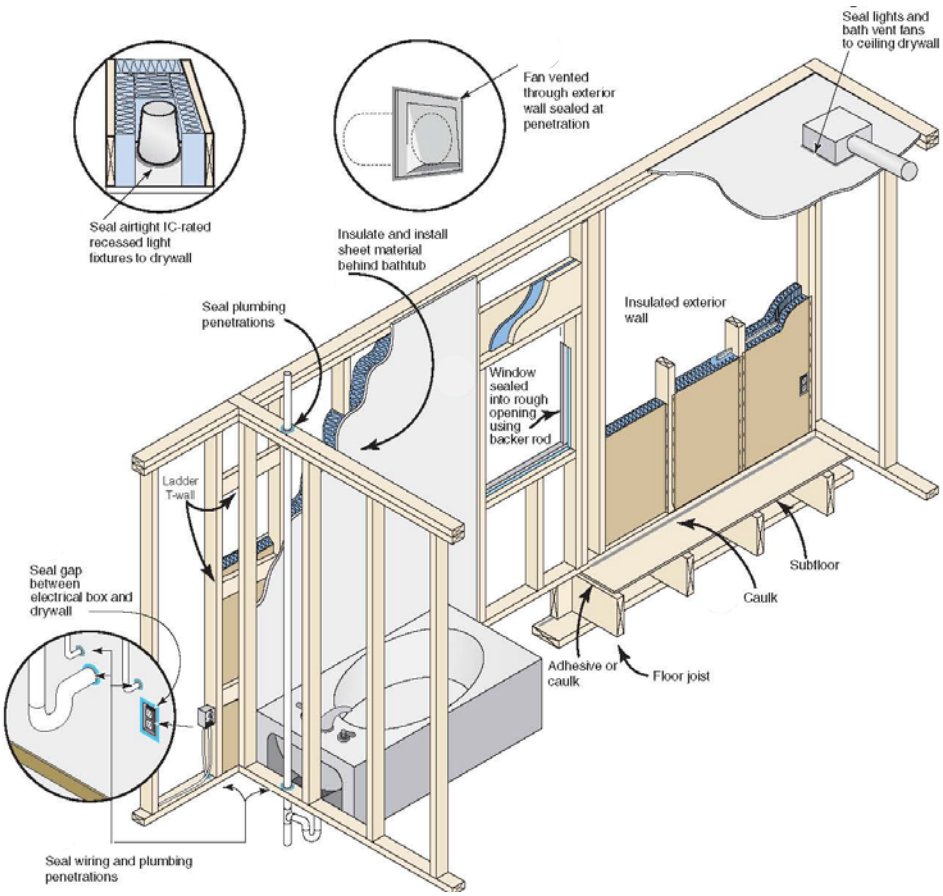
In humid cooling climate zones, moisture tends to move from outside to inside through the building shell. Air sealing penetration points throughout the shell is the best way to eliminate these pathways for moisture. In addition, air conditioners must work harder to remove moisture from the conditioned air. Think of the air conditioner as a huge sponge. It soaks up the moisture in the air throughout the house and then squeezes it to the outside. By removing the moisture, the house becomes cooler. Consequently, air sealing also keeps the air conditioner from frequent cycling, which results in energy savings.

Stains like this in insulation strongly indicate air bypass movement – insulation is acting like a filter.

Major air leaks will often be found between the conditioned space and intermediate zones such as floor cavities, attics, crawl spaces, attached garages, and porch roofs. The time and effort spent to seal major air leaks should depend on the size of the intermediate zone(s).

Major air leaks are not always easily accessible. When they are hard to reach, technicians sometimes blow dense-packed insulation into surrounding cavities, hoping that the insulation will resist airflow and plug cracks between building materials. [2]

Diagram 2.1 Whole House Air Sealing Key Points



Disclaimer: This image is intended solely to help graphically demonstrate the air leakage provisions of section 402.4 of the 2006 International Energy Conservation Code (IECC). It does not cover all air sealing locations or techniques. Other code provisions may be applicable as well.

Diagram 2.2 Plumbing and Electrical Air Sealing Key Points

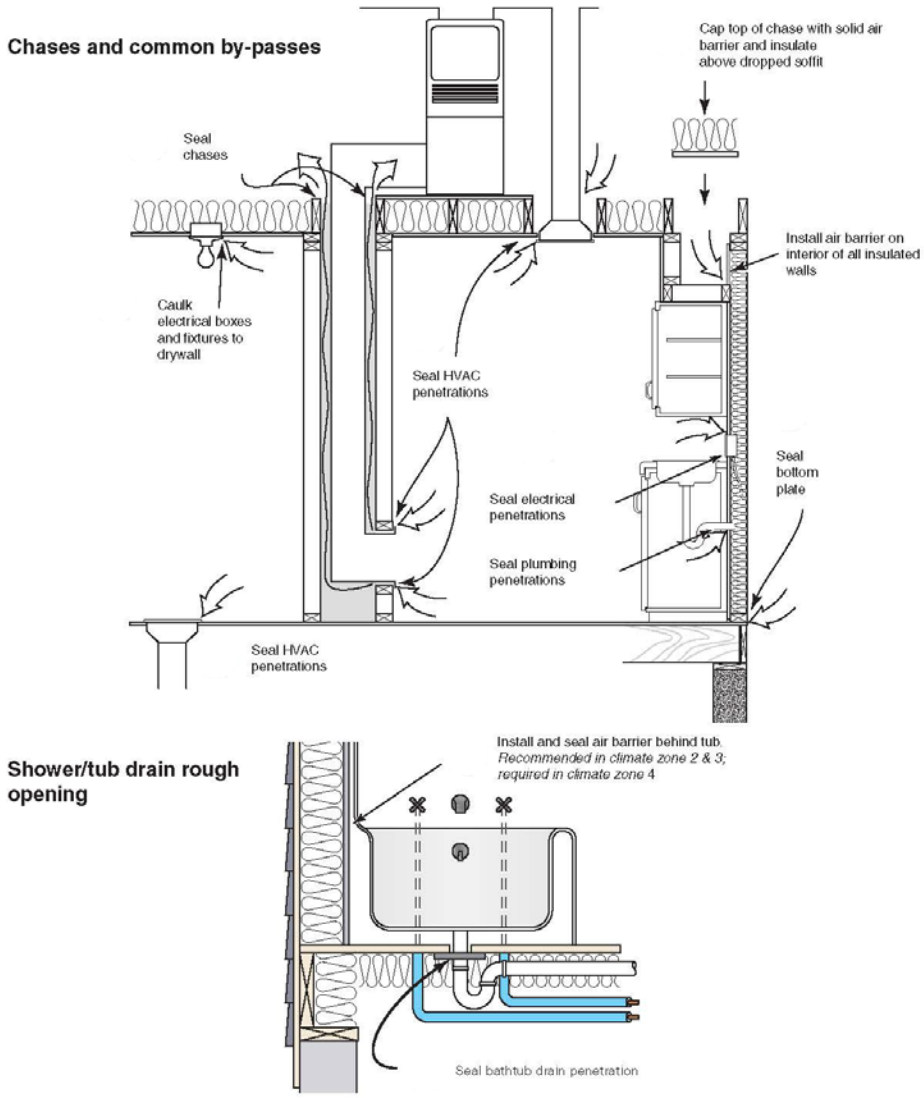


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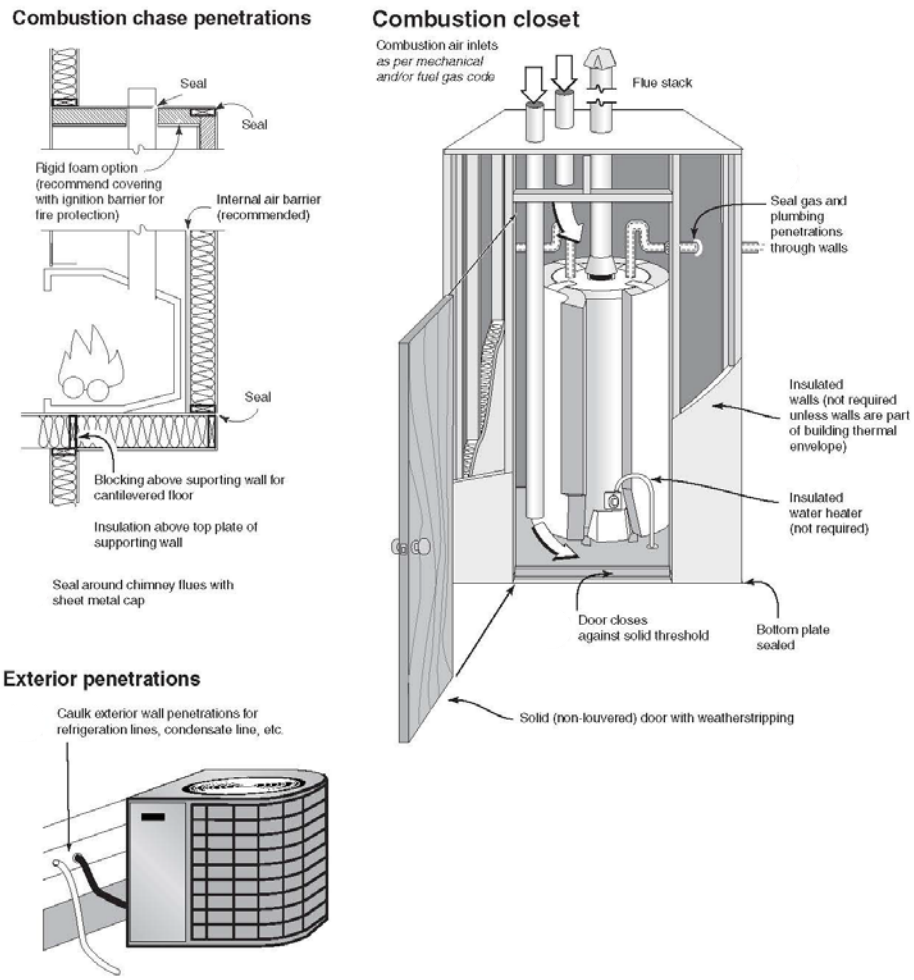
Diagram 2.3 Heating and Air Conditioning Air Sealing Key Points



Disclaimer: This image is intended solely to help graphically demonstrate the air leakage provisions of section 402.4 of the 2006 International Energy Conservation Code (IECC). It does not cover all air sealing locations or techniques. Other code provisions may be applicable as well.

Minor Air Sealing

Minor air sealing includes sealing small openings with materials such as caulk, weather stripping, or sash locks. These measures tend to please the home's occupants by reducing perceived drafts, slowing the entry of dirt, or making the interior paint look better. However, they rarely result in significant blower door reductions or changes in pressure diagnostic readings. [2]

Air Sealing Tips

Air barriers must be able to resist severe wind pressures. It is always preferable to use strong air barrier materials like plywood, drywall, or foamboard to seal air leaks, particularly in regions with strong winds. These materials should be attached with mechanical and/or adhesive bonds; never use plastic in Texas!

Caulk should only be used for sealing very small cracks. Use filler material under caulk when sealing cracks larger than 1/4".

Seal all air leaks and bypasses prior to insulating except where dense-packed insulation is also being used for sealing.

If ducts are located in attic, crawl space, attached garage, or in the floor cavity above garage, caulk or foam the joint between the boot and the ceiling, wall, or floor. [2]

NONFEASIBLE CRITERIA

WHEN NOT TO AIR SEAL

Air sealing reduces the exchange of fresh air in the home, and can alter the pressure balance within the home. Before air sealing, survey the home to identify both air-pollutants that may be concentrated by air sealing efforts, and combustion appliances that may be affected by changes in house pressure.

Don't perform air-sealing when there are obvious threats to the occupants' health, the installers' health, or the building's durability. If any of the following circumstances are present, do not perform air sealing until they are corrected.

- Moisture that has caused structural damage such as rot, mold, or mildew
- Sanitary issues are present
- Fire hazards
- Measured carbon monoxide levels that exceed the suggested action level and can't be corrected
- The building is already at or below its building tightness limit, and no mechanical ventilation exists or is planned
- Combustion appliances whose chimneys don't meet minimum standards

10 CFR § 440.21 Weatherization materials standards and energy audit procedures

(b) Only weatherization materials which are listed in appendix A to this part and which meet or exceed standards prescribed in appendix A to this part may be purchased with funds provided under this part. However, DOE may approve an unlisted material upon application from any State.

(d) Except for materials to eliminate health and safety hazards allowable under §440.18(c)(15), each individual weatherization material and package of weatherization materials installed in an eligible dwelling unit must be cost-effective. These materials must result in energy cost savings over the lifetime of the measure(s), discounted to present value, that equal or exceed the cost of materials, installation, and on-site supervisory personnel as defined by the Department. States have the option of requiring additional related costs to be included in the determination of cost-effectiveness. The cost of incidental repairs must be included in the cost of the package of measures installed in a dwelling. [2]

See 10 CFR 440: Appendix A.

STANDARDS

CAULKING and SPRAY FOAM STANDARDS

Item	Materials	Criteria/Requirements
Acceptable Materials	Acrylic latex plus silicone sealing compounds *	Conforms to 10 CFR 440 Appendix A
	Polyurethane foam	Conforms to 10 CFR 440 Appendix A
	Elastomeric sealants (including polysulfide, polyurethane, and silicone) *	Conforms to 10 CFR 440 Appendix A
	Masonry compounds	Commercially available

* Caulk shall be clear when dry, and paintable.

NOTE: All caulking is to be installed as directed by blower door tests, work order air sealing directives, and must have a savings to investment ratio (SIR) of 1.0 or better in the audit.

Air leakage in homes accounts for 5% to 40% of annual heating and cooling costs. Air leakage reduction is one of weatherization's most important functions, and often the most difficult.

Reducing air leakage accomplishes several tasks:

- Saves energy by protecting the thermal resistance of the shell insulation;
- Increases comfort by reducing drafts and moderating the radiant temperature of interior surfaces; and
- Reduces moisture migration into building cavities.

Gaps ≤ 1/4": Use caulk

Gaps 1/4" – 3": Use spray foam

Other: Use foam board, fiberglass, etc.

Special areas: Use high-temp caulk, flashing, etc.

Common Air Leakage Pathways [8]

Air sealing guided by using the blower door can save you time and money. You can achieve this by air-sealing while the blower door is operating. This technique can help you reach your air sealing goal.

- Between interior wall top plates and drywall
- Attic hatchways
- Through cracks in recessed fixtures
- Short circuits through attic insulation
- Between exterior wall top plates and drywall
- Through gaps in siding and sheathing
- Through holes in electrical boxes
- Between bottom plate and drywall
- Between bottom plate and subfloor
- Between rim joist and subfloor
- Between rim joist and top plate
- Between top plates and drywall
- Around window and door jambs
- Poorly weatherstripped windows and doors
- Between window rough framing and drywall
- Between bottom plate and drywall
- Between bottom plate and subfloor
- Between rim joist and subfloor
- Between rim joist and sill plate
- Between sill plate and foundation wall
- Through cracks in foundation wall
- Between floor slab and foundation wall
- Through cracks in floor slab

Air sealing reduces the exchange of fresh air in the home, and can alter the pressure balance within the home. Before air sealing, survey the home to identify both air pollutants that may be concentrated by air sealing efforts, and combustion appliances that may be affected by changes in house pressure.

Don't perform air sealing when there are obvious threats to the occupants' health, the installers' health, or the building's durability. If any of the above circumstances are present, do not perform air sealing until they are corrected.

Finish Bead (All types of caulk)

- Beads must be continuous, free of voids and effective in eliminating the air infiltration
- All excess caulk should be removed so that a neat appearance is achieved
- All caulk shall be troweled or finger wiped after application [2]

NONFEASIBLE CRITERIA

INTERIOR CAULK APPLICATION

Do Not Install:

1. When the common infiltration points (as listed) are inaccessible due to crowded, cluttered or other extremely adverse conditions;
2. Where interior sheathing is improperly applied so that interior sealing is not economically feasible;
3. When client refuses interior sealing (must be documented in client file folder);
4. When conditions exist in the interior of the unit which would pose a threat to the health or safety of the work crew; and/or
5. When not justified by a blower door test or the Audit with an SIR of 1.0 or greater.

These conditions must be well documented with pictures when possible. Documentation must be maintained in the client file.

Note: "Controlled" ventilation is essential to client health and safety. Refer to blower door standards and ASHRAE 62.2.2010

STANDARDS

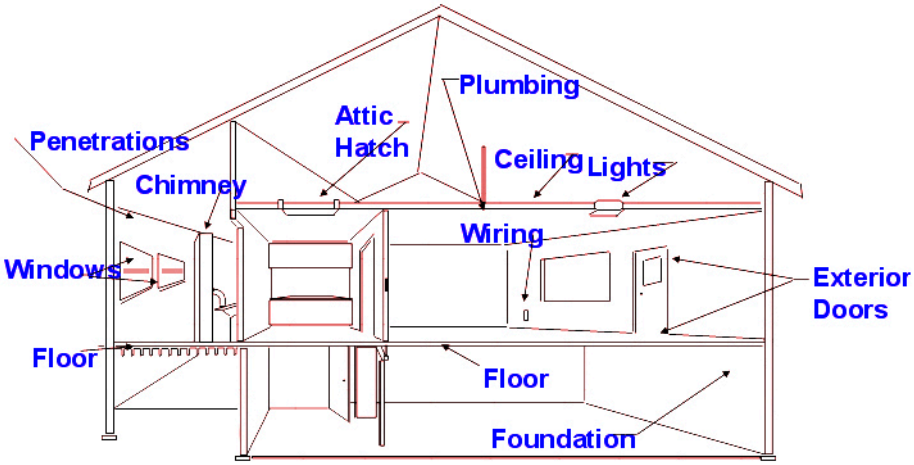
ALL TYPES OF CAULK

Item	Materials	Criteria/Requirements
Cracks	All types of caulk	▪ Interior cracks larger than 1/16" should be sealed ▪ Cracks larger than 1/4" should be filled before caulking ▪ Exterior cracks which allow moisture penetration should be addressed as referenced in "Interior cracks" above ▪ Note: Units which must be sealed solely from the outside shall use the standards referenced above for 1/16", 1/4" and 1" cracks ▪ All cracks must be sealed completely
Filler Material	All types of caulk	▪ Spaces wider than 1/4" but not wider than 1" should be filled to within at least 1/4" of the surface with one of the following: - closed cell foam tape - oakum - closed cell polyethylene rod - twine - flexible fiberglass - polyurethane foam ▪ Filler material must be covered with caulk
Surface Preparation Requirements	All types of caulk	▪ Surface must be reasonably free of loose or cracked caulk ▪ Surface must be free of dirt and debris so that applied caulk will adhere to surface ▪ Surface must be free of moisture unless allowed by specifications
Application Requirements	All types of caulk	▪ Follow manufacturer's instructions in all cases, with careful attention to: - application temperature limits - primer requirements for masonry surfaces

Attic Air Sealing

Other than obvious large holes in a structure, the attic consistently nets the largest cubic foot per minute (CFM) reduction for your time. Yes, attics are hot, dirty, and not a pleasant space in which to work; however, a few well spent hours of air sealing in the attic is worth the effort for the increase in energy savings and indoor air quality.

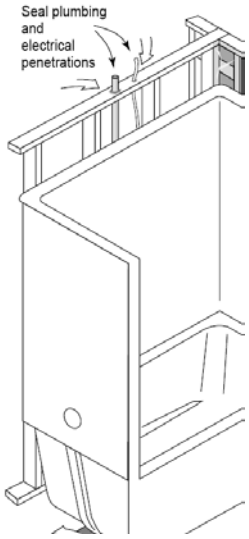
Diagram 2.4 Top Down Approach to Air Sealing



Infiltration points - Typical sources of air leakage in the home. [8]

Top Plates

Top plates



Plumbing penetrations and electrical penetrations:

- Seal all electrical wiring, plumbing, and heating, ventilation, and air conditioning (HVAC) penetrations between conditioned and unconditioned spaces with spray foam or caulk.

Heat Sources

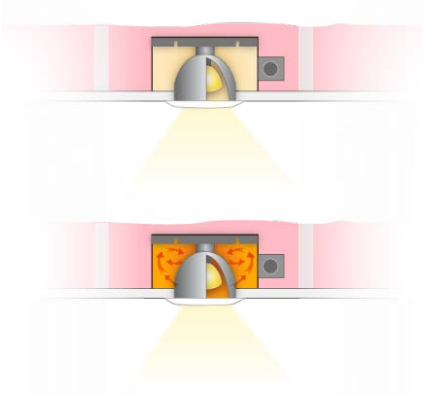
- Protect heat-producing fixtures such as recessed lights and exhaust fans that have lights or heaters. Install an airtight box if air leakage is suspected, or a metal collar if they are airtight.
- **N1102.4.5 Recessed Lighting**
  Recessed lights installed in the building thermal envelope shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed lights shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering. [6]
- Be sure to caulk joints where exhaust fan and recessed light housings come in contact with the ceiling with high-temperature silicone sealant.
- Install insulation blocking around unlined masonry chimneys, B-vent chimneys, and manufactured chimneys.
- Install insulation shields around all-fuel wood-stove chimneys with 6” of space between the chimney and insulation. Seal any bypasses around chimneys with metal and high-temperature caulk.

- If shields are used as a barrier around heat producing devices or masonry chimneys, fasten them securely to the ceiling joist so they maintain 3” of clearance and don’t collapse.
  - Don’t allow metal shields to contact wiring.
  - Cover the tops of shields while installing insulation, and uncover and clean them out afterwards.

Recess Light Fixtures

Prove 3” of air space between recessed lights and insulation or other flammables.

A fabricated airtight drywall box meets electrical code requirements and provides a good seal.



- Insulation Contact (IC) Rated fixtures can be covered in insulation
- Non-IC rated fixtures cannot.
- Covering non-IC rated fixtures leads to heat buildup, reduces bulb life, and is a fire hazard.

Chases/Bypasses

Seal All Bypasses

A properly sealed bypass

- **Duct chases:** If chase opening is large, seal with a rigid barrier such as fire-rated foam board, plywood or drywall, and seal the new barrier to ducts with caulk or foam. Smaller cracks between the barrier and surrounding materials may be foamed or caulked.
- **Masonry chimneys:** Seal chimney and fireplace bypasses with sheet metal (minimum 28 gauge thickness). Seal chimney or flue to ceiling structure with a high temperature sealant or chimney cement.
- **Tops and bottoms of balloon-framed interior partition wall cavities, missing top plates:** Seal with a fiberglass batt insulation plug covered with a 2-part foam air seal.
  - Seal with rigid barrier, such as 1/4” plywood or 1” foam board sealed to surrounding materials with caulk or liquid foam.
- **Joist cavities under knee walls in finished attic areas:** Connect knee wall with the plaster ceiling of the floor below by creating a rigid seal under the knee wall.

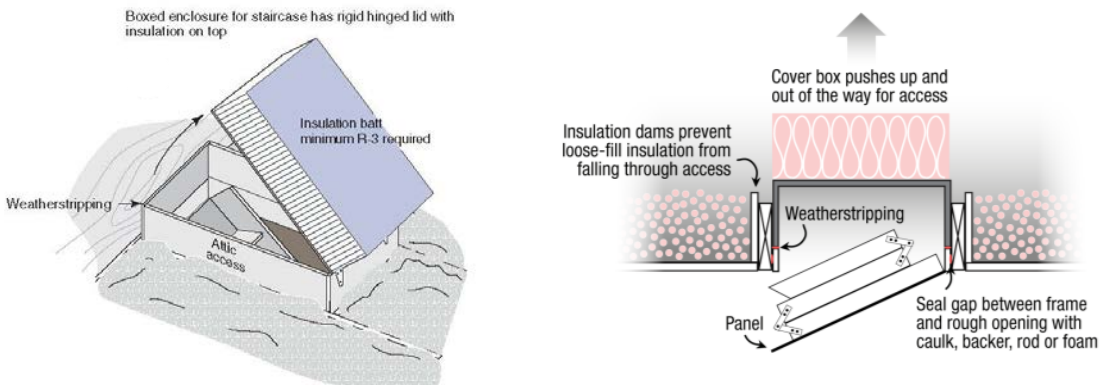
- **Two-level attics in split-level houses:** Seal the wall cavity with a rigid material fastened to studs and wall material.
- **Kitchen or bathroom interior soffits:** Seal the top of the soffit with fire-rated foil-faced foam board, plywood or drywall, fastened and sealed to ceiling joists and soffit framing.[2]

Attic Hatches

- The attic hatch is the most important door in the house to seal. A 1/4" gap around the perimeter of an attic access can potentially leak the same amount of air supplied by a typical bedroom heating duct.[4]
- Attic hatches and stairwell drops: Weatherstrip around doors and hatches. Caulk around frame perimeter. Seal penetration with caulk or foam.

Diagram 2.5 Attic Access Air Sealing Key Points

Attic Pull-Down Stairs



Scuttle Hole Cover

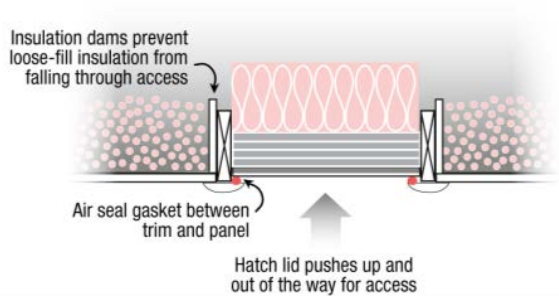
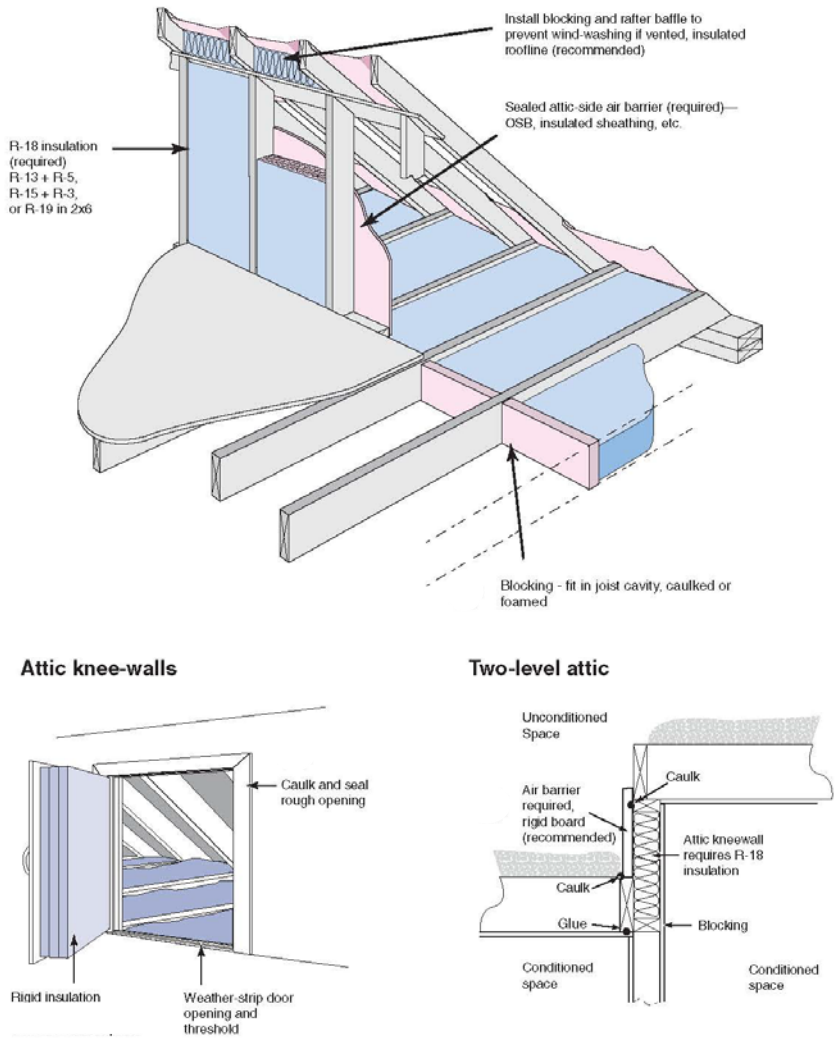


Diagram 2.6 Knee Wall Air Sealing Key Points



Disclaimer: This image is intended solely to help graphically demonstrate the air leakage provisions of section 402.4 of the 2006 International Energy Conservation Code (IECC). It does not cover all air sealing locations or techniques. Other code provisions may be applicable as well.

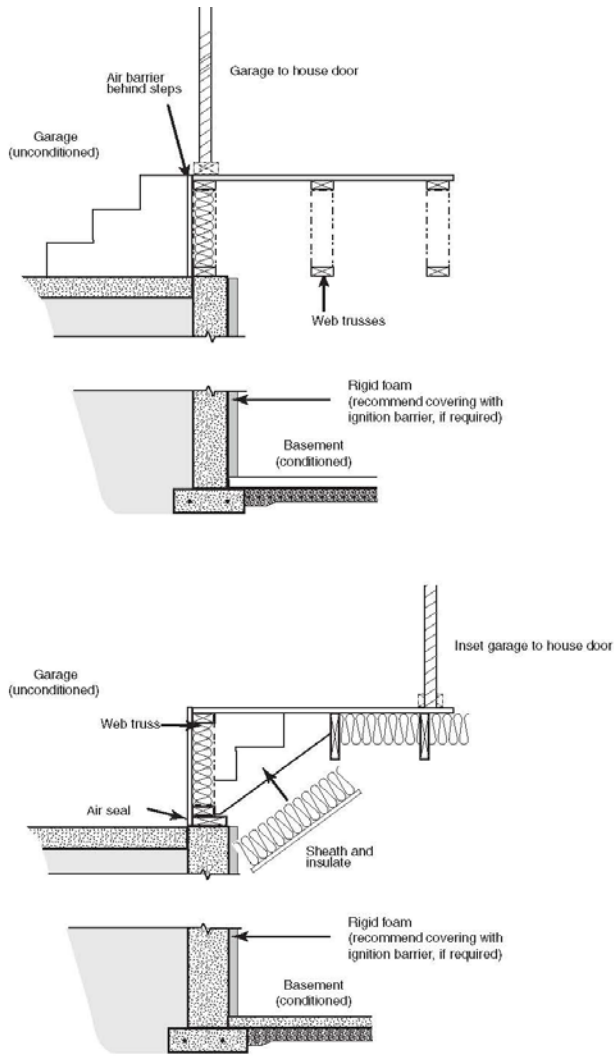
Garage to House Connections

Car exhaust, toxic chemicals and volatile organic compounds (VOCs) are present in most garages. These health dangers can find their way into the house through poorly sealed doors, ducts, electrical and plumbing penetrations, and other wall and ceiling penetrations.

VOCs are widely used as ingredients in household products, such as paints, varnishes, wax, fuels, and many cleaning, disinfecting, cosmetic, degreasing, and hobby products. These compounds vaporize at normal room temperatures, sometimes causing adverse health effects. These products can release organic compounds while in use and, to some degree, when they are stored. [5]

Make sure the door leading from the garage into the house closes tightly and is proper weatherstripped. Seal all penetrations between the garage and house. It is important to air seal the garage ceiling, if there is conditioned space above the garage or the attic space above it is connected to the main house.

Diagram 2.7 Garage to Home Air Sealing Key Points



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Walls

STANDARDS

WALL REPAIR

Item	Materials	Criteria/Requirements
Wall Repair	All materials	▪ Interior and exterior walls shall be repaired prior to insulating the wall cavity ▪ All repairs shall be durable and permanent
Entry Holes	All materials	▪ Exterior hole in wood siding shall be sealed with plastic or wood plugs and primed and/or painted to match siding ▪ Exterior holes in masonry or stucco siding shall be sealed with a mortar or a material specifically manufactured to repair stucco or masonry ▪ Mortar shall completely seal the opening and be textured to match surrounding surface ▪ Interior holes in drywall shall be plugged and taped or sealed with a material specifically manufactured to repair drywall or plaster. Holes shall be made ready for paint. ▪ Interior holes in plywood, chipboard or hardboard shall be plugged and sealed with caulk

Air Sealing Walls

Sometimes air sealing requires repairing damaged drywall.

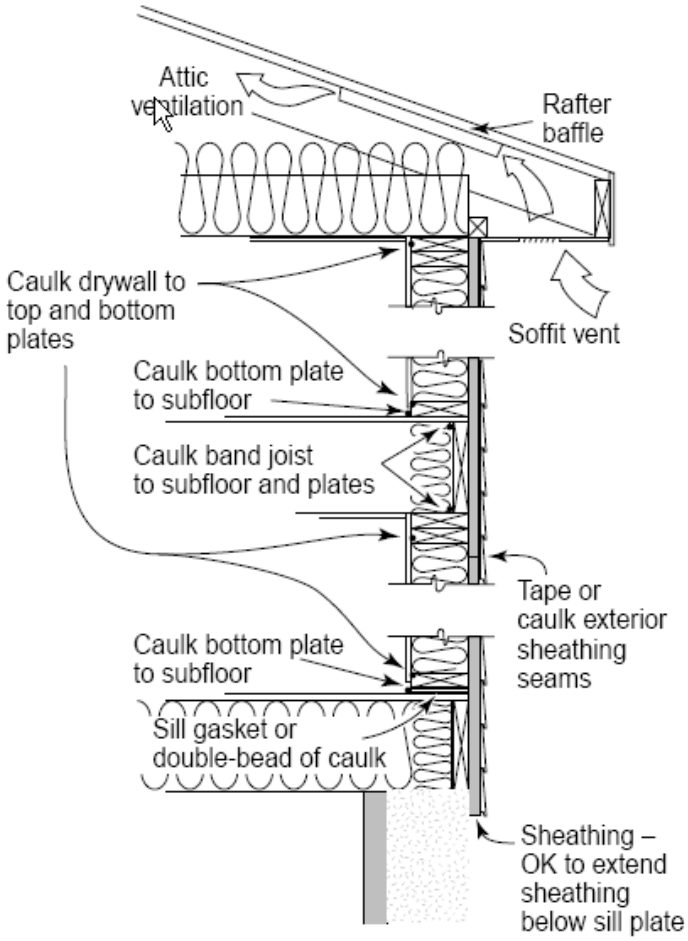
Air leakage, or infiltration, occurs when outside air enters a house uncontrollably through cracks and openings. Properly air sealing such cracks and openings in the home can significantly reduce heating and cooling costs, improve building durability, and create a healthier indoor environment. [5]

- **Holes and cracks in masonry surfaces:** Best sealed with a cement-patching compound or mortar mix.
- **Exterior walls.** There are a multitude of holes in a building shell from vents, flues, wiring, and plumbing.
- **Vent stacks, plumbing vents, open plumbing walls:** Seal joints with expanding foam or caulk. If joint is too large, stuff with fiberglass batt insulation, and spray foam over the top to seal the surface of the plug.
- **Interior walls:** may have some of the same holes. In addition, there may be drywall sections that need either sealing of cracks or holes. Often sections of drywall need to be added or replaced.
- **Large holes and other openings in the air barrier:** Seal with rigid material, caulk, spray foam, or expanding foam depending upon size and nature of opening. Work from largest to smallest when sealing.
- **Interior joints:** These can be caulked if blower door testing indicates substantial leakage. These joints include where baseboard, crown molding and/or casing meet the wall/ceiling/floor surfaces. Gaps

around surface-mounted or recessed light fixtures and ventilation fans can be caulked if needed, using high temperature caulk.

- **Pocket door cavities:** Cap the top of the entire wall cavity in the attic with rigid board, caulked and stapled. Where wall cavities containing the retracted pocket door halves connect with exterior framed walls, stuff narrow strips of unfaced fiberglass batts into the door opening with a broom handle far enough to allow for complete opening of the door. [2]

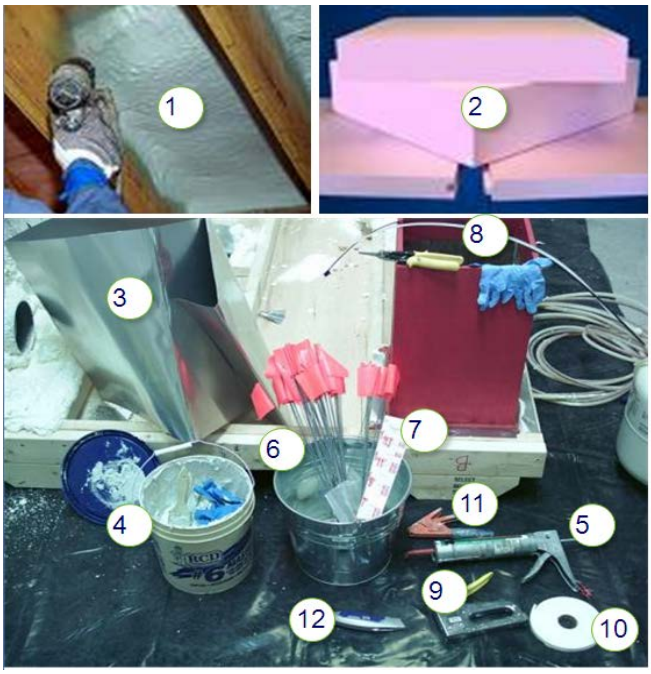
Diagram 2.8 Wall Air Sealing Key Points



Disclaimer: This image is intended solely to help graphically demonstrate the air leakage provisions of section 402.4 of the 2006 International Energy Conservation Code (IECC). It does not cover all air sealing locations or techniques. Other code provisions may be applicable as well.

Air Sealing Tools and Materials

Air Sealing and Attic Prep



1. Urethane foam (spray foam)
2. Foam board
3. Sheet metal/foil
4. Mastic and gloves
5. High-temperature caulk
6. Utility flags
7. Insulation rulers
8. Tin snips and zip ties
9. Stapler
10. Weatherstripping
11. Zip tie tightening
12. Utility knife

Weatherstripping

★ STANDARDS

WEATHERSTRIPPING STANDARDS

Item	Materials	Criteria/Requirements
Acceptable Materials	Foam tape	▪ Must be closed cell ▪ Must be UV resistant ▪ Must have adhesive backing
	Vinyl v-strip	▪ May only be applied to surfaces thoroughly cleaned with alcohol or other cleaning solvent ▪ Must be affixed with siliconized sealant
	Pile	▪ May replace existing material only
	Spring and cushion metal	▪ Must be made from bronze
	Jamb up	▪ Install top section first ▪ Bulb side touching door ▪ Must be attached with screws 9” apart and within 2” of each end; do not over-tighten screws ▪ Cut a 1/4” notch out of the bulb on the top of the two side pieces to fit nicely against the top piece
	Q-lon	▪ Must be attached (nailed) every 4”
Warranty	All types	▪ Must have a minimum of 1 year warranty
Where Installed	All types	▪ Must be placed at movable joints (i.e. doors and attic hatches) separating conditioned spaces from unconditioned spaces

Windows

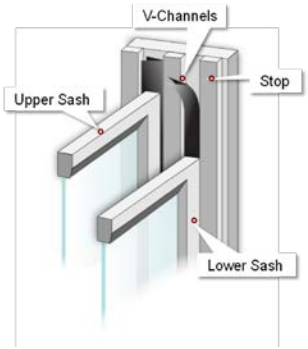
Window Repair and Air Leakage Reduction

With the exception of broken glass or missing window panes, windows are rarely the major source of air leakage in a home.

Window weatherstripping is typically not cost effective but may be installed to solve a comfort problem. Avoid expensive or time consuming window repair measures that are implemented to solve minor comfort complaints.

Re-glazing window sashes is time consuming, and is best accomplished as part of a comprehensive window rehabilitation project. Re-glazing wood windows may not be a durable repair without thorough scraping, priming and painting.

Window Repairs



Where applicable:
- Replace broken glass
- Replace broken sash locks
- Weather strip meeting rails and sliding surfaces
- Install pulley seals
- Caulk interior trim

Window Repair Measures

- Replace missing or broken glass. Use glazing compound and glazier points when replacing glass in older windows. Glass cracks that are not noticeably separated and less than 6” long can be left.
- Caulk interior and exterior window frame to prevent air leakage.
- Condensation and rain leakage. Use sealants with rated adhesion and joint-movement characteristics appropriate for both the window frame and the building materials surrounding the window.
- Replace missing or severely deteriorated window frame components. Extremely damaged wood should be filled with a marine epoxy, primed, and painted.
- Adjust window stops if large gaps exist between stop and jamb. Ensure that window operates smoothly following stop adjustment.
- Weatherstrip large gaps between the sash and the sill or stops. Weatherstrip the meeting rails if needed.
- Replace or repair missing or non-functional top and side sash locks, hinges or other hardware if such action will significantly reduce air leakage.
- Use lead-safe weatherization practices when working on windows. [2]

Glass Replacement Tools

- Remove broken pane
- Measure opening and cut new pane from glass sheet
- Install, point and glaze replacement pane

Common Weatherstripping [24]

Weatherstripping	Best Uses	Cost	Advantages	Disadvantages
TENSION SEAL ▪ Self-stick plastic (vinyl) folded along length in a V-shape or a springy bronze strip (also copper, aluminum, and stainless steel) shaped to bridge a gap ▪ The shape of the material creates a seal by pressing against the sides of a crack to block drafts	Inside the track of a double-hung or sliding window, top and sides of door	Moderate; varies with material used	▪ Durable ▪ Invisible when in place ▪ Very effective ▪ Vinyl is fairly easy to install ▪ Look of bronze works well for older homes	▪ Surfaces must be flat and smooth for vinyl ▪ Can be difficult to install, as corners must be snug ▪ Bronze must be nailed in place (every 3" or so) so as not to bend or wrinkle ▪ Can increase resistance in opening/closing doors or windows ▪ Self-adhesive vinyl available ▪ Some manufacturers include extra strip for door striker plate
FELT ▪ Plain or reinforced with a flexible metal strip; sold in rolls ▪ Must be stapled, glued, or tacked into place ▪ Seals best if staples are parallel to length of the strip	▪ Around a door or window (reinforced felt) ▪ Fitted into a door jamb so the door presses against it	Low	▪ Easy to install ▪ Inexpensive	▪ Low durability; least effective preventing airflow ▪ Do not use where exposed to moisture or where there is friction or abrasion ▪ All-wool felt is more durable and more expensive Very visible
REINFORCED FOAM Closed-cell foam attached to wood or metal strips	▪ Door or window stops ▪ Bottom or top of window sash ▪ Bottom of door	Moderately low	▪ Closed-cell foam an effective sealer ▪ Scored well in wind tests ▪ Rigid	▪ Can be difficult to install; must be sawed, nailed, and painted ▪ Very visible ▪ Manufacturing process produces greenhouse gas emissions
TAPE Nonporous, closed-cell foam, open-cell foam, or Ethylene Propylene Diene Monomer (EDPM) rubber	▪ Top and bottom of window sash ▪ Door frames ▪ Attic hatches ▪ Inoperable windows ▪ Good for blocking corners and irregular cracks	Low	▪ Extremely easy to install ▪ Works well when compressed Inexpensive ▪ Can be reinforced with staples	▪ Durability varies with material used, but not especially high for all ▪ Use where little wear is expected ▪ Visible
ROLLED OR REINFORCED VINYL Pliable or rigid strip gasket (attached to wood or metal strips)	▪ Door or window stops ▪ Top or bottom of window sash ▪ Bottom of a door (rigid strip only)	Low to moderate	▪ Easy installation ▪ Low to moderate cost ▪ Self-adhesive on pliable vinyl may not adhere to metal; some types of rigid strip gaskets provide slot holes to adjust height, increasing durability ▪ Comes in varying colors to help with visibility	Visible
DOOR SWEEP Aluminum or stainless steel with brush of plastic, vinyl, sponge, or felt	Bottom of interior side of in-swinging door; bottom of exterior side of exterior-swinging door	Moderate to high	▪ Relatively easy to install; many types are adjustable for uneven threshold ▪ Automatically retracting seeps also available, which reduce drag on carpet and increase durability	▪ Visible ▪ Can drag on carpet ▪ Automatic sweeps are more expensive and can require a small pause once door is unlatched before retracting

Weatherstripping	Best Uses	Cost	Advantages	Disadvantages
MAGNETIC Works similarly to refrigerator gaskets	Top and sides of doors, double-hung and sliding window channels	High	Very effective air sealer	
TUBULAR RUBBER AND VINYL Vinyl or sponge rubber tubes with a flange along length to staple or tack into place Door or window presses against them to form a seal	Around a door	Moderate to high	Effective air barrier	Self-stick versions challenging to install
REINFORCED SILICONE Tubular gasket attached to a metal strip that resembles reinforced tubular vinyl	On a doorjamb or a window stop	Moderate to high	Seals well	▪ Installation can be tricky ▪ Hacksaw required to cut metal ▪ Butting corners pose a challenge
DOOR SHOE Aluminum face attachment with vinyl C-shaped insert to protect under the door	To seal space beneath door	Moderate to high	▪ On the exterior, product sheds rain ▪ Durable ▪ Can be used with uneven opening ▪ Some door shoes have replaceable vinyl inserts	▪ Fairly expensive ▪ Installation moderately difficult ▪ Door bottom planning possibly required
BULB THRESHOLD Vinyl and aluminum	Door thresholds	Moderate to high	▪ Combination threshold and weatherstrip; available in different heights	Wears from foot traffic; relatively expensive
"FROST-BRAKE" THRESHOLD Aluminum or other metal on exterior, wood on interior, with door-bottom seam and vinyl threshold replacement	To seal beneath a door	Moderate to high	▪ The use of different materials means less cold transfer ▪ Effective	Moderately difficult to install, involves threshold replacement
FIN SEAL Pile weatherstrip with plastic Mylar fin centered in pile	For aluminum sliding windows and sliding glass doors	Moderate to high	Very durable	Can be difficult to install
INTERLOCKING METAL CHANNELS Enables sash to engage one another when closed	Around door perimeters	High	Exceptional weather seal	▪ Very difficult to install as alignment is critical ▪ To be installed by a professional only

Window Weatherstripping

Choose a type of weatherstripping that will withstand the friction, weather, temperature changes, and wear and tear associated with its location. For example, weatherstripping in a window sash must accommodate the sliding of panes up and down, sideways, or outward. The weatherstripping you choose should seal well when the window is closed while allowing it to open freely.

Choose a product for each specific location. Felt and open-cell foams tend to be inexpensive, susceptible to weather, visible, and inefficient at blocking airflow. However, the ease of applying these materials may make them valuable in low-traffic areas. Vinyl, which is slightly more expensive, holds up well and resists moisture. Metals (bronze, copper, stainless steel, and aluminum) last for years and are affordable. Metal weatherstripping can also provide a nice touch to older homes where vinyl might seem out of place. [24]

NONFEASIBLE CRITERIA

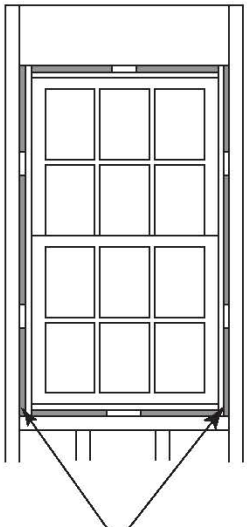
WINDOW WEATHERSTRIPPING

Do Not Install:

1. When already properly installed;
2. When windows are located between two conditioned or two unconditioned areas;
3. When windows are painted shut;
4. When storm windows are present;
5. When existing windows form an effective seal as installed; and/or
6. When not justified by a blower door test and a savings to investment ration (SIR) ranking of 1.0 or better by the audit.

Diagram 2.9 Window Air Sealing Key Points

Window rough opening



Use backer rod or spray foam (appropriate for windows) to fill gaps between window/door and rough opening.

Disclaimer: This image is intended solely to help graphically demonstrate the air leakage provisions of section 402.4 of the 2006 International Energy Conservation Code (IECC). It does not cover all air sealing locations or techniques. Other code provisions may be applicable as well.

Window Glass Replacement

★ STANDARDS

WINDOW WEATHERSTRIPPING

Item	Materials	Criteria/Requirements
Double Hung Windows	Wood, metal and plastic	▪ Sash locks (manufactured only) ▪ Shims may be used to form an effective seal ▪ Pulley seals will be installed where needed ▪ Closed cell foam may be used in compression only
Casement Windows	Wood, metal and plastic	▪ May use spring metal, cushion metal or rigid gasket ▪ Closed cell foam may be used in compression only
Horizontal Aluminum Slider	Metal	▪ May use replacement pile, closed cell foam, flex tape V-strip with siliconized adhesive or other effective material
All Metal Window	All types	▪ Replacement pile recommended ▪ Replacement must be correct size in both width and height

★ STANDARDS

GLASS REPLACEMENT

Item	Materials	Criteria/Requirements
Allowable Materials	Single strength glass (SS)	▪ Allowed for openings up to 100 U.I.*
	Double strength glass (DS)	▪ Required for opening greater than 100 U.I.* but not greater than 150 U.I.*
	Plate glass	▪ Recommend that openings greater than 150 U.I.* be converted to accept two or more standard replacement window units
	Safety glass	▪ As required by local code ▪ May use rigid plastic sheets in lieu of safety glass
	Plastic sheets	▪ Must be UV treated ▪ Must be at least 1/8” thick ▪ Polycarbonate recommended
	Plastic film	▪ Not allowed
Glazing Compounds	Wood sash	▪ Caulking tube-type glazing recommended (commercially available)
	Metal sash	▪ Caulking tube-type glazing not recommended ▪ Match existing glazing beads (or strips) where feasible
	Wood and metal	▪ Glazing materials must remain pliable
Treatment of Sash	Wood sash	▪ Must be clean and free of dirt or loose material ▪ Decayed or deteriorated sash must be replaced ▪ Follow manufacturer’s requirements for treating surface
	Metal sash	▪ Must be clean and treated with rust inhibitor
Push Points	Wood sash	▪ Must be installed ▪ Points spaced a maximum of 8” apart ▪ Points located within 4” of each corner
Spring Clips	Steel casement	▪ Recommend installation of spring clips ▪ Spaced a maximum of 12” apart ▪ Clips located within 4” of each corner
Cushion Bead	Wood and metal	▪ Required on all glass installations ▪ Bead must be continuous and free of voids ▪ Use appropriate material (i.e. glazing compound in wood sash windows; caulking compound recommended for metal sashes)

* U.I. = United Inches = One width measurement in inches plus one length measurement in inches.

Storm Windows

Storm windows are relatively expensive compared to other weatherization measures, and therefore are not always cost effective. Storm windows can preserve old worn primary windows, though, which can be cheaper than replacing the primary windows.

NONFEASIBLE CRITERIA

WINDOW GLASS REPLACEMENT

Do Not Install:

1. When small hole, 1/4" or less, is present and can be patched with clear silicone;
2. When crack is less than 6" long, and it cannot go any further; and/or
3. When not justified by a savings to investment ratio (SIR) ranking of 1.0 or better by the audit.

Aluminum storm windows are the best choice if they are well designed and installed properly.

- Frames should have sturdy corners so they don't rack out-of-square during transport and installation.
- Sashes must fit tightly in their frames.
- The gasket sealing the glass should surround the glass's edge and not merely wedge the glass in place against the metal frame.
- The window should be sized correctly and fit tightly in the opening.

Storm Window Installation Guidelines

- Do not install new storm windows to replace existing storms if the existing storms are in good condition or can be repaired at a reasonable cost.
- Caulk storm windows around the frame at time of installation, except for weep holes that should not be sealed. If weep holes are not manufactured into new storm window, weep holes should be drilled into them.
- Do not allow storm windows to restrict emergency egress or ventilation through moveable windows. Choose windows that are openable from the inside or install pin-on storm sashes that open along with the moveable primary window. [2]

STANDARDS

STORM WINDOWS

Item	Materials	Criteria/Requirements
Allowable Materials	▪ Window glazing ▪ Caulking ▪ Hardware and fasteners ▪ Aluminum frame ▪ Wood frame ▪ Rigid vinyl frame	▪ Glass recommended ▪ UV and scratch resistant plastic sheets. (Polycarbonate recommended) ▪ See caulking section (section 1) for requirements ▪ Shall be aluminum, stainless steel or other non-corrosive material ▪ Conforms to 10 CFR 440 Appendix A ▪ Interior use only

Item	Materials	Criteria/Requirements
Pre-Installation Requirements	Prime window	▪ Existing units, pane, frame, and/or sash must be structurally sound ▪ Replace loose and/or missing glazing compound ▪ Contact area must be smooth and even (free of protrusions) ▪ Water penetration points must be sealed ▪ Dry rot around contact area must be replaced ▪ Prime window panes should be wiped clean (outside for exterior or inside for interior) prior to storm window installation
Size, Shape and Opening Direction	Window	▪ Size, shape and opening direction (i.e. vertical or horizontal slider) must match prime window ▪ Applicable building code egress (building exit) requirements must be met ▪ When feasible, removable sashes should function properly (to allow cleaning with frame in place) ▪ No storm window shall exceed 150 United Inches
Glass Thickness Requirements	Frame type & pane thickness: ▪ Wood or aluminum: - single strength - double strength (3/16" minimum) ▪ Vinyl: - double strength (3/16" minimum)	▪ Maximum Pane Size (in U.I.*): - Up to 100 U.I. - 101 to 150 U.I. - 100 U.I. Over 100 U.I. requires vertical supports - 120 U.I. Over 120 U.I. not recommended
Thermal Barriers Glazing Tape	Metal	▪ Vinyl or elastomeric thermal barrier (glazing tape) ▪ Required to prevent metal to metal contact between storm and prime window frames
New (Untreated) Wood	All types	▪ All new, bare or untreated wood shall be sealed with primer or water seal and stain
Attachment	Exterior	▪ Must be permanently attached with screws (except drywall) or clips ▪ Screws must reach into structural framing member or at least 3/4" solid wood ▪ Must be secured within 4" of each of the four corners ▪ Maximum of 16" allowed between screws or clips
Sealing	Exterior/interior	▪ Permanent caulking or gasket required between prime and storm window ▪ Seal all joints, gaps, holes and penetrations except weep holes ▪ No less than 2 weep holes, 3/16" diameter each, shall be provided for each exterior window (to ensure proper drainage)
Air Space	Exterior/interior	▪ To 4" between storm and prime window
Interior Mounting	Interior	▪ Mount inside existing window jamb, where possible ▪ Use screws or clips ▪ Attach as directed ▪ Sashes must be removable
Sash Mounted Storm Windows	Window	▪ Not Allowed
General Operational Requirements	Permanently installed	▪ Operable prime windows shall remain operable without removing storm window frame ▪ Interior access to prime and storm window latches must not be impaired
General Post Installation Requirements	All material	▪ Storm window panes shall be wiped clean inside and outside ▪ All labels on storm window panes, except those required by local code, shall be removed

- U.I. = United Inches = One width measurement in inches plus one length measurement in inches.
- Glazing thickness must comply with local standards.
- Safety glass must be used as required by local code.

Doors

Door measures are usually not cost effective. Doors have a small surface area and their air leakage is more of a localized comfort problem than a significant energy problem most of the time. However, door operation affects building security and durability, so doors are often an important repair priority.

Door Weatherstrip, Thresholds, and Sweeps

Door weatherstrip, thresholds and sweeps are marginally cost effective. These measures should be addressed as air infiltration as indicted by blower door testing.

- Install thresholds and door sweeps if needed to prevent air leakage.
  - Thresholds and sweeps should not bind the door.
  - Thresholds should be caulked at the sill and jamb junction.
- Tighten door hardware and adjust stops so door closes snugly against its stops.
- Use a durable stop-mounted or jamb-mounted weatherstrip material to weatherstrip the door.
- New weatherstrip must form a tight seal with no buckling or gaps when installed.
- Plane or adjust the door so it closes without rubbing or binding on the stops and jambs, especially in homes that may have lead paint. [2]

★ STANDARDS

DOOR WEATHERSTRIPPING

Item	Materials	Criteria/Requirements
Entrance Door Jamb	Wood and metal	▪ May use rigid gasket ▪ May use spring and cushion metal ▪ Vinyl V-strip acceptable on metal jambs ▪ Closed cell foam may be used in compression only (not recommended)
Installation	Rigid gasket, spring and cushion, vinyl v-seal, replacement pile, jamb up or Q-Lon*	▪ Must be attached with screws/nails placed a maximum of 9" apart and within 2" of each end ▪ Must be installed with screws/nails placed every 4" and placed with 2" of each end ▪ Must form an effective seal ▪ Jamb up must be screwed; not nailed.
Warranty	All types	▪ Must have a minimum of 1 year warranty
Gasket to Gasket Contact	All types	▪ Gasket to gasket contact required at all corners (caulk may not be used to achieve this contact) ▪ Each section is not to have one continuous strip if possible ▪ Corner "V" notching of bulb-type materials, acceptable
Thresholds	Wood and metal	▪ Use only hardwood, treated wood or metal ▪ Gasket saddles are not recommended but may be used where appropriate ▪ Metal must be permanently screwed in place ▪ Wood must be nailed or screwed in place ▪ Perimeter of threshold must be caulked

Item	Materials	Criteria/Requirements
		▪ Screws coated or plated for exterior use should be used. Black/sheetrock screws are not allowed for attachment of thresholds
Door Bottom	All types	▪ Must use door shoe/bottom or sweep with saddle threshold ▪ Shoe/bottom must have vinyl or silicone gasket and elongated mounting holes ▪ Door shoe/bottom may be L or U shaped and may include rain drip ▪ Retractable door sweep may be used when applicable

* For replacement of original weatherstrip only

Cracks in exterior window and door frames: Sealing serves to keep bulk water out. If the crack is deeper than 5/16", it should be backed with a material such as a rodent resistant backer rod and then sealed with caulk. Any existing loose or brittle material should be removed before the crack is recaulked. [2]

Door Repair

Door repair items improve home security and building durability. Door repair can also save energy if the door currently has a poor fit.

Limit door repair to these tasks:

- Replace missing or inoperable lock sets.
- Reposition the lock set and strike plate.
- Reposition stops if necessary.
- Seal gaps between the stop and jamb with caulk.
- Install a door shoe if needed to repair damage. [2]

Minor Door Repair

STANDARDS

DOOR GLASS REPLACEMENT

Item	Materials	Criteria/Requirements
Safety Glass in Doors		Required for replacement of existing broken safety glass in doors, windows and patio doors

DOOR MODIFICATION STANDARD

Item	Materials	Criteria/Requirements
Door Modification	Wood	If core is exposed by trimming, the stile must be replaced or core edge effectively sealed against the weather A maximum of 1" may be cut from either door side Recommend a 5° bevel be cut on lockset edge

Floor/Foundation

Stopping the Chimney Effect

Outside air drawn in through the crawlspace or basement leaks are exacerbated by the chimney effect created by leaks in the attic. As hot air generated by the furnace rises up through the house and into the attic through leaks, cold outside air gets drawn in through basement leaks to replace the displaced air. This makes a home feel drafty and contributes to higher energy bills. After sealing attic air leaks, complete the job by sealing the crawl space or lower floor leaks to stop the chimney effect. [25]

Crawl Space Vapor Barrier

6 mil thick poly plastic laid on crawl-space soil and sealed around the concrete piers with mastic.

Seal All Gaps and Cracks around Rim Joists

Though you may not be able to see cracks in the rim joist cavities, it is best to seal the top and bottom of the inside of the cavity. Also, rim joist air sealing is especially important at bump out areas such as bay windows that hang off the foundation. These areas provide greater opportunities for air leakage and heat loss. Caulk is best for sealing gaps or cracks that are 1/4" or less. Use spray foam to fill gaps from 1/4" to about 3".

We also recommend you seal penetrations that go through the crawlspace or basement to the floor above. Generally, these are holes for wires, water supply pipes, water drain pipes, and plumbing vent stacks (for venting sewer gases).

Caution: When sealing any heat source, encased in a metal sleeve run a bead of high temperature caulk around the pipe sleeve and around the metal blocking. [25]

Areas to Foam or Caulk

- Foundation sill plate joints
- Bottom and top of rim joist on each end of the house
- All electrical, water, or gas penetrations, and any venting ducts that pass to the outside
- Bathtubs and shower stalls: Seal holes and cracks from underneath with expanding foam. Seal large openings with rigid materials caulked or foamed at edges. [25]

STANDARDS

FLOOR SEALING STANDARDS

Item	Material	Criteria/Requirements
Rim Joist Access		▪ Bottom wall trim shall be removed to expose the rim joist ▪ Exterior siding may be unfastened only if necessary ▪ Rim Joist access shall be considered NOT feasible if it will result in visible damage to the siding
Hole Location	End and side joist	▪ One hole for each joist cavity ▪ Centered on joist to minimize structural damage ▪ Care shall be exercised to avoid damage to plumbing/electrical lines attached to or adjacent to rim joist
Belly Injection		▪ Penetrations shall be made as needed to achieve complete coverage ▪ Holes cut for inspection and existing damage holes may be used for access ▪ Holes shall be of sufficient size and spacing to accommodate the directional nozzle or fill tube utilized ▪ Maximum insulation travel beyond the nozzle or fill tube shall be 2’

All air sealing should be blower door driven to achieve the maximum cubic feet per minute (CFM) reduction. TDHCA and the US Department of Energy (DOE) require a significant reduction in CFM readings from the initial blower door reading to the final reading when homes warrant. Subrecipients are required to attempt to reach the Minimum Ventilation Requirement (MVR), within reason: in cost effective savings to investment ratio (SIR) guidelines and if the proposed tightening measures are reasonable based on the whole-house assessment. The goal is to get as close to the MVR as possible.

Chapter 3: Insulation

Table of Contents

Attic Insulation

Insulation reduces heat transmission by slowing conduction, convection, and radiation through the building shell. Insulation combined with an air barrier forms the thermal boundary. Installing insulation is one of the most effective energy-saving measures. [2] The key to maximizing energy-savings is installation of insulation! As most tradesmen reluctantly do, but always come to realize - time spent in prepping for any job makes for efficient quality work.

The US Department of Energy (DOE) estimates that an uninsulated attic can increase home energy costs by 30%. Adding insulation to an attic prevents heat or cold from moving into the home, and expensive heated or cooled air from escaping the building. For these reasons, attic insulation is the second most important weatherization measure to consider, after air sealing.

Insulation is key to saving energy. The attic is the first place to hit when air-sealing and insulating. Find a way or make a way to get in! [8]

If an attic is lacking insulation---you must get in! Create an attic access hatch or gain access through an existing gable vent. If none exists then add one.[8]

The benefits of insulation toward energy savings is proved time and again when using an energy auditing tool. The pre to post retrofit energy and loads will drop as much as 50% when insulating a previously uninsulated unit, another reason for prep and installing insulation properly.

Attic Preparation [1,2,7,8]

Follow the preparatory steps outlined below to help create a durable attic.

- **Ensure a good roof.** Although proper construction from the beginning will help protect attics from rain, snow, and ice, weatherproofing after construction can also help. Flashing, a type of weatherproofing in walls and roofs, uses waterproof material like sheet metal to fill spaces, stop water penetration, and prevent leaks.
- **Protect insulation from moisture by repairing small roof and siding leaks, and by controlling vapor sources within the home.**
    - If attic-related moisture problems can't be repaired, don't insulate the attic.
    - Allowable Expenditures: 10 CFR 440.18 (9). The cost of incidental repairs if such repairs are necessary to make the installation of weatherization materials effective.

NONFEASIBLE CRITERIA

INSULATING ATTICS

Do not install:

- If roof leaks over conditioned spaces and cannot be repaired, or until the roof is repaired by another funding source or the client.
- If the ceiling over conditioned spaces cannot be made to support the weight of the insulation.

Blocking and Baffling [4]

Place soffit baffles to maintain attic venting.
Apply blocking around heat sources.

- **Seal air gaps or leaks into the attic.** Warm, humid air from kitchens, bathrooms, and dryers threaten attic durability. Many homes lack sufficient air sealing between the top floor and attic space that can prevent warm, humid air from kitchens, bathrooms, and dryers from accessing the attic.
    - Check for leaks or gaps around ductwork, wires, plumbing, lighting fixtures, and around attic entryways. Protect insulation from air movement with an effective air barrier.
    - Make sure that the air barrier and insulation are properly aligned.
- **Properly insulate the attic, including the eaves.** Inadequate attic insulation allows heat to escape in the colder months, undermining attic durability and increasing home heating bills.
    - Install insulation so it covers the entire area without voids, hill and valleys, or edge gaps.
- **Install chutes, dams, tubes, or other blocking materials to prevent blown insulation from plugging air channels between soffit vents and the attic.** These shields maximize the amount of insulation that may be installed over top plates without clogging ventilation paths. They also help prevent the wind-washing of insulation caused by wind through the soffit vents.
- **Install an attic access hatch if none is present.** The attic hatch should be at least 22" on each side if possible.
- **Ventilate the attic.** Improper attic ventilation allows moisture to build up and can cause mold, ruin insulation, and damage wood.
    - Replace the panels covering the underside of roof eaves (soffits) with ridged vents allowing air to enter beneath the roof overhang.
    - Pair these with a ridge vent for increased effectiveness.
    - Do not cover soffit vents or touch underside of decking.
- **Vent all kitchen and bath fans outdoors through roof or soffit fittings, if possible.**
    - Rigid metal piping on kitchen fans to penetrate the ceiling and flexible metal or rigid for fans within the attic whenever possible, and insulate the pipe to prevent condensation.
    - Avoid using flexible plastic ducting.
    - Check all fans for proper backdraft damper operation.

✓ GOOD TO KNOW

HOT CLIMATE

Why is vent baffling and proper attic ventilation important?

Roof shingles are often dark and have granular surfaces that increase surface area. The sun radiates heat to the shingles. The shingles conduct heat through the underlayment and roof decking, which radiates this heat toward the insulation, mechanical equipment, framing and ductwork. As these surfaces heat up the air around them becomes hotter and convection begins. This produces the stack effect causing the hot attic air to moves up and out. As the hot air exhausts through higher vents, the lower soffit vents draw in "cooler" air from outside. [15]

- Repair or replace the damper or the entire fan assembly if the damper doesn't operate freely.

Observe lead-safe weatherization practices with all tasks that may disturb interior paint.

★ STANDARDS

ATTIC PREPARATION

Item	Materials	Criteria/Requirements
Pre-Installation Procedures	Roof all materials	▪ All roof repair or replacement must be completed before insulation is installed ▪ Broken or cracked rafters shall be replaced or repaired with doublers which extend at least 2' each side of break or crack ▪ Rafter braces are recommended, but braces must be attached at wall plates ▪ Roof "bowls" (concave areas) should be eliminated by bracing or overlaying
	Ceiling all materials	▪ Ceiling must be structurally capable of supporting insulation weight ▪ Room-side lath strips may be installed with client approval, to cover or support damaged or questionable joints ▪ Thin panels may be laid over attic side of joist to keep weight of insulation off good 1/ 2" sheetrock or 1/ 2" ceilings with excessive joist spacing ▪ Weak or damaged sheetrock under board ceilings does not have to be replaced or repaired unless board cracks or joints allow insulation to fall through ▪ Board ceilings with lap or tongue/groove joints or butt joints with spaces equal to or less than 1/16" do not need to be sealed if insulation is installed
	Blocking all materials	▪ All required blocking shall be completed
	Venting all materials	▪ All required venting shall be completed
Blocking and Baffles	Loose fill	▪ Wood, metal, plastic or mineral fiber blankets must be used for blocking or baffles ▪ No paper or asbestos products may be used to construct permanent insulation blocks or baffles
	Mineral blankets (batts)	▪ No additional blocking or baffling is required when mineral blankets are used ▪ Minimum 3" clearance (from insulation edge to heat source) must be maintained ▪ Baffle all soffit vents.

Blocking Installation	All materials	▪ Items requiring 3" minimum clearance:
		- recessed lights
		- door bell transformer
		- chimneys
		  - metal flues (such as central wall furnaces or water heater exhaust)
		  - vents (such as bathroom exhaust vents)
		  - fan motors
		  - knob and tube wiring
		▪ Live knob and tube type wiring must not be covered, but blankets may be installed below wires if 3" clearance is maintained on top and sides
		▪ Items requiring 12" minimum clearance:
		- heating (furnaces)
		- water heaters (in attic)
		▪ Flag junction boxes, recessed fixtures, key plumbing lines.
		▪ Depth markers: Staple rulers every 15' for even coverage.

	Loose fill	▪ Wood, metal or plastic blocking materials must extend at least 4" above the insulation level and must be permanently attached

Item	Materials	Criteria/Requirements
		(stapled, nailed or screwed) to ceiling joist
	Batt	▪ Mineral fiber batts when used for blocking must be at least as high as the insulation level. (If a heat source is present extend batts away from the heat source a minimum of 24" in all directions)

Insulation Safety Procedures [2]

Comply with the following fire and electrical safety procedures before insulating.

- Ensure that there is no bare wiring and that wiring splices are enclosed in metal or plastic electrical boxes that are fitted with cover plates.
- Wear an approved respirator or dust mask while blowing insulation or installing batts.
- Install insulation blocking around unlined masonry chimneys, B-vent chimneys, and manufactured chimneys. Seal any bypasses around chimneys with metal and high-temperature caulk.
- Install insulation shields around all-fuel wood-stove chimneys with 6" of space between the chimney and insulation.
- If shields are used as a barrier around heat producing devices or masonry chimneys, fasten them securely to the ceiling joist so they maintain 3" of clearance and don't collapse. Don't allow metal shields to contact wiring. Cover the tops of shields while installing insulation, and uncover and clean them out afterwards.
- Depending upon the knob and tube wiring system in the attic the following approaches should be considered:
    - Verify that knob-and-tube wiring is live before specifying replacement. If the system isn't live, just specify insulation around and over the wiring.
    - Install batts to zone off the live wiring, leaving a 3" clearance around the knob and tube components, batt or blow insulation up to the batts blocking the knob-and-tube. See Best Practice at: http://www.tdhca.state.tx.us/ea/wap-best-practices.htm
    - Optimally, knob and tube wiring should be replaced prior to insulating. This usually falls outside the scope of the Weatherization Assistance Program (WAP). If an alternate funding can be secured to handle the knob-and-tube wiring, then insulation may be installed.

Knob and Tube Wiring

Knob and tube (K&T) wiring is not a reason to disqualify a home from the weatherization program. However, weatherization of K&T homes is a specific task requiring an understanding of how to keep insulation away from the K&T cost effectively and safely.

STANDARDS

ATTIC SAFETY

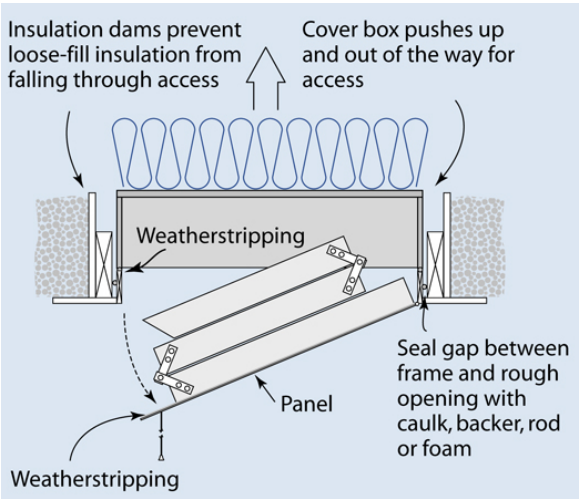
Item	Materials	Criteria/Requirements
Safety Concerns	All materials	▪ Insulation fibers should not be inhaled. A protective air filter mask shall be worn at all times ▪ Eyes should be protected at all times. Safety goggles shall be worn when insulation is installed ▪ Some insulation materials can irritate the skin. Long sleeves and slacks should be worn for protection ▪ Remember that the attic is a cramped space filled with numerous hazards. Be careful and watch your head. There must be at least 24" clearance (between the attic floor and the roof joists) for insulation to be safely installed. Installers should have good lighting and adequate ventilation. Ensure that additional attic ventilation, if required, is installed prior to insulation (this will make the attic more comfortable and safer for the installer)

Attic Access Hatches and Doors

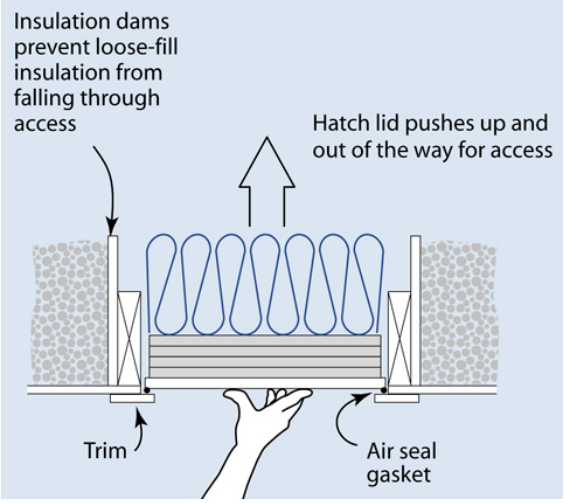
N1102.2.3 Access hatches and doors. Access doors from conditioned spaces to *unconditioned spaces* (e.g., attics and crawl spaces) shall be weatherstripped and insulated to a level equivalent to the insulation of the surrounding surfaces. Access shall be provided to all equipment which prevents damaging and compressing the insulation. A wood framed or equivalent baffle or retainer is required to be provided when loose fill insulation is installed, the purpose of which is to prevent the loose fill insulation from spilling into the living space when the attic access is opened and to provide a permanent means of maintaining the installed R-value to the loose fill insulation. [6]

Diagram 3.1 Attic Access

Attic Pull-Down Stairs



Scuttle Hole Cover



STANDARDS

ATTIC ACCESS

Item	Materials	Criteria/Requirements
Attic Access	All types	▪ If existing access is difficult to enter because of size or location, it must be enlarged or sealed and relocated, preferably to an unconditioned area such as a porch or garage ▪ New or enlarged access should be according to IRCC at least 22" x 30" ▪ Access opening shall be framed on attic side by 2" x 4" or 2" x 6" members secured to adjacent joist, trimmed on ceiling side with door or window trim located to support cover equally around opening. Minimum framing height must equal height of insulation ▪ Access located in conditioned areas must have foam tape or weather-strip installed on either the attic hatch or trim, whichever provides the most secure surface. ▪ Accesses located in insulated areas must be insulated to the R-value of the attic and attached to cover ▪ Insulation of disappearing or folding stairs in conditioned areas is recommended by construction of an insulated surrounding box and must be insulated to the same R-value as the attic.
Create an Access		▪ **Gable Vent Access.** Cut a hole for gable vent to use to insulate. When insulation is complete, install vent with screws for future access if needed. Baffle the gable to avoid winds from blowing the insulation. ▪ **Roof Vent Access.** If a large roof vent is needed for proper attic ventilation, create the roof vent hole and insulate from that access point. When done, install the vent. ▪ **Add a ceiling access hatch** either inside a closet or hallway, or in a garage. Follow proper size, weatherization and insulation of the new hatch, as stated previously.

STANDARDS

ATTIC/CEILING INSULATION

Item	Materials	Criteria/Requirements
Allowable Materials	**Mineral Fiber** ▪ Blankets ▪ Loose fill - Fiberglass - Cellulose	Conforms to 10 CFR 440 Appendix A
R-Values	All materials	▪ **Attic Floor (Ceilings): Minimum R-30** (higher if required by local code) ▪ **Knee Walls (if over 12" high): R19 preferred**, R-11 minimum ▪ Cover the rafters with a sealed air barrier, such as drywall or foil-faced hardboard. Caulk the barrier to the top plate of the knee wall itself. ▪ **Attic Access:** (hatch cover located in conditioned area only) - Insulate to attic R-value.
	Loose fill	▪ Permanently affix a certification card to a ceiling rafter so that it is easily visible from the attic entry. ▪ Certification Card is to state: the installed R-value, the number of bags installed, the date of installation and the installer's name ▪ It is recommended that a depth (or density) table be affixed next to the certification card (can be cut from a discarded insulation bag)

Installing Blown-In Insulation

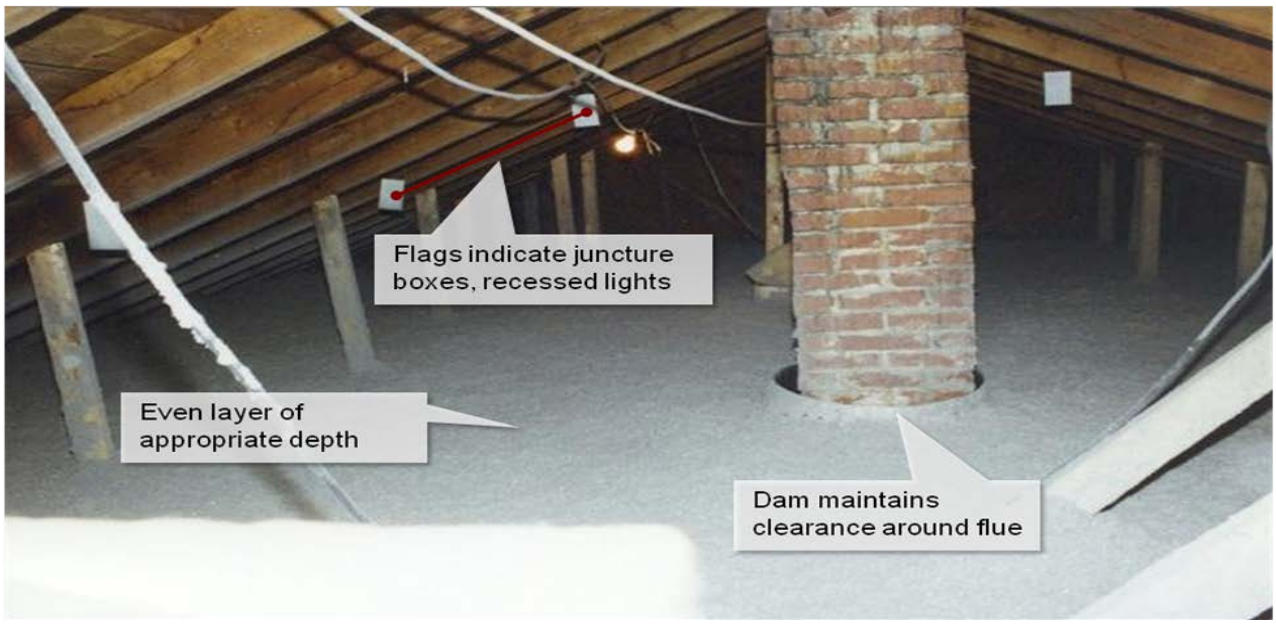
Blown insulation is preferred to batt insulation because blown insulation forms a seamless blanket. Blowing attic insulation at the highest achievable insulation density helps minimize settling and slows convection currents from moving within the insulation. [2]

STANDARDS

BLOWN INSULATION STANDARDS

Item	Materials	Criteria/Requirements
Attic	All types, loose-fill	▪ Maintain a high density by moving as much insulation as possible through the hose with the available air pressure. The more the insulation is packed together in the blowing hose, the greater its density. ▪ Fill the edges of the attic first, near the eaves or gable end, and move toward the center. Don't leave thin places over the wall plates. ▪ Install insulation at an even depth. Go back and use a stick to level the insulation if needed. ▪ Use depth markers (rulers), every 300sq ft of attic area to verify an even blow. ▪ Do not install insulation up against the deck or over the soffit vents ▪ Post an Insulation Certificate near the attic entrance.

Diagram 3.2 Properly Insulated Attic



Remember depth markers.

✓ GOOD TO KNOW

INSULATION

Any interior insulation type is acceptable that has vapor permeability. These include cellulose, fiberglass, and foam.

- When fiberglass batt insulation is specified, use high-density, unfaced batts. Batt facing is a vapor retarder and can trap moisture inside walls.
- Rigid insulation is made from fibrous materials or plastic foams that are pressed or extruded into sheets and molded pipe-coverings. These provide thermal and acoustical insulation, strength with low weight, and coverage with few heat loss paths. Such boards may be faced with a reflective foil that reduces heat flow when next to an air space. Foil facing also makes the board nearly impervious to water and vapor and so should be used with caution. Foam sheets that may be in contact with the ground should be borate-treated for termite resistance.
- Radiant barriers are sometimes used in buildings to reduce summer heat gain and winter heat loss. They can be effective in the hot and humid climate at reducing peak cooling loads, especially if ductwork or cooling equipment is located in the attic. All radiant barriers must have a low emittance (0.1 or less) and high reflectance (0.9 or more). [15]

Installing Batt Insulation

★ STANDARDS

WHERE TO INSTALL ATTIC/CEILING INSULATION

Item	Materials	Criteria/Requirements
Where to Install	All materials	▪ Attic floor ▪ Must be installed level at equal depths ▪ Maintain a minimum of 1” (3” preferred) clearance from underside of roof at eve ▪ Faced batts (with vapor barrier attached) should be installed with vapor barrier toward the heated side (in hot or hot/humid areas that means toward the roof decking; NOT the ceiling sheetrock)
	Batts or blankets	Knee walls; hatch covers in conditioned areas
Existing Insulation Procedures	Batt	▪ When installing batts over existing insulation, use unfaced batts. If unfaced batts are not available, make slashes (approximately every 6” to 8”) in the vapor barrier (to allow moisture to pass through the insulation) prior to installation. If the original batts were improperly installed (that is installed with the vapor barrier facing the wrong direction), slash the barrier, as stated above, before new batts are installed ▪ Cut batts carefully to ensure a tight fit against the ceiling joists and other framing.
	Loose fill	▪ When installing loose fill insulation over existing batts, address improperly installed vapor barriers in the manner outlined above ▪ When installing loose fill insulation over existing loose fill materials, careful attention should be paid to differing material’s densities. ▪ Since heavier materials will compress lighter materials (and thereby reduce their R-value and effectiveness), adherence to the following guidelines is important: - Cellulose has the greatest density of all loose fill materials and should not be installed over existing rockwool or fiberglass - Rockwool is heavier than fiberglass and should be installed only over existing cellulose or rockwool - Fiberglass is the lightest of all loose fill materials and may be installed over any existing loose fill material

Finished Knee Wall Attics

Finished attics require special care when installing insulation. They often include five separate sections that require different sealing and insulating methods:

1. Exterior walls of finished attic
2. Collar-beam attic, above finished attic
3. Sloped roof, where wall/roof finish is installed directly to roof rafters
4. Knee walls, between finished attic and unconditioned attic space
5. Outer ceiling joists, between knee wall and top plate of exterior wall

Follow these specifications when insulating finished attics:

- Seal large air leaks when they are adjacent to the conditioned space. Some small cavities can be sealed with densepack insulation.
- Inspect the structure to confirm that it has the strength to support the weight of the insulation.
- Create an airtight and structurally strong seal in the joist space under the knee wall. This can be done by either blowing densepack insulation into the joist cavities.
- Insulate sloped roof with densepack insulation. Insulate knee walls with densepack insulation or fiberglass batts. Prepare the knee wall for blowing by nailing house wrap to the knee wall with large-headed nails or stapling the house wrap through a strip of cardboard or thin wood. Or insulate the knee wall with high-density batts and apply house wrap to the attic side of the wall to prevent convection and air leakage.
- When the knee wall area is used for storage, cover insulation with a vapor-permeable material such as house wrap to prevent exposure to insulation fibers.
- Insulate knee wall access hatches and collar-beam access hatch with 3 or more inches of rigid-foam insulation, or a well-secured fiberglass batt. Weatherstrip the hatch and provide a positive closure. [2]

NONFEASIBLE CRITERIA

INSULATING ATTICS

Do not install:

1. When attic clearance is less than 24”
2. When live bare wires are present and cannot be protected
3. When roof is leaking over conditioned space and cannot be repaired
4. When ceiling cannot be made to support weight
5. Over unconditioned spaces (such as garages, carports or utility rooms)
6. When already installed to required R-value
7. Insulation **CANNOT** cover any of the following:
   a. live knob and tube wiring
   b. open junction boxes
   c. open (balloon framing) wall cavities (block or seal before insulating)
8. Open furr down cavities (block or seal before insulating
9. Recessed lights
10. Eave or soffit vents
11. Attic fans
12. When the SIR is less than 1

Wall Insulation

If you find the existing walls uninsulated or partially insulated, add insulation to provide complete coverage for all the home’s exterior walls. Properly installed densepacked cellulose or fiberglass wall insulation reduces air

leakage through walls and other closed building cavities because the fibers are driven into the cracks by the blowing machine.

Install wall insulation with a uniform coverage and density. Wall cavities encourage airflow like chimneys. Convection currents or air leakage can significantly reduce wall insulation's thermal performance if spaces remain for air to flow.

Two methods for installing sidewall insulation are commonly used: tube-fill method (one large hole) or the two-hole method. The tube-fill method is preferred because it ensures that a wall achieves an adequate coverage and density of insulation. [2]

An Infrared (IR) camera can be used to verify complete filling of each cavity. However, the installed insulation must achieve a steady state temperature before using an IR camera. For this reason, wait a day or two to check the filled cavities for quality work with an IR camera.

Inspecting and Repairing Walls [2]

- If condition of the siding, sheathing, or interior wall finish indicates an existing moisture problem, no sidewall insulation should be installed until the moisture problem has been identified and corrected.
- Seal gaps in external window trim and other areas that may admit rain water into the wall.
- Inspect indoor surfaces of exterior walls to assure that they are strong enough to withstand the force of insulation blowing. Add screws or other reinforcement to weak walls if feasible.
- Inspect for interior openings from which insulation may escape such as balloon framing openings in the attic or crawl space, pocket doors, un-backed cabinets, interior soffits, and closets. Seal openings as necessary to prevent insulation from escaping.
- Confirm that exterior wall cavities aren't used as return ducts. Avoid these cavities, or re-route the ducting.
- Do not insulate cavities with wiring of any type other than Romex.

Trouble Shooting

If you've blown for over **four minutes** without reaching proper density, find out where cellulose is going!

★ STANDARDS

WALL REPAIR

Item	Materials	Criteria/Requirements
Repair	All Materials	▪ Interior and Exterior walls shall be repaired prior to insulating the wall cavity ▪ All repairs shall be durable and permanent

Insulation Installation [8]

The most critical part of insulation is the ***installation***. Most insulation is only delivering one half or less of the rated R-value! Air movement, gaps, misalignment, compression, and voids all rob insulation of the ability to do its job.

NONFEASIBLE CRITERIA

WALL INSULATION

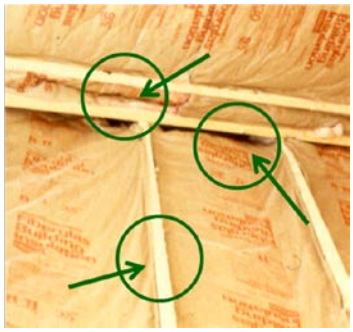
Do not insulate:

- Cavities serving as HVAC ducts
- Cavities with wall heaters
- Cavities with operating knob and tube wiring
- Walls with leaks or unrepaired damage
- Interior or exterior walls with substandard sheathing

Four R-Value Killers

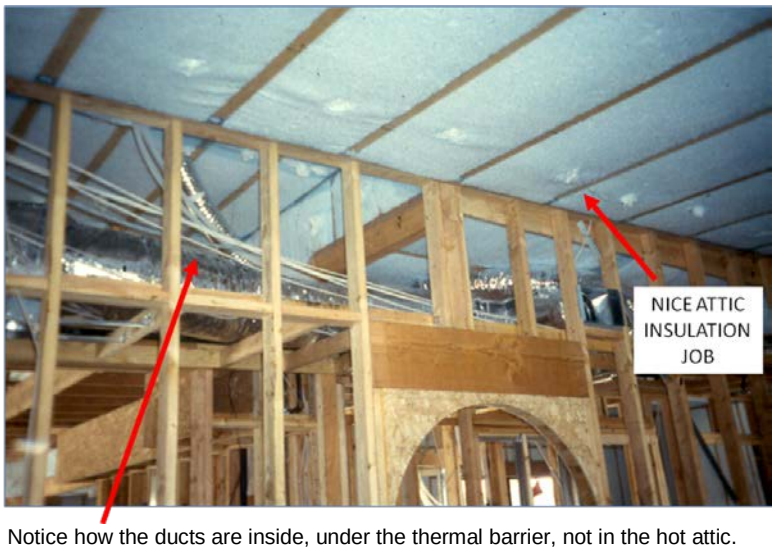
1. **Compression:** Compression reduces the R-value of the insulation equal to the amount of compression. If you install a 6" batt in a 4" wall cavity, the R-value will be one third of the original R-value. Compression makes insulation a conductor by eliminating the open spaces of the insulation meant to slow down air flow.
2. **Air Movement:** If air can move past or around insulation it will! This air movement will carry heat with it. An air barrier in contact with the insulation is a **requirement.**
3. **Misalignment**: Misalignment happens when insulation is not touching the surface you are trying to insulate. An example would be laying insulation over wires and boards --it isn't touching the wall or ceiling. This results in the insulation having virtually no R-value.
4. **Gaps:** We see gaps in insulation all of the time. The batt doesn't quite fit, there is a gap of 1/4" between the batt and the back side of the sheetrock, or the stud, or the bottom plate. This small gap reduces the R-value of that batt by over 45%. An R-11batt would be equal to R-6 of insulation.
5. For insulation to work to its rated R-value, there can be no:
   - Gaps
   - Voids
   - Misalignment
   - Compression
   - Air Movement [8]

Poor Insulation Installation



Watch for compression, air movement, misalignment, and gaps.

Diagram 3.3 Work to R-Value



Notice how the ducts are inside, under the thermal barrier, not in the hot attic.

STANDARDS

WALL INSULATION

Item	Materials	Criteria/Requirements
Allowable Materials	Mineral Fiber - Fiberglass	▪ Batts only ▪ Conforms to 10 CFR 440 Appendix A ▪ Must have vapor barrier facing warm side
	Rock Wool	▪ Batts Only ▪ Must have vapor barrier facing warm side
	Cellulose - Loose Fill	Conforms to 10 CFR 440 Appendix A
R- Values	All Materials	▪ R-11 Minimum (Overall ▪ R-Value that includes: - interior and exterior - sheathing and siding must - be a minimum of R-15)
Dense Pack	Cellulose Only - Tube Fill Method	▪ Insulation shall be installed at a minimum weight of 3.4 pounds per cubic foot ▪ Cavities less than 3' in height or where it is not possible to tube fill may be insulated using the two hole method
Loose Fill	Cellulose or Fiberglass - Two Hole Method	▪ Side wall cavities shall be checked for obstructions prior to insulating the cavity ▪ Entry holes shall be properly sized for the type of insulation being installed
Single Wall Construction	Fiberglass/Rockwool batts	▪ Entry holes shall be placed no lower than 1ft from the top plate and no higher than 48' from the bottom plate ▪ Shall be install with Kraft side(vapor barrier) facing the warm side ▪ Shall be covered with sheetrock, plywood, chipboard or hardboard ▪ Drywall shall be taped and receive at least one coat of joint compound ▪ Plywood, Chipboard or hardboard joints shall be caulked. Note: drywall, plywood, chipboard or hardboard shall not be installed in areas exposed to the weather or to high moisture

Item	Materials	Criteria/Requirements
Entry Holes	Cellulose/Fiberglass	▪ In every stud cavity ▪ Exterior holes in wood siding shall be sealed with plastic or wood plugs and sealed to protect the wood; making paint ready. ▪ Exterior holes in masonry or stucco siding shall be sealed with a mortar or a material specifically manufactured to repair stucco or masonry ▪ Mortar shall completely seal the opening and be textured and painted, if necessary, to match the surrounding surface ▪ Interior holes in drywall shall be plugged and taped or sealed with a material specifically manufactured to repair drywall or plaster. Holes shall be made ready for paint ▪ Interior holes in plywood, chipboard or hardboard shall be plugged and sealed with caulk

Open-Cavity Wall Insulation [2]

Fiberglass batts are the most common open-cavity wall insulation. They achieve their rated R-value only when installed carefully. If there are gaps between the cavity and batt at the top and bottom, the R-value can be reduced by as much as 30%. The batt should fill the entire cavity without spaces in corners or edges.

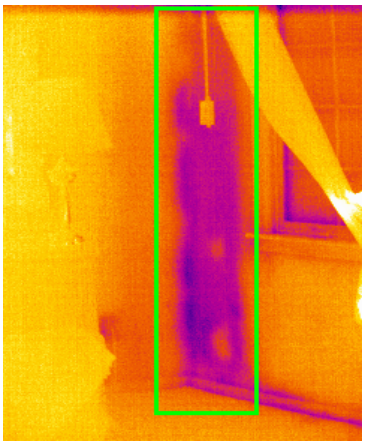
- Use unfaced friction-fit batt insulation where possible. Fluff to fill entire wall cavity.
- Choose R-13 batts rather than R-11, if the cavity permits.
- Staple faced insulation to outside face of studs on the warm side of the cavity. Do not staple on the side of the studs.
- Cut batt insulation to the exact length of the cavity. A too-short batt creates air spaces above and beneath the batt, allowing convection. A too-long batt will bunch up, creating air pockets.
- Split batt around wiring, rather than letting the wiring bunch the batt to one side of the cavity.
- Insulate behind and around obstacles with scrap pieces of batt before installing batt.
- Fiberglass insulation exposed to the interior living space must be covered with an appropriate material to prevent occupants from touching the insulation. Fiberglass insulation with a fire-resistant foil-scrim-kraft (FSK) facing does not require an additional covering.
- Seal the edges and seams with urethane adhesive to create an airtight seal.

Dense-Packing Wall Insulation

- Dense-pack wall insulation is best installed using a blower equipped with separate controls for air and material feed.
- Mark the fill tube in 1' intervals to help the installer verify when the tube has reached the top of the wall cavity.
- To prevent settling, cellulose insulation must be blown at 3.5-4.5 pounds per cubic foot density. Follow the manufacturer's label for densepacked fiberglass insulation. Blowing insulation this densely requires using a fill tube.

Wall Insulation Procedure [2]

1. Drill 2" to 3" diameter holes to access stud cavity.
2. Probe all wall cavities through holes, as you drill them, to identify fire blocking, diagonal bracing, and other obstacles.
   - After probing, drill whatever additional holes are necessary to ensure complete coverage.
3. Start with several full-height, unobstructed wall cavities so you can measure the insulation density and calibrate the blower.
   - An 8' cavity (2" x 4" on 16" centers) should consume a minimum of 10 pounds of cellulose.
   - Fiberglass will vary by manufacturer to calibrate to the manufacturer's label.



An Infrared camera can help reveal if a quality job has been achieved.

4. Insert the hose all the way to the top of the cavity. Start the machine, and back the hose out slowly as the cavity fills. Work the hose back and forth in the cavity to pack the insulation tighter.
5. Shut off the flow of material when about 6" from the end.
6. Seal and plug the holes, and replace the siding.

Problems with low density insulation: Blowing insulation through one or two small holes usually creates voids inside the wall cavity. This is because insulation won't reliably blow at an adequate density more than about 1' from the nozzle. Use tube-filling methods, using a 1.5" hose inserted through a 2" or larger hole.

Insulating Balloon-Framed Walls [2]

When insulating balloon-framed walls, try to blow an insulation plug into each floor cavity in order to insulate the perimeter between the two floors. This also seals the floor cavity so it does not become a conduit for air migration. If the process is requiring too much insulation, try placing a plastic bag over the end of the fill tube and blowing the insulation into the plastic bag. The bag will limit the amount of insulation it takes to plug this area.

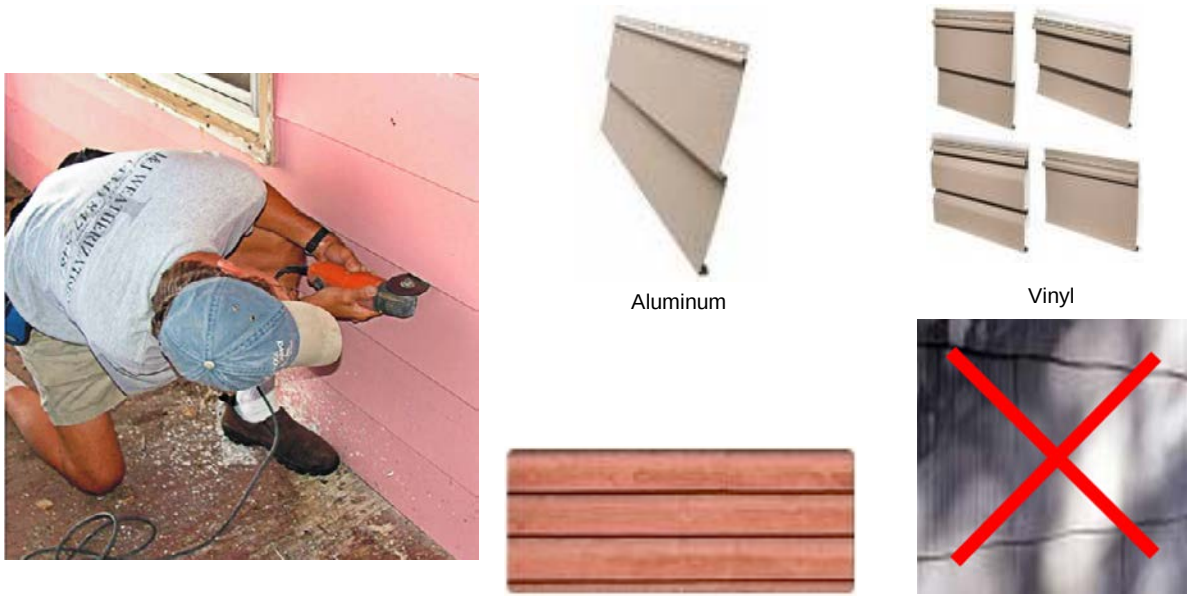
Removing Siding and Drilling Sheathing [2]

Avoid drilling through siding. Where possible, carefully remove siding and drill through sheathing. This avoids the potential lead-paint hazard of drilling the siding. It also makes it easier to insert flexible fill tubes since the holes pass through one less layer of material.

If the siding cannot be removed, consider drilling the walls from inside the home. Obtain the owner's permission before doing so, and practice lead-safe weatherization procedures.

- Do not drill through asbestos siding. If present, install insulation from the inside.
- Metal or vinyl siding may be removed with a zip tool.
- Homes with brick veneer or blind-nailed asbestos siding may be insulated from the inside. Holes drilled for insulation must be returned to an appearance as close to original as possible, or so they are satisfactory to the customer.

Diagram 3.4 Removing Siding



STANDARDS

SIDING REMOVAL

Item	Materials	Criteria/Requirements
Siding Removal	All Materials	▪ Siding that has been removed shall be reinstalled using the original system. ▪ Slate, vinyl, steel or aluminum siding that has been removed shall have the entry holes sealed with a plastic or wood plug or covered with felt prior to reinstalling siding ▪ Removal of siding is allowed to perform energy conservation measures. All precautions must be taken not to damage siding. ▪ Asbestos siding should never be cut or drilled. Recommended, where possible, to insulate through home interior.

Floor Insulation [26]

How to insulate a crawl space depends on whether it's ventilated or unventilated. Traditionally, crawl spaces have been vented to prevent problems with moisture; most building codes require vents to aid in removing moisture from the crawl space. However, many building professionals now recognize that building an unventilated crawl space (or closing vents after the crawl space dries out following construction) is the best option in homes using proper moisture control and exterior drainage techniques. There are two main reasons for this line of thinking:

- Ventilation in the winter makes it difficult to keep crawl spaces warm
- Warm, moist outdoor air brought into the crawl space through foundation vents in the summer often makes it difficult to dehumidify a crawl space. In fact, this moist outdoor air can lead to increased moisture levels in the crawl space.

Check local codes before to determine how to proceed.

STANDARDS

FLOOR INSULATION

Item	Materials	Criteria/Requirements
Allowable Materials	Mineral Fiber - Rockwool batts	Must meet or exceed Appendix A of 10CFR440
	- Fiberglass batts	Must meet or exceed Appendix A of 10CFR440
	- Loose Fill (Fiberglass, Rockwool or Cellulose)	▪ Mobile Home Belly Blow Only ▪ Must meet Appendix A of 10CFR440
Recommended Installation - Site Built Pier and Beam	Fiberglass/Rockwool batts	▪ Kraft faced vapor barrier must face toward the warm side. ▪ Must be sized to fit space between floor joist ▪ Retainers or straps must be used to hold batts permanently in place ▪ All bypasses must be sealed
	Loose Fill (Fiberglass, Rockwool or Cellulose)	Not acceptable

Item	Materials	Criteria/Requirements
Recommended Installation - Mobile Homes	Fiberglass/Rockwool batts	▪ Kraft faced vapor barrier must face toward the warm side. ▪ Must be sized to fit space between floor joist ▪ Retainers or straps must be used to hold batts permanently in place ▪ All bypasses must be sealed ▪ Belly Board or industry accepted rodent barrier must be repaired or replaced
	Loose Fill (Fiberglass, Rockwool or Cellulose)	Belly Board Penetration ▪ Preferred in all cases ▪ Required to insulate all interior areas not accessible through rim joist Rim Joist Penetration ▪ Acceptable when joist size and condition allow for safe and proper installation ▪ May be used to insulate joist cavities or portions of cavities which have unobstructed access from the outside perimeter ▪ Penetration points shall be those most feasible ▪ A combination of belly and joist penetrations may be used to achieve optimum results
Recommended Installation - Coverage		▪ All areas not occupied by ducts, plenums or other obstructions shall be insulated ▪ R-Value shall be a minimum R-15 or meets local code ▪ The cavity beneath an appliance enclosure which has combustion air venting shall not be insulated unless the venting is ducted through the belly board
Access Holes - Rim Joist Access		Bottom wall trim shall be removed to expose the rim joist ▪ Exterior siding may be unfastened only if necessary ▪ Rim Joist access shall be considered NOT feasible if it will result in visible damage to the siding
Access Holes - Hole Location	End and Side Joist	▪ One hole for each joist cavity ▪ Centered on joist to minimize structural damage ▪ Care shall be exercised to avoid damage to plumbing/electrical lines attached to or adjacent to rim joist
Access Holes - Belly Injection		▪ Penetrations shall be made as needed to achieve complete coverage ▪ Holes cut for inspection and existing damage holes may be used for access ▪ Holes shall be of sufficient size and spacing to accommodate the directional nozzle or fill tube utilized ▪ Maximum insulation travel beyond the nozzle or fill tube shall be 2'

Insulating an Unventilated Crawl Space [26]

If you have or will have an unventilated crawl space, then your best approach is to seal and insulate the foundation walls rather than the subfloor.

The advantages of insulating the crawl space are as follows:

- You can avoid the problems associated with ventilating a crawl space.
- Less insulation is required (around 400 sq ft for a 1,000 sq ft crawl space with 3' walls.)
- Piping and ductwork are within the conditioned volume of the house so they don't require insulation for energy efficiency or protection against freezing.

- Air sealing between the house and the crawl space is less critical.

The disadvantages of insulating a crawl space include the following:

- The insulation may be damaged by rodents, pests, or water.
- A radon mitigation system will require ventilation of the crawl space to the exterior. Not planning for radon-resistant construction may necessitate air sealing the floor to mitigate the radon through ventilation.
- The crawl space must be built airtight, and the air-barrier must be maintained.
- The access door to the crawl space must be located inside the home through the subfloor unless an airtight, insulated access door in the perimeter wall is built and maintained.

Insulating a Ventilated Crawl Space [26]

Here are some guidelines to follow for insulating a ventilated crawl space:

- Carefully seal any and all holes in the floor above ("ceiling" of the crawl space) to prevent air from blowing up into the house.
- Insulate between the floor joists with rolled fiberglass. Install it tight against the subfloor.
  - Seal all of the seams carefully to keep wind from blowing into the insulation.
  - Adequately support the insulation with mechanical fasteners so that it will not fall out of the joist spaces in the years to come.
  - *Do not* just rely on the friction between the fiberglass and wood joists to secure it in place.
- Cover the insulation with a house-wrap or face it with a vapor barrier. The orientation of the vapor barrier depends on the home's location or climate. In Texas, and in certain regions of the Gulf States, the vapor barrier should face downward. In colder parts of the country, the vapor barrier should face upward
- Install a polyethylene vapor retarder, or equivalent material, over the dirt floor.
  - Tape and seal all seams carefully.
  - May also cover the polyethylene with a thin layer of sand or concrete to protect it from damage.
  - *Do not* cover the plastic with anything that could make holes in it, such as crushed gravel.

NONFEASIBLE CRITERIA

CRAWL SPACE INSULATION

Do not insulate:

- Cavities serving as HVAC ducts
- Cavities with wall heaters
- Cavities with operating knob and tube wiring
- Walls with leaks or unrepaired damage
- Interior or exterior walls with substandard sheathing

STANDARDS

FLOOR INSULATION

Item	Materials	Criteria/Requirements
Installation Procedures	- Batts	▪ The insulation must be split and run around the plumbing. ▪ Seal all air leaks between the conditioned area of the home and the crawl space. High-priority leaks include holes around bathtub drains and other drain lines, plenums for ductwork, and penetrations for electrical wiring, plumbing, and ductwork (including duct boot connections at the floor). ▪ Insulation batts with an attached vapor barrier are typically used to insulate framed floors. Obtain insulation with the proper width for the joist spacing of the floor being insulated. Complete coverage is essential. Leave no insulation voids. The batts should be installed flush against the subfloor to eliminate any gaps, which may serve as passageways for cold airflow between the insulation and subfloor. The batts also should be cut to the full length of the joist being insulated and slit to fit around wiring and plumbing. ▪ Insulate the band joist area between the air ducts and the floor as space permits. Use insulation hangers (wire staves) spaced every 12”-18” to hold the floor insulation in place without compressing the insulation more than 1”. [4] ▪ The orientation of the vapor barrier depends on the home's location or climate. In Texas, and in certain regions of the Gulf States, the vapor barrier should face downward. In colder parts of the country, the vapor barrier should face upward. ▪ Insulated ductwork in the crawl space. ▪ Insulate all hot and cold water lines in the crawl space unless they are located within the insulation. ▪ Close crawl space vents after ensuring that the crawl space and all the construction materials are dry.
	-Loose fill	▪ For insulating truss floor systems, it is better to install netting or foam board insulation to the underside of the floor trusses. Then, fill the space created between the netting or insulation and subfloor with loose fill insulation.

Spray Foam Insulation [27]

In new construction, foamed in-place insulation makes it relatively easy to completely fill wall and ceiling cavities. When insulating an existing home (if areas are accessible) what it costs in material may be offset by the labor of air-sealing and insulation. Spray polyurethane foam (SPF) is an approved air sealer.

Most spray polyurethane foam is a two-part foam. A chemical reaction occurs upon the mixing of the two ingredients. The mixture, when sprayed, becomes a foam that expands and eventually hardens. Per WPN 11-6: “Use EPA recommendations when working within the conditioned space or when SPF fumes become evident within conditioned space. When working outside the building envelope, isolate the area where foam will be applied, take precautions so that fumes will not transfer to inside conditioned space, and exhaust fumes outside the home.”

Open-Cell Foam

Open-cell foam has an R-value per inch of about 3.9, a density of one half pound per cubic foot, and is vapor permeable. Open-cell foam forms a complete air barrier. It is recommended for walls, floors, unvented and vented crawl spaces, unvented and vented attics, and ceilings.

✓ GOOD TO KNOW

HOT HUMID CLIMATE

Open-cell foam is appropriate for hot humid climates like most of Texas. Open-cell foam provides energy savings, increased durability, and significantly reduces unmanaged moisture and air infiltration. [15]

In addition, raised floors in hot humid climates are suspect to bugs and vermin. Two types of insulation exist that can provide resistance to both: applied foam and rigid board.

Closed-Cell Foam

Closed-cell foams stop air and moisture, has a density of two pounds per cubic foot, and an R-value per inch of about 6.5. Compared to less expensive insulation types, such as fiberglass or cellulose that have half this R-value, spray foam is a viable candidate for certain applications. Its density and glue-like characteristics can also add structural strength to a wall, ceiling, or roof assembly.

Safety Measures for Spray Foam: [19, 22 & 28]

- Use caution when opening containers; remove pressure slowly and safely
- Wear NIOSH approved respiratory protection
- Adequately ventilate the area
- Wear protective clothing and gloves to avoid absorption through skin
- Eyes are a route of entry—wear eye protection
- Post warning signs and caution tape to keep unprotected individuals away from the sprayed area and up to 30 minutes following the completion of the spraying.
- No "hot work" such as cutting torches or welding is to take place within 35' of exposed foam.
- Use fire-retardant spray foam around heat sources, if not fire-caulked

Chapter 4: Ventilation

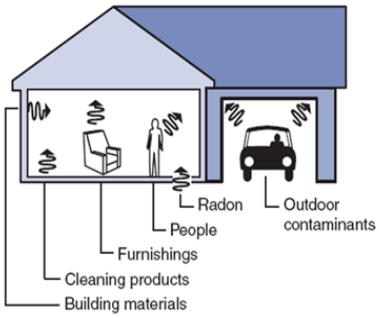
Table of Contents

Ventilation Basics

Why Ventilation is Important

A home needs ventilation - the exchange of indoor air with outdoor air – to reduce indoor pollutants, odors, and moisture. Ventilation is important in homes with pollutant and odor sources, such as tobacco smoke, new furniture, new carpet, etc. Excess moisture in a home can also generate high humidity levels, which can lead to mold growth and structural damage to a home. Contaminants such as formaldehyde, volatile organic compounds, and radon can accumulate in poorly ventilated homes, causing health problems. Ventilation is an important health and safety concern in the most airtight homes.

Indoor Air Pollution Sources [10]



Ventilation and Indoor Air Quality

The fundamentals of residential indoor air quality (IAQ) begin with source control. Air leakage ventilation is unpredictable and wastes energy. On windy cold days there is too much air coming into the home. On warm still days there is too little. Air sealing, eliminating sources of moisture and ventilation need to be addressed. [9]

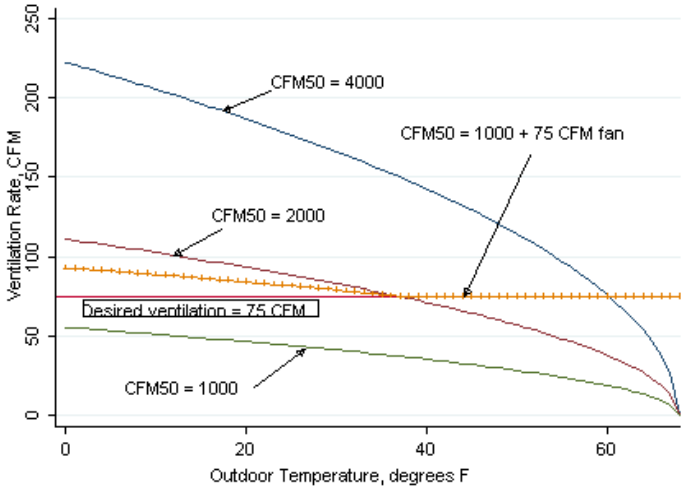
Acceptable indoor air quality (IAQ) is defined as, “air toward which a substantial majority of occupants express no dissatisfaction with respect to odor and sensory irritation and in which there are not likely to be contaminants at concentrations that are known to pose a health risk.”

Diagram 4.1 below, taken from a 2011 ACI presentation by Rick Karg, Paul Francisco and Iain Walker, shows:

- As the outdoor temperature drops, the stack effect increases and natural ventilation goes up sharply. This is especially unfortunate from an energy efficiency perspective since we pay the most to condition interior air when exterior temperatures fall.
- A single story 1,500 sq ft house without a fan:
  - Left at 4,000 CFM50 leaks 225 CFM at 0°F but still gets inadequate fresh air whenever the exterior temperature exceeds 60°F.
  - Brought to a rather loose 2,000 CFM50 doesn’t get enough fresh air any time the exterior temperature is over 35°F.
  - Sealed to 1,000 CFM50 never gets adequate fresh air!
  - Leaving the house at 2,000 CFM50 and adding a fan provides proper ventilation from 35°F and up but, because the house is still relatively loose, too much air enters whenever the exterior temperature drops below 35°F.

- We do our clients a real disservice when we rely on looseness and natural ventilation for IAQ.

Diagram 4.1 Chart from 2011 ACI Presentation by Rick Karg, Paul Francisco and Iain Walker



Homes with a natural air change rate lower than the building tightness limit should have mechanical ventilation systems. The choice comes down to ventilating the whole house or providing spot ventilation in the kitchen and bathroom where most moisture and odors are generated. Ideally all kitchens and bathrooms should be equipped with exhaust fans. Kitchen and bath fans must be vented outdoors.

Mechanical Ventilation

Mechanical ventilation can help remove and dilute pollutants, but ventilation should not be relied upon as a sole method of pollutant control. Technicians should survey the home for pollutants before performing air-sealing, and perform the following pollutant control measures, if needed:

- Repair roof and plumbing leaks;
- Install a ground moisture barrier over any bare soil in crawl spaces;
- Duct dryers and exhaust fans to the outdoors;
- Confirm that combustion appliance vent systems operate properly; and
- Move paints, cleaning solvents and other chemicals out of the conditioned space, if possible.

The home's occupants have control over the introduction and spread of many home pollutants. Always educate the residents about minimizing pollutants in the home. [2]

ASHRAE 62.2-2010 for WAP Homes [20]

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. [29]

ASHRAE 62.2-2010, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, applies to single-family, multifamily up to three stories, and manufactured and modular buildings. The 62.2-2010 standards consider chemical, physical, and biological contaminants for residential buildings.

Weatherization Program Notice (WPN) 11-6: *Implementation of ASHRAE 62* will be required one year after the date this guidance becomes effective (estimated by 2013).

Whole-building ventilation is required in all new homes. Per ASHRAE 62.2, "a mechanical exhaust system, supply system, or combination thereof shall be installed for each dwelling unit to provide whole-building ventilation…" With the implementation of ASHRAE 62.2-2010, homes will need to be tightened as much as possible and then ventilated appropriately. "Build 'em tight and ventilate 'em right!" [9]

Bathroom and Kitchen Ventilation

ASHRAE 62.2 requires local ventilation in bathrooms and kitchens in all new homes. Older homes receiving weatherization work must meet ASHRAE Alternative Compliance.

TABLE 4.1 ASHRAE 62.2-2010 REQUIREMENTS [20]

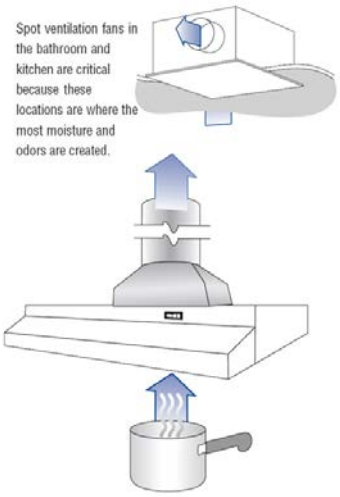
Area to be Ventilated	Ventilation Rates
Kitchens	100 CFM on demand or 5 ACH, based on kitchen volume Example: 12' x 12' x 8'= 1152 sq ft 1152 x 5 ACH=5760/60 minutes= 96 CFM A 100 CFM range hood would be appropriate for this kitchen
Bathrooms – Toilet Rooms	50 CFM on demand or 20 CFM continuous

Chapter 15, section M1507 of the International Residential Code (IRC) further requires that exhaust air from bathrooms and toilet rooms not be recirculated within a residence or to another dwelling unit and shall be exhausted directly to the outdoors. Exhaust air from bathrooms and toilet rooms (and kitchen exhausts) shall not discharge into an attic crawl space or other areas inside the building." [6]

Energy Star Fans and Timers

ASHRAE 62.2-2010 Appendix A

Bath and Kitchen Vent Fans [10]



Existing homes fall under Appendix A of ASHRAE 62.2-2010. This alternative compliance supplement provides a method of meeting local exhaust requirements in kitchens and bathrooms that do not have any existing local fan, or where the local fans do not meet the CFM requirement. Determining the whole building ventilation requirements for existing homes (those built prior to ASHRAE 62.2-2010) is a sum of three calculations:

1. The minimum ventilation requirement (MVR)
2. The alternative compliance supplement
3. The infiltration credit

How Appendix A Works

1. **The Minimum Ventilation Requirement** uses the square footage and number of bedrooms in the home to be weatherized. Table 4.2 provides a quick guide for the base formula using the number of bedrooms.

   Base formula, step by step:

   Step 1. Multiply the number of bedrooms + 1 or the number of people by 7.5 CFM per person:

   4 bedrooms 7.5 CFM/person = 30 CFM

   If more people than bedroom +1 number, use the number of occupants

   Step 2. Calculate 1 CFM per 100 sq ft of floor area:

   1,500 ft^2/100 ft^2 per required CFM = 15 CFM

   Step 3. Add them together:

   30 CFM + 15 CFM = 45 CFM continuous

TABLE 4.2 Minimum Ventilation Requirements, CFM [20]

Floor Area (ft^2)	Bedrooms				
	0-1	2-3	4-5	6-7	>7
<1500	30	45	60	75	90
1501-3000	45	60	75	90	105
3001-4500	60	75	90	105	120
4501-6000	75	90	105	120	135
6001-7500	90	105	120	135	150
>7500	105	120	135	150	165

2. **Alternative Compliance Supplement** calculation lets you take the inadequate CFM delivery or total lack of required local ventilation fans into account.
   - Kitchen requires 100 CFM on demand or 5 ACH continuous, based on kitchen volume.
   - Bathroom requires 50 CFM on demand or 20 CFM continuous. Not required in half baths.
   - Operable windows in those rooms reduce deficit by 20 CFM. Only one deficit reduction per room.
   - Deficit cannot drop below zero.

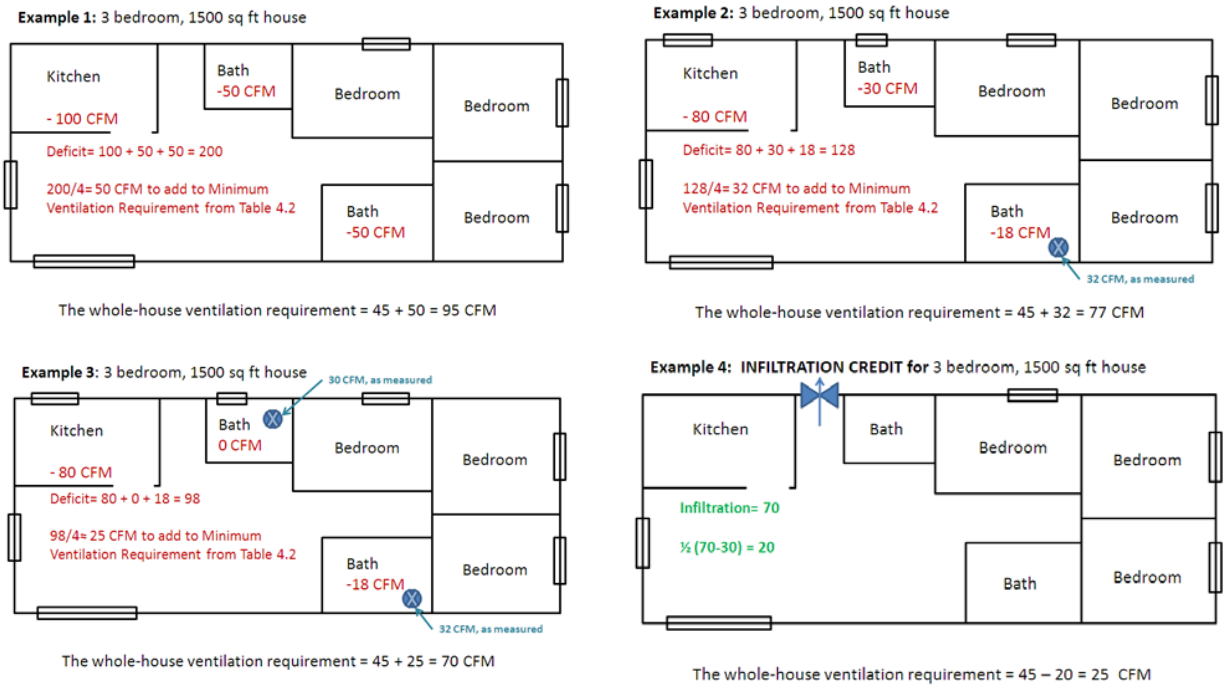
In each room where local ventilation should be, such as in bathrooms and kitchens, you must determine the deficit relative to the required rate (Table 4.1 above). A fan flow meter connected to a manometer measures fan flow. This is necessary for deficit calculations, and to verify delivered CFM of newly installed fans.

a. How much less than 50 CFM in bathrooms?
b. How much less than 100 CFM in kitchens?

For each room with an operable window, reduce the room's deficit by 20 CFM in that room. Add up all deficits and divide by 4 and add this supplement number to the MVR.

Fan Flow Meter

Diagram 4.2 Examples of Whole-House Ventilation Requirements



3. **Infiltration Credit** for existing dwellings built prior to 2011, is calculated using the following formula:
   IF: Natural infiltration > 2A/100 (2 x the square footage (A) of conditioned space ÷ 100)
   THEN: Infiltration credit = 0.5 (Natural infiltration – 2A/100)

   Input the calculations from Steps 1-3 as in the example below, to obtain the CFM necessary to meet ASHRAE 62.2-2010 for existing homes.[20]

Example:

	CFM
MVR	30
Alt. compliance supplement	+15
Infiltration credit	- 10
Whole Building Ventilation	**35**

Ventilation Strategies

Natural Ventilation [29]

Natural ventilation is uncontrolled air movement or infiltration through open windows and doors, and cracks and small holes in a home, and does not provide adequate moisture control as fresh outdoor air replaces indoor air in a home.

Natural ventilation is highly dependent upon exterior temperature. Natural air changes per hour (ACH) is variable, and thus cannot be depended upon for the desired amount of ventilation needed for acceptable indoor air quality (IAQ).

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

Today, natural ventilation is usually not the best ventilation strategy, especially for homes that are properly air sealed for energy efficiency.

Whole-House Ventilation [29]

The decision to use whole-house ventilation is typically motivated by concerns that natural ventilation will not 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 to the house.

Exhaust Fans

Exhaust fans can also provide whole-house ventilation. Makeup air comes from outdoors through the home's air leaks. Manual switches, dehumidistats, and timers are used to control exhaust fans for whole-house ventilation. Exhaust fans typically run from two to six hours per day when providing whole-house ventilation. [2]

High quality exhaust fans should have tight-sealing backdraft dampers. Backdraft dampers are located in the fan housing, in the vent duct, or in the termination fitting in the roof or wall.

A low noise level is important in encouraging occupants to use exhaust fans. The sound output of exhaust equipment is rated in sones, and these ratings vary from about 5 sones for the noisiest residential exhaust fans to about 0.5 sones for the quietest fans. Choosing an ENERGY STAR® labeled exhaust fan will ensure quiet, long-lasting quality equipment. The success of spot ventilation and whole-house ventilation depends on how much noise the fan makes. Occupants may not use the fans or may disconnect automatic controls if the fans are too noisy.

Exhaust Ventilation Systems [29]

Exhaust ventilation systems work by depressurizing the building, thus forcing inside air out of a home. By reducing the inside air pressure below the outdoor air pressure, they extract indoor air from a house while make-up air infiltrates through leaks in the building shell and through intentional, passive vents.

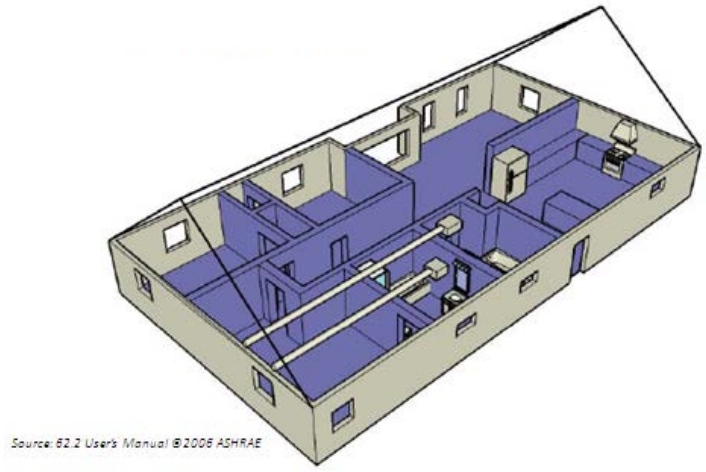
Exhaust ventilation systems are relatively simple and inexpensive to install. Typically, an exhaust ventilation system is composed of a single fan connected to a centrally located, single exhaust point in the house. A preferable design option is to connect the fan to ducts from several rooms, preferably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

✓ GOOD TO KNOW

HOT-HUMID CLIMATE

Exhaust ventilation systems are most applicable in cold climates. In climates like Texas, with warm humid summers, depressurization can draw moist air into building wall cavities, where it may condense and cause moisture damage. Negative pressure can also cause dust and dirt to be pulled down from the attic, pollutants to be pulled in from an attached garage, or potential back-drafting of combustion appliances. [20]

Diagram 4.3 Exhaust Only Ventilation



Supply Ventilation Systems [29]

Fresh Air Ventilation

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

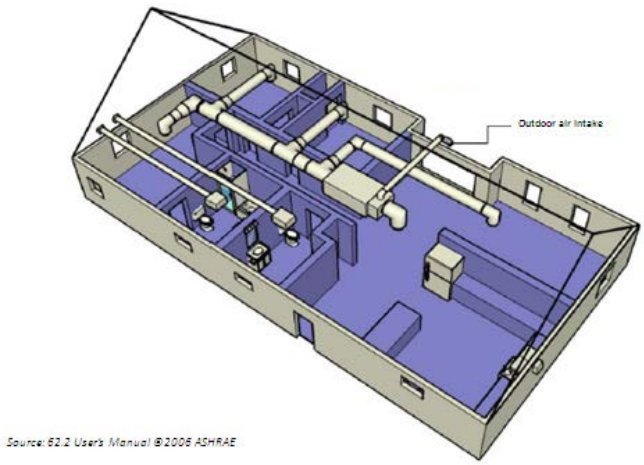
As with exhaust ventilation systems, supply ventilation systems are relatively simple and inexpensive to install. A typical supply ventilation system has a fan and duct system that introduces fresh air into usually one - but preferably several - rooms of the home that residents occupy most often, such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

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 backdrafting of combustion gases from fireplaces and appliances. Supply ventilation also allows outdoor air introduced into the house to be filtered to remove pollen and dust or dehumidified to provide humidity control.

Supply ventilation systems work best in hot or 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 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 in the house at discrete locations, outdoor air may need to be mixed with indoor air before delivery to avoid cold air drafts in the winter and hot air currents in the summer. An in-line duct heater is another option, but it will increase operating costs.

Diagram 4.4 Supply Only Ventilation



Balanced Ventilation Systems [29]

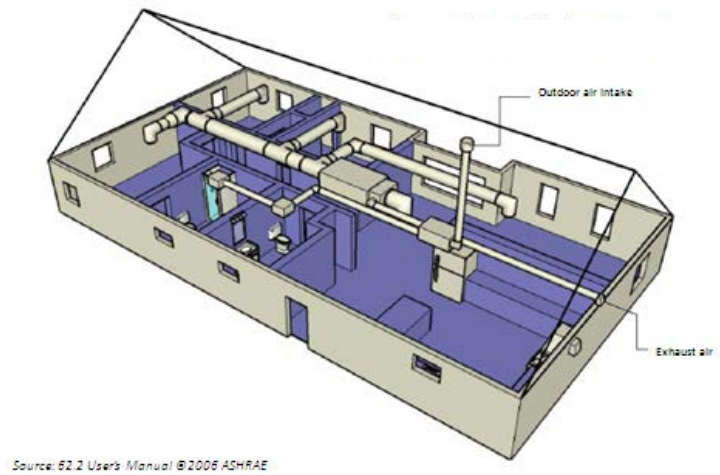
Balanced ventilation systems, if properly designed and installed, neither pressurize nor depressurize a house. Rather, they introduce and exhaust approximately equal quantities of fresh outside air and polluted inside air, respectively.

A balanced ventilation system usually has two fans and two duct systems. It facilitates good 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.

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 and hot air currents in the summer. [4]

Diagram 4.5 Balanced Ventilation System

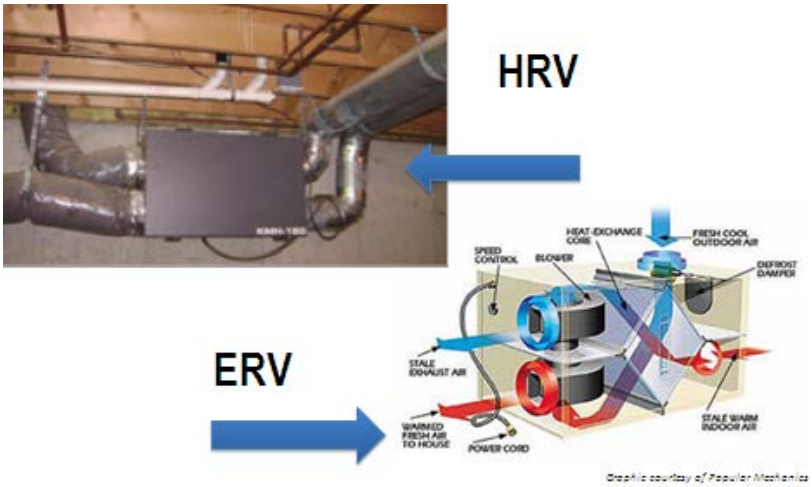


Energy Recovery Ventilation Systems [20, 29]

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

Diagram 4.6 Heat Recovery Ventilators (HRV)/Energy Recovery or Enthalpy Recovery Ventilators (ERV)



The main difference between an HRV and an ERV is the way the heat exchanger works. With an ERV, the heat exchanger transfers sensible heat and humidity, while an HRV only transfers sensible heat.

Because an ERV transfers some of the moisture from the exhaust air to the usually less humid incoming winter air, the humidity of the house air stays more constant. This also keeps the heat exchanger core warmer, minimizing problems with freezing.

In the summer, an ERV 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. If you use an air conditioner, an ERV generally offers better humidity control than an HRV system. However, there is some controversy about using ventilation systems at all during humid, but not overly hot, summer weather. Some experts suggest that it is better to turn the system off in very humid weather to keep indoor humidity levels low. The system can also be set up so that it only runs when the air conditioning system is running, or use pre-cooling coils.

Most 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 or summers, and where fuel costs are high. In mild climates, the cost of the additional electricity consumed by the system fans may exceed the energy savings from not having to condition the supply air.

Table 4.3 Whole Building Ventilation Options Comparison [20]

Option	Pressure	Advantages	Disadvantages
Exhaust Only	Negative	▪ Simple, low-cost installation.	▪ No energy recovery. ▪ Location of supply air uncertain. ▪ Distribution uncertain.
Supply Only	Positive	▪ Simple, low-cost installation. ▪ Distribution control.	▪ No energy recovery.
Balanced HRV	Neutral	▪ Energy recovery. ▪ Lower operating cost. ▪ Good air in/out control. ▪ Good distribution.	▪ High cost of installation. ▪ Difficult to install in existing dwellings.
Balanced ERV	Neutral	▪ Energy recovery. ▪ Lower operating cost. ▪ Good air in/out control. ▪ Good distribution. ▪ Humidity control.	▪ High cost of installation. ▪ Difficult to install in existing dwellings.

Installation and Maintenance of Recovery Systems

ERV 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 electric 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 some heating, ventilation, and air conditioning (HVAC) contractors have enough technical expertise and experience to install them.

In general, provide a supply and return duct for each bedroom and for 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 (never use ordinary duct tape on ducts.)

ERV 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 on heat exchanger surfaces.

✓ **GOOD TO KNOW**

VENTILATION IN COOLING CLIMATES

Homes in hot humid climates, such as Houston or Corpus Christi, Texas, need to consider the combination of latent and sensible heat loads. The energy required to change a substance from a gas to a liquid, or a liquid to a solid, is known as *latent heat*. This adds to the moisture in a home. Heat that results in a temperature change is known as *sensible* heat. Conduction and convection contribute to sensible heat. To control sensible heat loads we can insulate the home or add solar screens. To reduce the latent heat we can ventilate. However, new research indicates that venting crawlspaces may actually make moisture problems worse, especially in warm humid climates. Building scientists have found that warm moist air entering the crawlspace increases the relative humidity when it cools. The release of moisture, in the crawlspace, causes condensation in the building structure. Over time, mold and structural deterioration occur causing potential health problems and reducing the durability of the home.

As we make homes more energy efficient by air-sealing, insulating, and ventilating a home, we change the ratio between sensible and latent heat loads, from typical 70:30 to more like 50:50. This change in loads often results in the existing air conditioner (AC) being oversized. Reducing the AC tonnage and adding a dehumidifier will change the relative humidity in the home; thus, increasing client comfort and using less energy. A dehumidifier can remove as much as three pints of water for the same energy it takes the AC to remove one pint of water. Installing a 40 pint/day dehumidifier that is tapped into the AC condensate line, or installed on a shelf above the washing machine with a line to the drain, can handle additional moisture in an economic way. [10]

Spot Ventilation or Source Control [29]

Spot ventilation is controlled air movement, using localized exhaust fans, to quickly remove pollutants and moisture at their source. Exhaust fans installed in the bathroom, but 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 molds from a crawl space
- Dust from an attic
- Fumes from an attached garage
- Flue gases from a fireplace or fossil-fuel-fired water heater and furnace.

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

Fan Control

The fan control pictured is one of many fan controls available. Once the cover plate is installed, the only function of the exposed switch is to boost the fan speed to full for 20 minutes. After 20 minutes the fan reverts to the installer determined control settings. The (replaceable) internal battery retains the settings for ten+ years through power failures, etc. Settings cannot be tampered with without removing the switch cover wall plate.

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

Attic Ventilation [2]

Attic ventilation is intended to remove moisture from the attic during the heating season and/or to remove solar heat from the attic during the cooling season. Many building codes require a minimum ratio of one square foot of net free area to 150 sq ft of attic area if a vapor barrier is not present. With a vapor barrier, only one square foot per 300 sq ft of attic area is required. Preventing moisture from entering the attic in the first place is the best way to keep attic insulation dry. Ceilings should be thoroughly air-sealed to prevent moist indoor air from leaking through the ceiling.

STANDARDS

ATTIC VENTILATION

Item	Materials	Criteria/Requirements
Attic Ventilation	All types	▪ Square feet of net free area per 300 sq ft of attic floor area is allowed when: - A properly installed vapor barrier exists if unit is in district heating factors 1.0, 1.25 or 1.5 - If high-low venting can be achieved by positioning the vents so that 50% of the venting is “high” (in the upper 60% of the attic space) and the other 50% is “low” (in the lower 40% of the attic space) ▪ 1 sq ft of net free area per 150 sq ft of the attic area is required if none of the above conditions exist ▪ Net free area or free vent opening means an opening which is not restricted by wire mesh or grill work. - A vent with 1/8” or 1/4” wire mesh, for example, should be 1.25 times larger than the basic size. An 18” x 24” gable vent with 1/4” wire mesh would, by these calculations, count for only 2.25 sq ft of “free venting.” - A vent covered by 1/16” mesh (or 1/4” mesh and a louver) should be twice as large to meet the venting standard (i.e. 1/150 or 1/300). A vent covered by 1/16” mesh and a louver will provide only one third the free vent opening for its size ▪ **Allowable types of vents:** - Gable - Soffit - Ceiling (unconditioned areas only) - Eave - Bird board - Static roof vent (gravity) - Ridge vent ▪ **Note: Turbine (or wind turbine) vents are not allowed.**
Vent Pipes	All types	▪ Must meet local codes or National Fire Protection Association (NFPA) codes and standards ▪ It is recommended that operable range-vent fans be vented to the outside, when feasible, and pipes must be sealed at ceiling ▪ Installation of non-electric dampers in exhaust vents is recommended, but not required ▪ All vents extending through roofs shall have a weather resistant flashing to prevent water leaks and a vent cap ▪ Client health and safety concerns require that certain gas-fired appliances be vented to the outside atmosphere

Chapter 5: Windows and Doors

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Windows and Doors

If windows and doors are in poor condition, their repair is often essential for a building's survival even if it's not an energy saving measure. Repairs that go beyond the cost effective standards of the Weatherization Assistance Program should be limited to funds that are dedicated to repair work. All tasks relating to window and door repair should be accomplished using lead-safe weatherization methods. [2]

For these reasons, most window and door measures are addressed either through air sealing, storm windows or repairs that were addressed in Chapter Two.

Windows

Window Replacement

Replace windows only when the window is missing, or damaged beyond repair. Replacement windows should be double-glazed low-E units with a window unit U-value of 0.46 or less as rated by the National Fenestration Rating Council (NFRC) or approved equal. (See climate zone energy efficiencies for windows.) Replacement windows must meet the 2000 International Residential Code specified in your area. [2]

✓ GOOD TO KNOW

HOT CLIMATE

Texas heat and sun contribute to increased air-conditioning costs. Newer Energy Star windows have even lower U-factors and Solar Heat Gain Coefficients that can reduce the solar heat gains into the home; consequently, reducing costs for air-conditioning. Look for the best priced window with the lowest U-factor and SHGC ratings. Windows that rank in the Audit may be replaced. [10,17]

Diagram 5-1 Window Types

Casement Awning Picture Double Hung Slider

Performance Ratings [30]

The NFRC label can be found on all ENERGY STAR qualified windows, doors, and skylights and provides performance ratings in five categories:

1. **U-Factor** measures the rate of heat transfer and tells you how well the window insulates. U-factor values generally range from 0.25 to 1.25 and are measured in Btu/h·ft²·°F. The lower the U-factor, the better the window insulates.

2. **Solar Heat Gain Coefficient (SHGC)** measures the fraction of solar energy transmitted and tells you how well the product blocks heat caused by sunlight. SHGC is measured on a scale of 0 to 1; values typically range from 0.25 to 0.80. The lower the SHGC, the less solar heat the window transmits.

3. **Visible Transmittance (VT)** measures the amount of light the window lets through. VT is measured on a scale of 0 to 1; values generally range from 0.20 to 0.80. The higher the VT, the more light you see.

4. **Air Leakage (AL)** measures the rate at which air passes through joints in the window. AL is measured in cubic feet of air passing through one square foot of window area per minute. The lower the AL value, the less air leakage. Most industry standards and building codes require an AL of 0.3 CFM/ft².

NONFEASIBLE CRITERIA

WINDOW REPLACEMENT

Do Not Install:

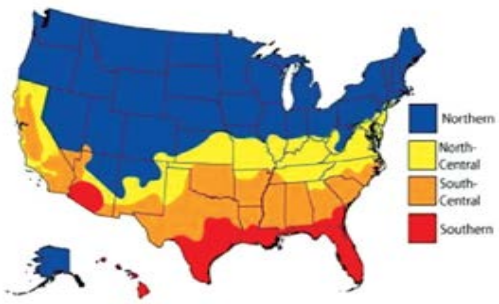
- When existing window may be repaired to effectively prevent air infiltration and moisture penetration; AND
- **When not justified by an SIR ranking of 1.0 or better by the Audit**

Note: Check measurements of new windows for correct sizes before installation.

5. **Condensation Resistance** measures how well the window resists water build-up. Condensation Resistance is scored on a scale from 0 to 100. The higher the condensation resistance factor, the less build-up the window allows. [43]

Selecting Energy Efficiency by Climate Zone

Climate Zone	U-Factor	SHGC	
Northern	≤ 0.30	Any	Prescriptive
	-0.31	≥ 0.35	Equivalent Energy Performance
	-0.32	≥ 0.40	
North-Central	≤ 0.32	≤ 0.40	
South-Central	≤ 0.35	≤ 0.30	
Southern	≤ 0.60	≤ 0.27	



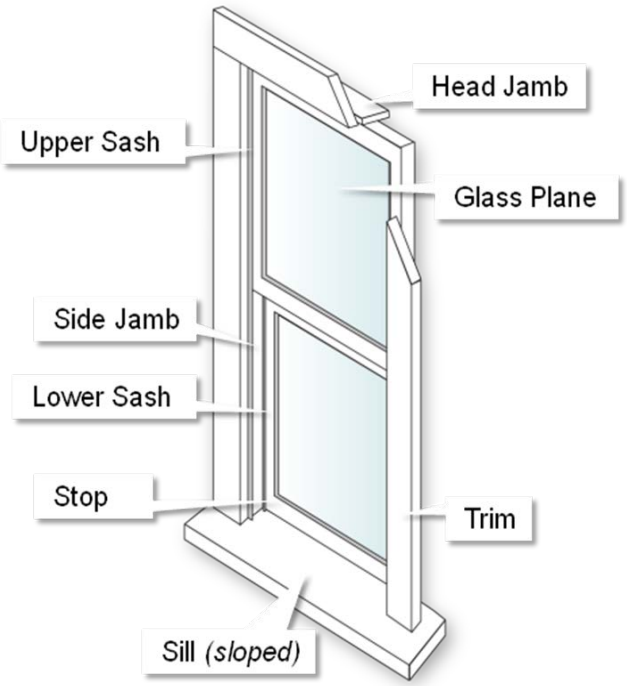
ENERGY STAR Program Requirements for Windows, Doors, and Skylights: Version 5.0 (April 7, 2009)

★ STANDARDS

WINDOW REPLACEMENT

Item	Materials	Criteria/Requirements
Acceptable Replacement Windows	Slider (vinyl, wood, metal) Double Hung Jalousie/metal casement	▪ Replace with steel frame or rigid vinyl frame windows ▪ Conforms to 10 CFR 440 Appendix A ▪ Replace with double hung or single hung window ▪ Replace with double hung, single hung or slider as appropriate ▪ If replacement is not feasible (or client refuses), interior storm windows may be installed. Use of this treatment must be well documented in client file folder. Any other treatment of jalousie or metal casement windows must be justified and documented in client file folder ▪ All replacement windows must conform to applicable DOE standards with documentation available for review
Sash	Wood	▪ Decayed or deteriorated sashes must be replaced
Structural Integrity	Rough window frame	▪ Structural framing must be repaired or replaced as needed before installing replacement window ▪ Framing members must be free of dry rot or pest damage
Jambs	All types of replacement windows	▪ It is strongly recommended that replacement windows be sized to fit existing jamb openings (i.e. "custom" windows should be used for non-standard installation). Prime (new construction) windows which fit existing opening may be used only if custom replacement windows are not available. Installation of new construction windows shall be in a manner to effectively prevent air infiltration and water penetration and shall be neat in appearance ▪ Any damaged window stop must be replaced
Sills	All openings	▪ Must be replaced when dry rot or deterioration is present ▪ Must be sealed with a minimum of 2 coats of approved sealant ▪ Must be installed with a 5 degree slant toward ground
Cavities	Insulation	▪ Opening between rough framing and window jamb (cavity) shall be insulated when cavity is exposed prior to or during weatherization work. Use low expanding foam to insulate. ▪ Exposed openings between rough opening and jamb must be insulated
Casing	Wood	▪ Paint grade acceptable unless existing jamb is natural finish ▪ Match existing casings and miters, whenever possible
	Nails/screws	▪ Use finishing or casing nails/screws for interior casings ▪ Use coated or plated nails/screws for exterior casings

Diagram 5.2 Window Terminology



Typical wood window (exterior).

Solar Screens [2]

Much of the solar energy that strikes a home's windows will pass through the glass and enter the living space. This solar heat accounts for up to 40% of summer overheating in many homes. It works far better to block solar heat before it enters the home than to cool the home after it overheats.

Window shading increases comfort, reduces the cost of cooling, and is one of the most cost effective weatherization measures in hot climates. Not all windows cause overheating, so you should direct your efforts towards windows where the most heat enters.

Sun screens, made of mesh fabric that is stretched over an aluminum frame, are one of the most effective window shading options. They absorb or reflect a large portion of the solar energy that strikes them, while allowing a slightly diminished but acceptable view out of the window.

Sun screens are installed on the outside of the window, and work well on fixed, double-hung, or sliding windows. They aren't suitable for jalousie windows. For casement and awning windows, install sun screens on the window sash rather than on the window frame.

★ STANDARDS

SOLAR SCREENS

Item	Materials	Criteria/Requirements
Allowable Materials	Screen/frame	▪ Solar screens shall be fiberglass materials in aluminum frame ▪ Rescreen wood frames, when possible ▪ Screens must have a shading coefficient of 0.35 or lower ▪ Frames: 3/8” x 5/16” x .020 Center Bar: 5/16” x 5/8” x .020
Pre-Installation Requirements		▪ Windows should receive at least two hours of direct sunlight per day
Size and Shape		▪ Solar screen must match prime and or storm window (or door)
General Installation		▪ All screens must be mounted with such hardware as to allow easy removal ▪ Bedroom windows are considered emergency fire exits under the Uniform Building Code. Bedroom solar screens shall not be installed with screws or other external hardware which prevents easy exit from inside the dwelling ▪ Install sun screens on the exterior of the window frame, trim, or sash. Drill pilot holes for screws that pass through the aluminum frame, or use clips that are screwed to the window frame outside the sun screen. Use aluminum fasteners on aluminum frames to avoid corrosion.

Doors

Door measures are usually not cost-effective. Doors have a small surface area and their air leakage is typically more of a localized comfort problem than a significant energy problem. However, door operation affects building security and durability, so door repair is an important consideration.[2]

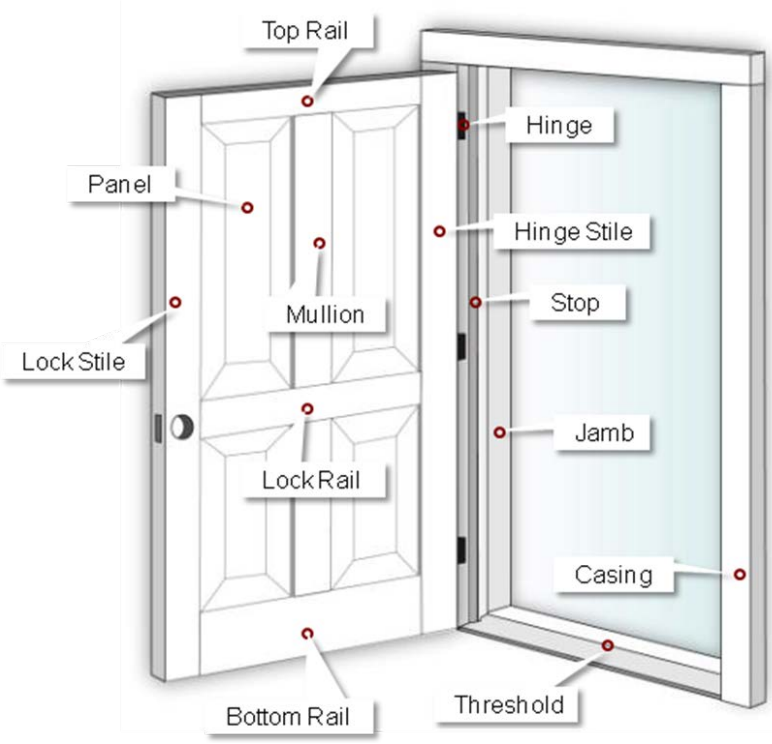
★ STANDARDS

DOOR REPLACEMENT

Item	Materials	Criteria/Requirements
Replacement Doors	Wood	Conforms to 10 CFR 440 Appendix A
	Metal	▪ Conforms to 10 CFR 440 Appendix A ▪ Must have minimum 20 minute fire rating
Dimension	Wood and Metal	▪ Match existing thickness, where applicable ▪ Use 1 3/4” thick door where feasible ▪ Seal to protect
Door Composition	Veneer/Metal	▪ Veneer must be a minimum of 1/8” thick ▪ Hardboard acceptable ▪ Exterior grade glue only ▪ Solid core wood or foam filled metal doors required for exterior use ▪ Foam filled wood doors are not acceptable for exterior use

Doors must rank in the Audit with an SIR of 1 or better. If the door is below an SIR of 1, you must have Program Officer approval along with photo documentation.

Diagram 5-3 Door Terminology



Door Replacement [17]

Should the door (slab) be deteriorated to a point at which the building envelope is compromised, and does not rank in the Audit with an SIR of 1 or greater, the door may be considered as a repair measure to ensure the protection of the building envelope. When a decision has been made to replace a door, subrecipients must clearly document the deterioration of the door with a narrative description of the deterioration and photographic documentation indicating that the door is broken, punctured, rotted, delaminated, has water damage, or is damaged beyond repair. If there is still any question as to whether the door is in the "replacement category," consult your TDHCA program officer. Send him or her documentation, description and photos of the questionable door.

When a door is replaced, care should be taken not to enter the door into the Audit as an infiltration measure under the "Ducts and Infiltration". Instead the door replacement should be listed as a weatherization-related repair item in "general repairs" section

NONFEASIBLE CRITERIA

DOOR REPLACEMENT

Do Not Install:

- Doors should not be replaced for aesthetic reasons, for example, stripping paint, buckled doors, or non-functional screen doors are not reasons to replace the door. Just because a door doesn't look appealing is not a reason to replace the door. In general, especially in the case of infiltration or door integrity, it is preferred to have the door repaired vs. replacing the entire door.
- Existing R-value, no matter how low, is not a justification to replace the door. [17]
- If the door does not rank with an SIR of 1 or greater in the audit.

of the “user-defined measures” tab. (See *Authorizing Weatherization-Related Repairs* Best Practice, dated 14 July 2010.) Replacement costs must be included in whole-house SIR.

Chapter 6: Heating and Cooling

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Heating

The overall goal of heating system replacement is to provide a gas-fired heating system in virtually new condition, even though existing components like the gas lines, chimney, or ducts may remain. Any necessary maintenance or repair on these remaining components should be considered part of the installation. Any design flaws in the original system should be diagnosed and corrected during the heating system replacement. [3]

All Systems Maintenance to be Performed by Heating System Professional

- Check the condition of your vent connection pipe and chimney. Parts of the venting system may have deteriorated over time. Chimney problems can be expensive to repair, and may help justify installing new heating equipment that will not use the existing chimney.
- Check the physical integrity of the heat exchanger. Furnace heat exchangers mix combustion gases with house air when they leak - an important safety reason to have them inspected.
- Adjust the controls on the furnace to provide optimum air temperature settings for both efficiency and comfort. [31]

Space Heaters

Three types of space heaters will be addressed: electric, unvented and vented gas- or liquid-fueled. Space heaters that do not meet the guidelines set forth in the Weatherization Program Notice (WPN) 11-06 must be removed from the home and disposed of properly; they may not be left on the premise.

NONFEASIBLE CRITERIA

ELECTRIC SPACE HEATERS

DOE does not allow repair, replacement, or installation of electric space heaters. DOE will not preclude the use of other funding sources for the replacement or major repair of electric space heater.

Electric Space Heaters

The Department does not encourage electric space heaters, because of the following:

- High cost of electricity as compared to fossil fuels;
- Lower output ratings (size);
- Risk of fire hazards; and,
- Inadequate electrical systems in older homes frequently cannot safely carry the power required to operate an electric heater.

Electric space heater

Work on such systems may make local agencies liable for inadequate electric wiring and damages that may result.

STANDARDS

ELECTRIC SPACE HEATER

Item	Materials	Criteria/Requirements
Electric Space Heaters	Per WPN 11-06	▪ Repair, replacement, or installation is NOT allowed ▪ Removal is recommended
	Audit **Must meet the requirements of 24 CFR 3280.707 when installed in mobile homes**	▪ Check circuitry to ensure adequate power supply ▪ Inform client of the fire dangers associated with electric space heaters.

Unvented Gas- and Liquid-Fueled Space Heaters [32]

Gas- and liquid-fueled space heaters.

The U.S Department of Energy (DOE) strongly encourages removal of all unvented gas- and liquid-fueled space heaters and replacement with vented, code-compliant heating systems as a prerequisite to weatherization.

However, the DOE will allow unvented gas- or liquid-fueled space heaters to remain as secondary heat sources in single-family houses provided they comply with the International Residential Code (IRC) and the International Fuel Gas Code (IFGC). DOE is allowing this flexibility primarily to provide low-income clients an emergency back-up source of heat in the event of electrical power outages. Therefore, preference should be given to code-compliant units that do not require electricity.

Specifically, any unvented gas- and liquid-fueled space heaters that remain in a completed single-family house after weatherization:

- Shall not have an input rating in excess of 40,000 Btu/hour;
- Shall not be located in, or obtain combustion air from sleeping rooms, bathrooms, toilet rooms, or storage closets unless:
  - Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bathroom:
    - Has an input rating that does not exceed 6,000 Btu/hour;
    - Is equipped with an oxygen-depletion sensing safety shut-off system; and
    - The bathroom meets required volume criteria to provide adequate combustion air;
  - Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bedroom:

NONFEASIBLE CRITERIA

UNVENTED SPACE HEATERS

DOE will not permit any DOE-funded weatherization work where the completed dwelling unit is heated with an unvented gas- and/or liquid-fueled space heater as the primary heat source. This policy applies to unvented natural gas-fired space heaters, unvented propane-fired space heaters, and unvented kerosene space heaters. This policy is consistent with the IRC and the IFGC.

- Has an input rating that does not exceed 10,000 Btu/hour;
- Is equipped with an oxygen-depletion sensing safety shut-off system; and
- The bedroom meets required volume criteria to provide adequate combustion air.

- Shall require the enforcement of minimum ventilation guidelines as determined by the greater of:
  - 7.5 cubic feet per minute (CFM) per person,
  - Number of bedrooms plus one x 7.5 CFM, or
  - .35 air changes per hour.

The above minimum ventilation guidelines are natural ventilation rates, not with the house depressurized to negative 50 Pascals, with a blower door.

STANDARDS

UNVENTED SPACE HEATER

Item	Materials	Criteria/Requirements
Unvented Space Heaters	Per WPN 11-06	▪ Removal is required, except as secondary heat where the unit conforms to ANSI Z21.11.2. Units that do not meet ANSI Z21.11.2 must be removed prior to weatherization but may remain until a replacement heating system is in place.
	Audit/Final **Must meet the requirements of 24 CFR 3280.707 when installed in mobile homes**	▪ Test home for ambient CO levels (<9 ppm action level; <25ppm replace appliance) ▪ Check units for ANSI Z21.11.2 label Inform client of dangers of unvented space heaters: CO, NO_2, and moisture

Vented Space Heaters [32]

Vented gas- and liquid-fueled space heaters should be treated the same as furnaces in terms of repair and replacement, as well as combustion appliance safety testing. This policy applies to vented natural gas- and propane-fired space heaters, and oil-fired space heaters, which are always vented.

NONFEASIBLE CRITERIA

SECONDARY SPACE HEATERS

The Weatherization Program can replace the primary unvented space heater with a vented unit, but cannot expend DOE funds to replace one of the existing secondary space heaters with a code-compliant unvented unit with an oxygen-depletion sensing safety shut-off system. [32]

STANDARDS

VENTED SPACE HEATER

Item	Materials	Criteria/Requirements
Vented Space Heaters	Per WPN 11-06	▪ Should be treated as a furnace ▪ Venting should be tested, consistent with furnaces
	Monoxor II or Combustion Analyzer	▪ Must be tested for carbon monoxide output as per Health & Safety Policy ▪ Must be assessed at initial assessment, the operating efficiency determined and entered into the Audit
	Audit/Final **Must meet the requirements of 24 CFR 3280.707 when installed in mobile homes**	▪ Must be repaired, retrofit or replaced when indicated by an SIR of 1 or better ▪ Repairs/retrofit must reduce CO levels to >25 ppm or less ▪ Replacements must have a factory installed oxygen depletion sensor system vented space heaters must meet ER = .80 standard ▪ Electric or kerosene space heaters will not be allowed

Electric Furnaces and Electric Baseboard Heat [3]

The purpose of servicing electric furnaces and electric baseboard heat is to clean the heat exchangers and blower. Sealing ducts is also very important because electric heat is so expensive. For the same amount of heat, electric resistance heat costs between two and three times more than natural gas or a heat pump.

Electric Furnace, Electric Baseboard Maintenance

- Check and clean thermostat.
- Clean and lubricate blower, if appropriate.
- Clean or replace all filters.
- Vacuum and clean housing around electric elements, if dirty.
- Clean fins on electric baseboard systems, if applicable.

Electric furnaces can be a problem for utility companies if they are using more 5-kW heating elements than are necessary to heat the home - the utility has a higher peak demand than it would if only the minimum number of elements were used. During mild weather, a couple elements are needed. In severe weather all elements might be needed.

A standard heating thermostat, combined with an outdoor thermostat, can be used to stage heating elements for different weather. This is not an energy saving measure; it is a power saving measure. Since staging elements benefit the utility company, they may be willing to pay for the savings to the utility power system.

Heating Element Maintenance

- Replace air filters at regular intervals. The electric heating elements should be dusted and vacuumed if they are dirty. However, cleaning the heating elements shouldn't be necessary if air filters are changed regularly.
- Seal ducts absolutely airtight and insulate supply ducts.
- Install an outdoor staging thermostat to reduce peak load and/or increase comfort.

Safety Measures

- Make sure that the baseboard heater sits at least an inch above the floor to facilitate good air convection.
- Clean fins and remove dust and debris from around and under the baseboard heaters as often as necessary.
- Avoid putting furniture directly against the heaters. To heat properly, there must be space for air convection.

Fuel Furnaces

Older furnace systems had efficiencies in the range of 56% – 70%; modern conventional heating systems can achieve efficiencies as high as 97%, converting nearly all the fuel to useful heat. [3]

Table 6.2 Types of Gas Furnaces [3]

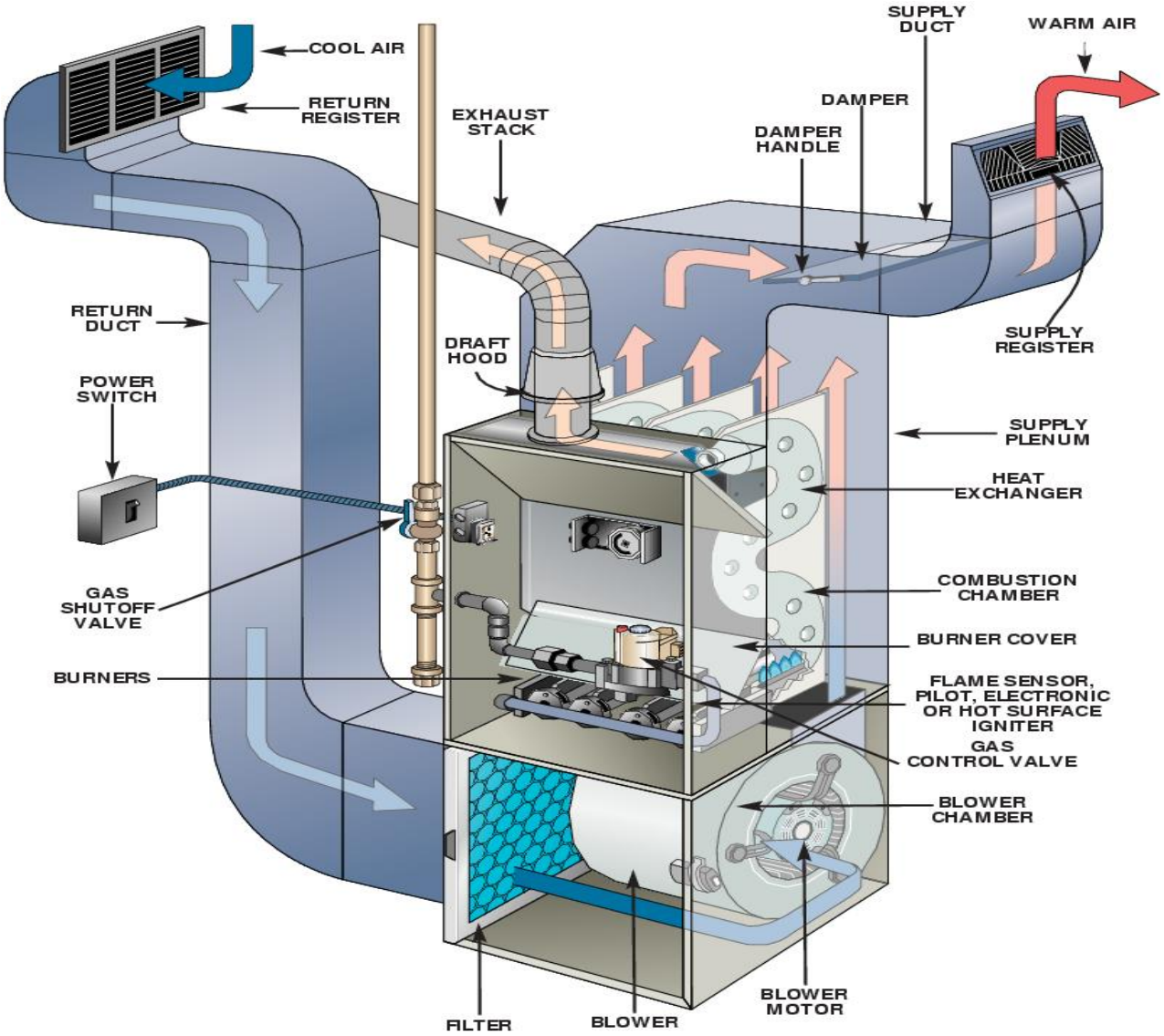
	 **75- Efficiency Furnace**	 **80+ Efficiency Furnace**	 **90+ Efficiency Furnace**
Description	These older furnaces are very inefficient and often have safety issues due to using indoor combustion and dilution air.	The new furnace should have an Annual Fuel Utilization Efficiency (AFUE) of at least 80% and bring outside air directly into the burner and exhaust combustion products directly to the outside, without the need for a draft hood or damper.	These high efficiency furnaces work so well that they generally produce an acidic exhaust gas that is not suitable for old, unlined chimneys, so the exhaust gas should be vented using a non-corrosive pipe (PVC). Condensing furnaces with 90+ AFUE are vented horizontally or vertically through PVC Schedule 40 pipe. Vent piping should be sloped back toward the appliance, so the condensate can be drained and treated if necessary.
Characteristics	▪ Standing pilot light, draft diverter, no draft fan, indoor combustion and dilution air. ▪ AGA Venting Category I: use standard venting; masonry or Type B vent.	▪ No draft diverter, draft fan, electronic ignition, indoor combustion air, no dilution air. ▪ AGA Venting Category III: use only pressurizable vent as specified by manufacturer.	▪ No draft diverter, draft fan, low-temperature plastic venting, positive draft, electronic ignition, condensing heat exchanger, outdoor combustion air is strongly recommended. ▪ AGA Venting Category IV: use only pressurizable condensing-service vent as specified by manufacturer.

Table 6.1 Annual Estimated Savings for Every $100 of Fuel Cost by Increasing Your Heating Equipment Efficiency* [31]

Existing System AFUE	New/Upgraded System AFUE								
	55%	**60%**	**65%**	**70%**	**75%**	**80%**	**85%**	**90%**	**95%**
50%	$9.09	$16.76	$23.07	$28.57	$33.33	$37.50	$41.24	$44.24	$47.36
55%	- -	$8.33	$15.38	$21.42	$26.66	$31.20	$35.29	$38.88	$42.10
60%	- -	- -	$7.69	$14.28	$20.00	$25.00	$29.41	$33.33	$37.80
65%	- -	- -	- -	$7.14	$13.33	$18.75	$23.52	$27.77	$31.57
70%	- -	- -	- -	- -	$6.66	$12.50	$17.64	$22.22	$26.32
75%	- -	- -	- -	- -	- -	$6.50	$11.76	$16.66	$21.10
80%	- -	- -	- -	- -	- -	- -	$5.88	$11.11	$15.80
85%	- -	- -	- -	- -	- -	- -	- -	$5.55	$10.50
90%	- -	- -	- -	- -	- -	- -	- -	- -	$5.30

***** Assuming the same heat output.

Diagram 6.2 Inside a Gas Furnace



Forced-Air System Repairs [3]

- Remedy carbon monoxide (CO)
  - Causes of CO Production:
    - Improper gas pressure. In Texas, we often find low gas line pressure.
    - Poor air to fuel ratio. Adjust the air intakes.
    - Dirty burners
    - Poor draft (low or high)
    - Flame impingement – flame touching
    - Blocked or poorly designed vent systems
- Adjust blower control and supply-air temperature
- Clean and oil the blower. Remove and clean the blower. Use a brush to remove all dirt and residue from the blower. If you also remove the motor you can then use a hose and household cleaners to remove the accumulated dirt. If you find that the blower is dirty, then you can expect that the coil is too.
  - Remove dirt, soot, or corrosion from the furnace or boiler
  - Check fuel input and flame characteristics, and adjust if necessary
  - Seal connections between the furnace and main ducts.

Dirty blower

★ STANDARDS		
HEATING		
Item	**Materials**	**Criteria/Requirements**
Central Heaters Wall & Floor Furnace	Monoxor II or Combustion Analyzer	▪ Must be tested for Carbon Monoxide output as per Health & Safety Policy
	Audit/Final	▪ Must be assessed at initial assessment, the operating efficiency determined and entered into the Audit
	Must meet the requirements of 24 CFR 3280.707 when installed in mobile homes	▪ Must be repaired, retrofit or replaced when indicated by an SIR of 1 or better ▪ Replace with high efficiency units only: Gas heating appliances ER =.80 or greater ▪ Replacement units must meet the heat load of a manual J

ER = Energy Ratio EER = Energy Efficiency Rating COP = Coefficient of Performance

Heat Pumps

Generally speaking in Central Texas the best option from an efficiency perspective is to replace all electric resistance heating systems with high efficiency heat pumps. **Heat pumps deliver about two to three times more heat for each unit of electricity consumed.** [3]

> ✓ **GOOD TO KNOW**
>
> **HOT, HUMID CLIMATE**
>
> Heat pumps are preferable to electric resistance heating in all but the mildest of climates, such as southern Texas, where there are fewer than 500 annual heating degree days. A unit with a Heating Seasonal Performance Factor (HSPF) of 7.7 or more will reduce the electric consumption during heating by more than 50% relative to electric resistance heating. [15]

Central Heat Pumps

Most residential central heat pumps are split systems with the evaporator and air handler indoors, and the condenser and compressor outdoors. A heat pump will capture heat from the air in the winter time for cost effective heating. Yes, there is heat in cold air! There is usable heat in the air as low as 0°F. A balance point of 40°F is often quoted, although many are found to balance at much lower temperatures. When we weatherize a home and make it more energy efficient, we can achieve a lower balance point. It is much more efficient and less expensive to transfer existing heat than to generate heat. In the summer months, the unit will capture heat from inside the home and transfer it outside.

The size of the heat pump that is ideal for cooling is not always the same as the ideal size for heating. If the heating load is lower than the cooling load, design if for cooling load. If the cooling load is too large it cause increased humidity and discomfort.

Heat pumps do not recover quickly or efficiently from long setback temperatures. In fact, this will trigger the backup heat to turn on negating the energy savings that heat pumps can provide. Install thermostats specifically designed for heat pumps. These will maintain comfortable temperatures and maximize energy savings. Proper client education on the thermostat is essential when installing a heat pump.

- Multiple returns ensure sufficient return airflow to the unit. An outdoor thermostat prevents strip heat from operating until outdoor temperature is less than 35-40°F. This thermostat stages elements as needed.
- A two-stage thermostat activates the compressor first and subsequently activates the strip heat only when the compressor cannot satisfy the load.

Central Heat Pump Maintenance

- Supply ducts should be airtight and sized to provide the needed airflow. Supply ducts are to be insulated in unconditioned areas.
- The coil should be cleaned every year or two. Weeds, grass and shrubs are not allowed to grow within 3’ on all sides. Educate the client.

- Verify the refrigerant charge and airflow by superheat/sub-cooling method.
  - The performance and efficiency of residential air conditioners and heat pumps is very dependent upon having the correct amount of refrigerant in the system.

Central Heat Pump Trouble Shooting Tips

Cooling Mode Problem	Tip
Compressor continually runs	▪ Check refrigerant level ▪ Check thermostat setting (too high or low?), or is it located near a source of heat? ▪ Check outside coil - is it blocked? ▪ Check for limited air movement; Blocked registers or dirty air filter
House humid and won't cool	▪ Check for low refrigerant level ▪ Evaluate compressor ▪ Check for open window or door ▪ Check for duct leakage

Heating Mode Problem	Tip
Condenser appears to be giving off steam	▪ This is actually the defrost cycle giving off water vapor, which is a normal process
Thermostat's auxiliary heat light is on	▪ Typically happens when the outside temperature is below the balance point (40° or less). This means the supplemental heaters are working; or ▪ Occupant has adjusted the thermostat up more than 1.5°, causing the supplemental heaters to engage
Little air flow from supply registers	▪ Check for and replace dirty filters ▪ Check for belt or blower motor failure ▪ Check that return filter is not blocked
Compressor continuously runs	▪ Check that thermostat is not set too high or is exposed to a cold draft ▪ Check for low refrigerant level ▪ Check that the condenser is not blocked by plants or ice

Room Heat Pumps

Individual room heat pumps are more efficient since they have the advantage of no ducts and are factory-charged with refrigerant. Room heat pumps can provide all or part of the heating and cooling needs for small homes.

Room heat pumps draw a substantial electrical load, and may require 220-240 volt wiring. Provide a dedicated circuit that can support the equipment's rated electrical input (This cost should be included in the total cost of the replacement.) Insufficient wiring capacity can result in dangerous overheating, tripped circuit breakers, blown fuses, or motor-damaging voltage drops. In most cases a licensed electrician should confirm that the house wiring is sufficient. Do not run portable heat pumps or any other appliance with extension cords or plug adapters.

Room Heat Pump Installation Specifications

- Install the unit in a central part of the home where air can circulate to other rooms. Choose a location near an electrical outlet, or where a new outlet can be installed if it is needed.

- Do not install the unit where bushes will interfere with its outdoor airflow. Heat pumps need lots of outdoor air circulation to operate at maximum efficiency.
- If you install the unit in a window, use a portable unit that can be stored out of the way in the off-season. Install the unit in a double-hung or sliding window. Portable units do not work well in out-swinging casement windows or up-swinging awning windows.
- If you install the unit in a framed opening in the wall, use the same guidelines you would to frame a new window or door. Provide headers, beams, or other structural supports where studs are cut, or install it in an opening under an existing window where structural support is already provided by the window framing.
- Provide solid supports underneath the unit. These can be manufactured brackets, wood-framed brackets, or brackets fabricated from metal. Fasten the unit with screws to the window jamb and/or sash.
- Seal around the exterior siding and trim to keep rain out of the wall cavity. Seal the unit to the opening with the shields provided by manufacturer or with plywood, caulking, or sheet metal.

The use of ductless and ducted mini-split air conditioning and heat pump systems has grown a great deal over the last few years. They offer a retrofit option when duct installation or improvements prove challenging. These options cost more, but may be more cost effective compared to the replacement of a damaged and leaky old duct system. They also often offer very high efficiencies with systems commonly achieving ratings of between 15 and 21 SEER.

Venting [3]

Combustion gases are vented through vertical chimneys or other types of approved horizontal or vertical vent piping. Identifying the type of existing venting material, verifying the correct size of vent piping, and making sure the venting conforms to the applicable codes are important tasks in inspecting and repairing venting systems. Too large a vent often leads to condensation and corrosion. Too small a vent can result in spillage. The wrong vent materials can corrode or deteriorate from heat.

Vent Connectors [3]

Types of Vent Connectors

Double-wall vent connectors are the best option, especially for appliances with some horizontal vent piping. A double-wall vent connector helps maintain flue-gas temperature and prevent condensation.

Gas appliances with draft hoods, installed in attics or crawl spaces must use a Type-B vent connector.

Type-L vent pipe is commonly used for vent connectors for solid fuels but can also be used for gas.

Follow manufacturer’s venting instructions along with the IFGC to establish a proper venting system.

Vent Connector Specifications

- A vent connector is almost always the same size as the vent collar on the appliance it vents.
- Single-wall vent-pipe sections should be fastened together with three screws or rivets.
- The vent connector should be sealed tightly where it enters a masonry chimney.
- Vent connectors should be free of rust, corrosion and holes.
- The chimney combining two vent connectors should have a cross-sectional area equal to the area of the larger vent connector plus half the area of the smaller vent connector. This common vent should be no larger than 7 times the area of the smallest vent.
- The horizontal length of vent connectors should not be more than 75% of the chimney's vertical height or have more than 18" horizontal run per inch of vent diameter.
- Vent connectors must have upward slope to their connection with the chimney. A slope of at least 1/4" of rise per foot of horizontal run along their entire length is recommended to cause combustion gases to rise through the vent and to prevent condensation from pooling and rusting the vent.
- When two vent connectors connect to a single chimney, the vent connector servicing the smaller appliance shall enter the chimney above the vent for the larger appliance.
- Codes require a "Clearance" or air space which is the distance that must be left between all parts of a flue vent pipe and any material that is combustible like wood, or the paper on sheetrock. Codes also call for keeping all insulation materials back from the flue vent by the same distance.[3] Single-wall vents require a minimum of a 6" clearance to combustibles. Type-B double-wall vents require at least a 1 inch clearance to combustibles.[12]

Diagram 6.3 Vent Pipe

B-Vent

L-Vent

Single-wall
Black Pipe

Table 6.3 Approved Vent Connectors for Gas-Fired Units

Type	Description	Use
B-Vent	Consisting of a galvanized-steel outer pipe and aluminum inner pipe	Not air tight, for negative pressure systems only. Most commonly used vent in Texas.
L-Vent	Connector with a stainless-steel inner pipe and either galvanized or black-steel outer pipe.	Not air tight, for negative pressure systems only.
Galvanized-steel pipe	≥ 0.019” thick or 20 gauge	For vent connectors 5” in diameter or less.
	≥ 0.023” thick or 22 gauge	For vent connectors 6” to 10” in diameter.

Venting Repairs [3]

- Remove chimney obstructions.
- Repair disconnections or leaks at joints and where the vent connector joins a masonry chimney.
- Install a wind-dampening chimney cap.
- Install a new chimney liner.
- Increase the pitch of horizontal sections of vent.

Appliance Access and Location

Appliances must remain accessible for inspection, service, repair, and replacement without the need to remove permanent construction. Appliances must be located or protected so they are not subject to flooding or damage. They must have adequate clearances for ventilation and for protection of adjacent combustible surfaces. The codes have special rules to help maintain access and working space for specific locations, such as underfloor areas and attics. Check manufacturer’s instructions for clearances. [12]

Cooling

✓ GOOD TO KNOW

HOT-HUMID CLIMATE

In addition to wasting energy and money, oversized air conditioning systems in a hot and humid climate may cause moisture problems. Besides cooling, air conditioners provide the valuable service of removing moisture from the air. If humidity is not removed, reducing the temperature will create condensation on cool surfaces and create cold, clammy conditions. To compensate for the clamminess, occupants are likely to set the temperature much lower than would be the case if the space were drier, wasting energy and causing even more condensation and discomfort.

In addition to “right-sizing” the unit for optimum comfort, an efficient building envelope often allows for downsizing of air conditioning units, further reducing initial cost. In larger homes, downsizing may allow one unit to replace two, for additional savings in cost and maintenance. In any home where oversized air conditioners lead to short cycling, the system may not provide adequate dehumidification.

Mini-split air conditioners and heat pumps offer the most efficient heating and cooling for warm and moderate climates. Mini-splits also offer flexibility for buildings without ducts or with duct systems that are worn out, poorly designed, or poorly installed. [15]

Cleaning and Maintenance [3]

Cleaning Air Conditioning Coils


Cleaning coils in place.

Clean filters and air conditioning coils are a minimum requirement for efficient operation. Keeping filters clean and sealing ducts are the best way to keep coils clean. Cleaning an indoor air conditioning coil is much more difficult than changing or cleaning a filter. When a filter is dirty or absent, dirt collects on the coil, fan blades, and other objects in the air stream. The dirt deposits reduce airflow and will eventually cause the evaporator coil to freeze or ice up and the air conditioning system to fail.

Dirt builds up on a coil from the side where the air enters. The heaviest deposits of lint, hair, and grease will coat that side of the indoor coil. The best strategy is to dampen this surface layer and brush or vacuum the heavy dirt off before trying to wash the finer dirt out with a biodegradable indoor coil cleaner and water. A non-toxic foaming coil cleaner that is not acid based (phosphoric acid is often used) is recommended. It is safer for the crews and the occupants.

The outdoor coils of air conditioning systems are not protected by filters. They get dirty depending on how much dust is in the outdoor air. If there is little dust and pollen in an area, the outdoor coil may only need cleaning every three years or so. However, if there is a lot of pollen and dust, annual cleaning is a good practice. It is a safe assumption that all outdoor coils need cleaning. Use a biodegradable cleaner designed for cleaning outdoor coils. If the cost for cleaning a room air conditioner approaches the cost of a replacement unit, then replacement should be recommended. We often see the coil fins smashed or bent badly. This reduces airflow significantly. Use a fin comb to straighten the fins to restore efficient airflow.

Cleaning Room AC and Heat Pump Coils [3]

Room air conditioners have foam or fiberglass filters that lie up against the inside coil. It’s good practice to carry a roll of filter material to replace worn out or non-existent filters. Cleaning the indoor coil is easy since the heaviest dirt collects on the surface of the coil facing the inside of the home. Cleaning the outdoor coil is more difficult. Usually cleaning the outdoor coil involves removing the room air conditioner from the window and taking it to an outdoor location where you can use a garden hose. The housing of the air conditioner must be removed to clean the outdoor coil. Again, use biodegradable, non-acid based indoor coil cleaner for the indoor coil and outdoor coil cleaner for the outdoor coil. Each is designed for a different variety of dirt and has different environmental specifications.

Cleaning Steps: Room AC Indoor, Outdoor Coil

1. Remove the grille and filter on the interior side of the unit.
2. Unplug and remove the air conditioner temporarily from the window or wall. With some units, the mechanical parts slide out of the housing, and with others you must remove the whole unit, housing and all.
3. Take the unit to a clean outdoor area that drains well, such as a driveway or patio.
4. Cover the compressor, fan motor, and electrical components with plastic bags held in place with rubber bands.
5. Dampen each of the coils with a light spray of water, then rake as much dirt off the coils as you can with an old hairbrush. Room air conditioner performance deteriorates as it accumulates dirt. The unit will eventually fail to cool the room or break down unless cleaned.
6. Spray indoor coil cleaner into the indoor coil and outdoor coil cleaner into the outdoor coil, and let the cleaner set for a minute or two.
7. Rinse the cleaner and dirt out of the coils with a gentle spray of water from a hose.
8. Repeat the process again until the water draining from the coils is clean.
9. Straighten bent fins with a fin comb to prevent bent fins from reducing airflow.

Cleaning Blowers and Indoor Coils [3]

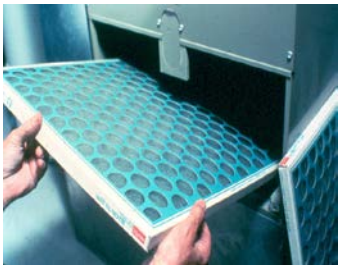
Every indoor coil should be protected by an air filter that fills the entire cross-sectional area of the return duct leading to the blower and indoor coil. Filters are easier to change or clean compared to cleaning a blower or coil. If equipped with clean, well-fitting filters, the blower and coil will remain clean for many years. However, many coils have not had the benefit of such filters and are packed with dirt.

Cleaning Steps: Blowers, Indoor Coils

1. Shut off the main switch or pull the electrical disconnect to the air handler.
2. Open the blower compartment and look into the blades of the blower using a flashlight. Reach in and slide your finger along a fan blade. Have you collected a mound of dust?
3. If the blower is dirty, remove and clean it. If you remove the motor, use hot water or household cleanser to remove the dirt.
4. If the blower is dirty, the indoor coil is probably also dirty. Visually inspect the coil if you have access. If needed, create an access hatch.
5. If the coil is dirty, clean it using a brush, biodegradable, non-acid based indoor coil cleaner and water. Consider replacing the coil if it is extremely dirty. A-coils are found in upflow and downflow air handlers. In downflow models, the dirt collects on top and on upflow units dirt collects on the bottom. Clean the coil, drain pan, and drain line.

6. Straighten bent fins with a fin comb to prevent bent fins from reducing airflow.
7. Clean the drain pan and drain line.

Filter and Blower Maintenance [3]



When replacing dirty filters, Advise clients to check the filter each month and change it if it is dirty.[5]

A dirty filter can reduce airflow significantly. Take action to prevent filter-caused airflow restriction by taking the following steps:

- Insure that filters are easy to change or clean.
- Stress to the client the importance of changing or cleaning filters, and suggest to the client a regular filter maintenance schedule.
- Clean the blower. This task involves removing the blower and removing dirt completely with a brush or water spray.
- Special air cleaning filters offer more resistance than standard filters, especially when saturated with dust. Avoid using them, unless you test for airflow after installation. Most air conditioners cannot move enough air to work correctly through a filter that is thicker than one inch or a higher Minimum Efficiency reporting Value (MERV) rating than 8. Purchase filters to be left with the client when needed.
- Measure the current draw of the blower motor in amps. If the amp measurement exceeds the motor full load amp (FLA) rating by more than 10%, replace the motor.

Improving Airflow for Central Systems [3]

Central air conditioning units and central heat pumps should deliver 400 cubic feet per minute (CFM) of airflow per ton of capacity. Airflow may be restricted due to inadequate return air capacity.

An additional grille may be installed when the return air size is inadequate. If the location allows, the minimum square footage should be met. The table below indicates the minimum square feet needed to operate at maximum efficiency. According to Manual D by the Air Conditioning Contractors of America (ACCA), non-filtered return air grilles should allow 300 CFM per gross square feet of filter area, or 200 CFM for a filtered grille.

Table 6.4 Sizing Return Air

BTUs	CFM/ton	Min. Sq. Ft. Filter Grille	Min. Sq. Ft. Non-Filter Grille
18,000	600	3.0	2.0
24,000	800	4.0	2.7
30,000	1000	5.0	3.3
36,000	1200	6.0	4.0
42,000	1400	7.0	4.7
48,000	1600	8.0	5.3
60,000	2000	10.0	6.7

One ton = 12,000 BTUs

Replacing Air Conditioners and Heat Pumps [3]

Replacing older inefficient air conditioners, those at or below a seasonal energy efficiency ratio (SEER) of 10, and heat pumps with new efficient units, those at SEER 14.5 or better under the current ENERGY STAR rating, can be a cost effective energy conservation measure. In many homes, replacing units involves only swapping air handlers and outdoor units. In other homes, the ducts need extensive repair and reconfiguring. In some homes it may be wise to discard an old central ducted forced air system in favor of a more efficient mini-split central system or one or more room units. When replacing room air conditioners or room heat pumps, simply choose the most efficient model based on the energy efficiency ratio (EER). Room air conditioner and heat pump units offer very efficient heating and cooling.

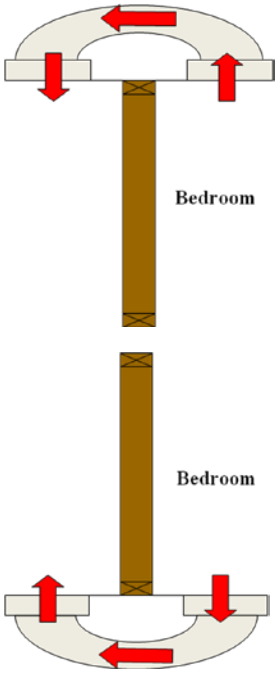
Seal all Penetrations!

Replacing Forced Air System [3]

Central forced air heat pump and air conditioning systems present three logical choices for replacement:

1. Size the new air handler to fit the existing ducts, performing building-shell improvements as necessary to reduce the heating and cooling load.
2. Make appropriate modifications to the existing duct system to optimize the performance of the new system.
3. Discard the ducts and replace the forced-air system with a ductless mini-split system. If the existing ducts will remain, evaluate the existing forced air ducts to identify duct modifications necessary to optimize performance and efficiency of the new system. Duct modifications include repair, duct sealing and insulation, installing additional supply or return ducts, or replacing the ducts with new ones.

Jump Duct Option



STANDARDS		
COOLING		
Item	**Materials**	**Criteria/Requirements**
Central Air Conditioners	Amp Meter **Must meet the requirements of 24 CFR 3280.714 when installed in mobile homes**	▪ Must be assessed at initial assessment, the operating efficiency ▪ Determined and entered into the Audit. ▪ Must be repaired, retrofit or replaced when indicated by an SIR of 1 or better ▪ Replace with high efficiency units only; use Energy Star rated units when available. ▪ Must be sized to fit existing blower units and duct systems
Whole House Window Units	Amp Meter **Must meet the requirements of 24 CFR 3280.714 when installed in mobile homes**	▪ Must be assessed at initial assessment, the operating efficiency determined and entered into the Audit ▪ Must be repaired, retrofit or replaced when indicated by an SIR of 1 or better ▪ Replace with high efficiency units only; use Energy Star rated units when available. ▪ Replace with same size unit except where smaller, more efficient unit will cool the same space
Room Air Conditioners	Amp Meter **Must meet the requirements of 24 CFR 3280.714 when installed in mobile homes**	▪ Must be assessed at initial assessment, the operating efficiency determined and entered into the Audit ▪ Must be repaired, retrofit or replaced when indicated by an SIR of 1 or better ▪ Replace with Energy Star rated or better, when available ▪ Replace with same size unit except where smaller, more efficient unit will cool the same space (10,000 Btu Maximum)

ER = Energy Ratio EER = Energy Efficiency Rating COP = Coefficient of Performance

Evaporative Coolers [3]

Evaporative coolers, also called swamp coolers, offer a highly efficient cooling strategy in dry climates. They work well where the summertime relative humidity remains less than 50%. Though they are not rated with a seasonal energy efficiency ratio (SEER), evaporative coolers have a cooling efficiency two to three times the SEER of the most efficient compressor-based air conditioners.

Evaporative Cooler Maintenance

Evaporative coolers see a lot of water, air, and dirt during operation. Dirt is the enemy of evaporative cooler operation. Evaporative coolers process a lot of dirt because their aspen pads are good filters for dust-bearing outdoor air. Evaporative coolers may cool better and filter better when the aspen pads are doubled up. Airborne dirt that sticks to the cooler pads washes into the reservoir. Most evaporative coolers have a bleed tube or a separate pump that changes the reservoir water during cooler operation to drain away dirty water. A cooler may still need regular cleaning, depending on how long the cooler runs, how hard the water is, and how well the dirt-draining system is working. Older cooler sumps were lined with an asphaltic paint and flexible asphaltic liners, but the newer ones have factory powder coatings that are far superior and less environmentally harmful. Do not paint or install asphaltum liners in a powder-painted cooler sump because asphaltic material will not stick to the factory finish. You will find some coolers in very poor condition. Consider whether replacement is a better option than cleaning in these cases.

Evaporative Cooler Maintenance Specifications

- Be sure to disconnect the electricity to the unit before servicing or cleaning it.
- Aspen pads can be soaked in soapy water to remove dirt, then rotated to distribute the wear, dirt, and scale, which remains entrained after cleaning.
  - Clean louvers in the cooler cabinet when you clean or change pads.
  - Replace the pads when they become unabsorbent, thin, or loaded with scale and entrained dirt.
- If there is a bleed tube, check discharge rate by collecting water in a cup or beverage can. You should collect a cup in three minutes or a can in five minutes.
- If the cooler has two pumps, one is a sump pump. It should activate to drain the sump every five to ten minutes of cooler operation.
- If there is any significant amount of dirt on the blower's blades, clean the blower thoroughly. Clean the holes in the drip trough that distributes the water to the pads.
- The reservoir should be thoroughly cleaned each year to remove dirt, scale, and biological matter. Gather silt and debris using two old hand towels or rags working together from the corners of the sump pushing the dirt and silt into the sump drain or into a bucket.
- Pay particular attention to the intake area of the circulating pump during cleaning. Debris can get caught in the pump impeller and stop the pump.
- Check the float assembly for positive shutoff of water when the sump reaches its level. Repair leaks and replace a leaky float valve.
- Investigate signs of water leakage and repair water leaks.

✓ GOOD TO KNOW

EVAPORATIVE COOLER: REPAIR OR REPLACE?

Total up the cost of all required new parts. Compare this cost with the cost of a new EC correctly sized for the home. If the total cost of the necessary parts is 60% or more than the total cost of a new system, then a new EC system can and should be purchased for the unit.

The justification for an EC replacement should include:

- the collected prices of parts;
- the new EC system price;
- detailed photos documenting the condition of the old EC; and
- a signed statement recording the percentages and documenting the agency's decision to replace the evaporative cooler. [17]

Evaporative Cooler Installation

Evaporative coolers are installed in two ways: the cooler outlet blows air into a central location, or the cooler outlet joins duct-work which distributes the cool air to different rooms in the house. Single outlet installations work well for compact homes. Ducted systems work better for more expansive homes. Most people install downflow evaporative coolers on the roofs of their homes. Evaporative coolers are also installed on stands or hung with chains on platforms. These coolers vent their cool air through windows or ducts cut through walls. Some horizontal ducted evaporative coolers are ground-mounted on concrete pads for easy access. The best place for a horizontal flow evaporative cooler is in the shade on the windward side of the home.

Evaporative Cooler Installation Specifications

- The cooler should have a fused disconnect and water shutoff nearby.
- The cooler should have at least 3 feet of clearance all around them for airflow and maintenance access.
- The cooler should be installed below, and at least 10 feet away from, chimneys or other roof vents.
- The cooler should be securely fastened; use chains and eyebolts for window or wall installations.
- Install the cooler with weighted dampers to allow easier changeover from evaporative cooling and either heating or air conditioning.
- Use thermostats to control evaporative coolers and minimize energy use, water use, and maintenance. Thermostats also reduce the chance of over cooling with unnecessary nighttime operation. Using a 24-volt transformer and thermostat is better than using a line voltage thermostat, which allows more temperature variation.
- Install evaporative coolers that have two speeds for cooling or venting. The vent settings activate the blower but not the pump, to use the cooler as a whole house fan at night and during mild weather.
- Select a control equipped with a pump-only setting, to flush dirt out of the pads before activating the blower after the cooler has been off for days or weeks.
- Choose a cooler that has a bleed tube or sump pump to drain dirty water from the sump.

Evaporative coolers produce high air flows; the ductwork connected to them should be sized appropriately. The cooler's supply outlet can supply one or more registers through a dedicated duct system. Or, the supply outlet can connect to ducts that join to furnace or air conditioner ducts. Coolers sharing ducts with forced air furnaces require dampers to prevent heated furnace air from blowing into the idle evaporative cooler during the winter, and prevent moist cool air from blowing into the furnace during the summer. Moist cool air can condense and cause rust inside the furnace. These shared systems must be installed with great care. The dampers often stick in an open position even with careful installation.

Up-ducts are ceiling vents that exhaust warm air as the evaporative cooler pushes cooler air in. Up-ducts are preferred by home owners who do not like leaving windows open for security or privacy reasons. Up-ducts also help maintain a positive pressure in the home, preventing wind-driven hot air from entering through open windows. It is essential to have adequate attic ventilation when using up-ducts. Attic vents should have one to 1.5 times the net free area of the up-ducts.

2009 IRC: Evaporative Cooling Equipment: M413.1

Cooling equipment that uses evaporation of water for cooling, shall be installed in accordance with the manufacture's installation instructions. Evaporative coolers shall be installed on a level platform or base not less than 3" [76mm] above the adjoining ground and secured to prevent displacement. Openings in exterior walls shall be flashed in accordance with Section P2902.

M1413.2 Protection of potable water

The potable water system shall be protected from backflow in accordance with the provisions in Section P2902.

Programmable Thermostats

Homeowners can save about $180 a year by properly setting their programmable thermostats and maintaining those settings.[32] Determine if a programmable thermostat is appropriate for your client. Programmable thermostats are excellent energy savers for households where no one is home during the workday. However, for households that have stay-at-home occupants, it might not be appropriate. Whenever one is installed, educate the client on proper use.

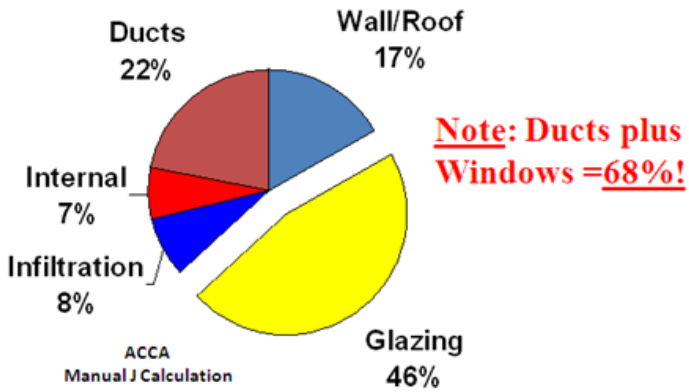
Programmable thermostat.

STANDARDS	
PROGRAMMABLE THERMOSTAT	
Thermostat Location	**Where NOT to Locate Thermostat**
▪ On interior walls and near the center of the conditioned zones. ▪ At a height of 4' to 5' off the floor. ▪ In an area that is utilized frequently by occupants.	▪ On exterior walls ▪ Near supply registers or radiators ▪ Near or above appliances ▪ Where thermostat will be exposed to direct sunlight ▪ In areas of high moisture ▪ In a draft from a cold space ▪ When client is unable to operate a programmable thermostat

Ductwork

Ducts located outside the thermal boundary or in an intermediate zone like a ventilated attic or crawl space should be sealed. The following is a list of duct leak locations in order of their relative importance. Leaks nearer to the air handler see higher pressure and are more important than leaks located further away. [3]

Diagram 6.4 Biggest Contributors to Cooling Loads*



* New Texas home with aluminum windows and double pane *clear* glass. [10]

Duct Sealing Procedures [3, 10]

- First, seal all return leaks within the combustion zone to prevent this leakage from depressurizing the combustion zone and causing backdrafting.
- Plenum joint at air handler: These joints may have been difficult to fasten and seal because of tight access. Go the extra mile to seal them airtight by caulking this important joint even if it requires cutting an access hole in the plenum.
  - Avoid using mastic and fabric mesh at the metal panel so you can open it in the future as during furnace replacement.
  - If the plenum is duct board you should use mastic and fabric mesh tape to seal it.
- Joints at branch takeoffs and start collars: These important joints should be sealed with a thick layer of mastic. Fabric mesh tape is a plus for new installations or when access is easy. Joints in sectioned elbows, known as gores, are usually leaky.
- Tabbed start collars: Attach the start collar to the main duct with three to five screws if the plenum is metal or be sure all of the tabs are bent over and apply mastic plentifully if the plenum is duct board. Seal under the flange of the tabbed start collar to the plenum with mastic so it won't pull off of the plenum.
- Flexduct-to-metal start collar joints: Apply mastic to the metal Stat collar inside of the bead on the collar. Clamp the flexduct's inner liner over this strip of mastic with a plastic strap, using a strap tensioner.

✓ GOOD TO KNOW

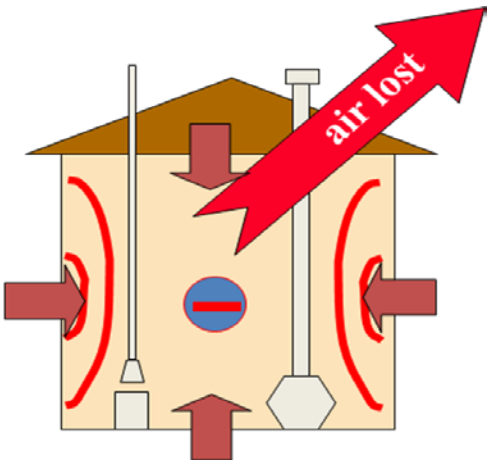
HOT, HUMID CLIMATE

Sealing ductwork is very important. In the hot and humid climate it may be the simplest and most important step in controlling indoor humidity in some homes. Leaky ductwork in an unconditioned attic or crawlspace can draw unhealthy and humid air into the air distribution system. Sealing ducts with mastic is desirable even for ducts located in conditioned spaces. Properly sealed ducts make sure air gets to the spaces intended, rather than leaking into a plenum space. It also minimizes the chances of creating pressure differentials from space to space that would induce airflow through the envelope. The process of sealing each joint reduces the chances of unconnected ductwork, a surprisingly common mistake.[15]

- Clamp the insulation and outer liner with another strap. Remember, it is the inner liner air seal that is the important one, not the outer liner! Many crews concentrate on the outer liner leaving the inner liner to start collar and collar to plenum less well sealed.
- Support ducts and duct joints with duct hangers where needed. Seal all joints, gaps, and cracks between support boards, the PVC pipe with the refrigerant lines and the platform and holes where the refrigerant lines run through the platform. Seal leaky joints between building materials composing cavity-return ducts, like panned floor cavities and furnace return platforms. Seal leaky joints between supply and return registers and the floor, wall, and ceiling to which they are attached.
- Seal penetrations made by wires or pipes traveling through ducts. Even better, move the pipes and wires and patch the holes. [3]
- Most Texas homes have flex duct systems. The primary leakage areas in flex duct systems are:
    - Appliance fan cabinet seams
    - Plenum connections to appliance
    - Take-offs from the plenums
    - Duct connections to boots
    - Boot flanges to ceiling sheetrock
- These are primary because they are close to the fan and under the greatest pressures. Also, examine the bottom of the fan cabinet from within. Oftentimes the bottom may be missing or poorly attached to the cabinet walls. [10]

Diagram 6.5 Duct Sealing Examples

Diagram 6.6 Duct Leakage *to* the Outside [10]



- Supply leaks depressurize the whole house.
- The house then sucks in air equaling the air blown from the house to the outside.
- Trading cool, dry air for hot, humid air.
- Possible back drafting of CO!

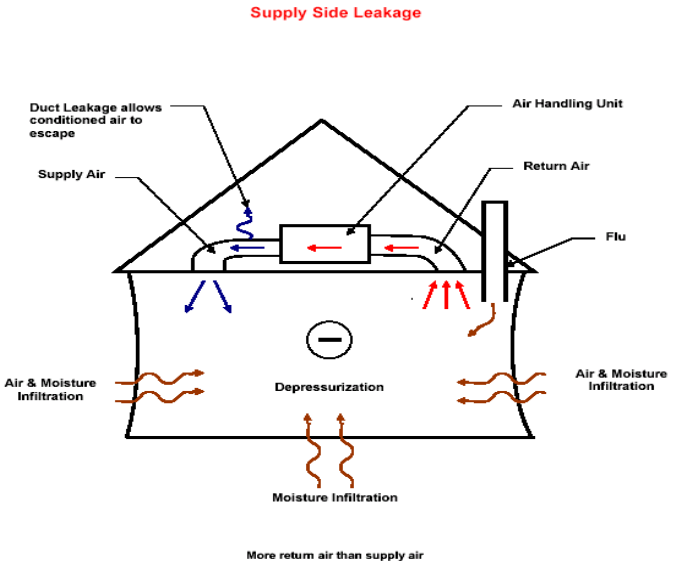
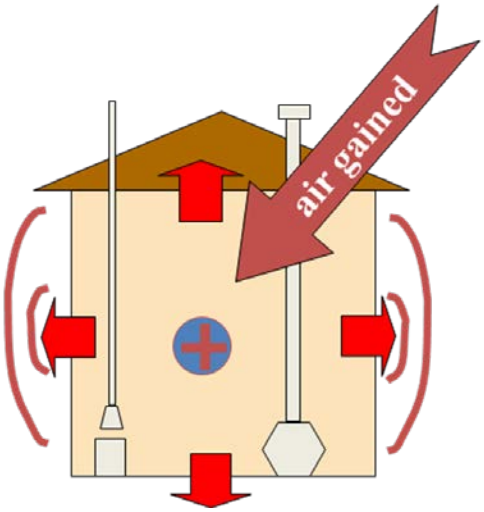
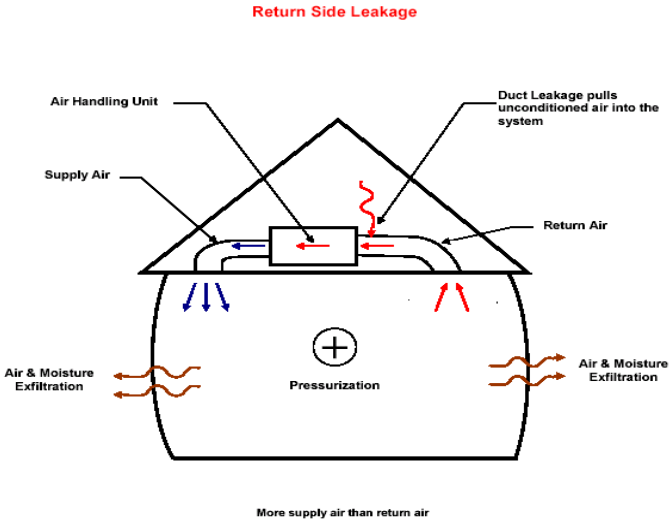


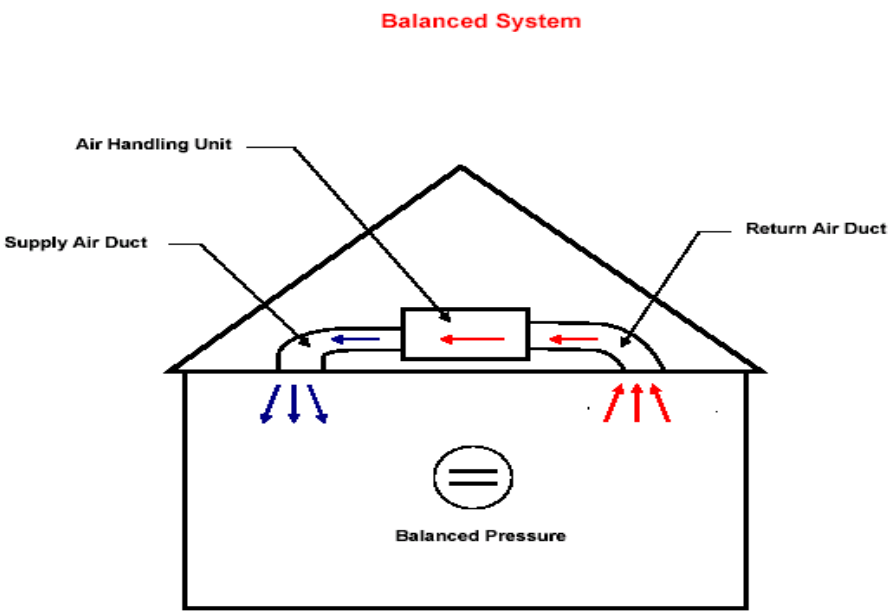
Diagram 6.7 Duct Leakage *from* the Outside [10]



Return Leaks

- Return leaks add air to the house so it becomes pressurized.
- The return leak sucks in air from wherever it is bringing in dirty, moldy, hot and humid air from the attic or crawlspace.
- Can cause back drafting of appliances near it or the furnace unit in the closet.





Duct Air Sealing Materials

Duct mastic is the preferred duct-sealing material because of its superior durability and adhesion. Apply at least 1/16" thick and use rein-forcing mesh for all joints wider than 1 1/8" or joints that may experience some movement. Codes call for UL 181A or B mastic. The A listed product is for use on foil or metal duct materials. The B listed product is for use on flex duct. There are chemicals in the A product that can rot flex duct so be sure to get the right one.

Use mastic! It is superior to all other products. [10]

For health and safety reasons, only use **water based** mastics. Mastics with petroleum based solvents can pose severe health risks including hospitalization of the crew or client.

Siliconized acrylic-latex caulk is acceptable for sealing joints in panned joist spaces, and is used for return ducts. Joints should rely on mechanical fasteners to prevent joint movement or separation. Tape should never be expected to hold a joint together nor expected to resist the force of compacted insulation or joint movement. Aluminum foil or cloth duct tape are not good materials for duct sealing because their adhesive often fails after a short time. [3]

Building Cavities as Return Ducts [3, 10]

Using building cavities as a return duct is a common practice and always a recipe for a big air leak. Relining a return is preferred to sealing the cavity. Relining materials include metal, fiberglass duct board, and foam insulation panels. Pre-insulated foam panels are light-weight, easy to cut into custom shapes, and provide insulation benefits. As with any material, seal all joints with UL181A or B water based mastic and foil tape. The return cavity should be sealed if relining is not possible. Remove the pan covering the cavity and seal any visible gaps or cracks between building components with UL181A or B water based mastic. When replacing the pan be sure to fasten it securely with staples and seal the edges well with mastic and foil tape. Also seal with mastic any joints or cracks within reach through return register. [3]

Often these building cavity return duct systems are difficult to access when attempting to seal them. Consider whether or not it is possible to seal the cavity closer to the blower fans and moving the return grill to that location. Remember to seal off the old return if choosing this option. Studies have shown that return grills location is not particularly critical. However, having enough return grille and proper duct diameter are essential. Place return grilles high for cooling climates and low for heating climates. [10]

Table 6.5 Estimated Supply Duct Flows and Grille Sizing

Duct Size in Inches	Flex Supply CFM	Flex Return CFM	Metal Supply CFM	Metal Return CFM
5	46	32	65	42
6	78	52	105	72
7	115	80	160	115
8	165	110	225	155
9	225	155	310	210
10	300	205	420	260
12	480	325	665	450
14	720	490	1010	680
16	1050	705	1450	960
18	1450	960	1950	1330
20	1475	1275	2600	1750

Table 6.6 Estimated Return Grille Sizing

Capacity	Filter Grille	Non-Filter Grille	Return Duct Size
1.5	3.0 sq ft	2.0 sq ft	16”
2.0	4.0 sq ft	2.66 sq ft	18”
2.5	5.0 sq ft	3.33 sq ft	18”
3.0	6.0 sq ft	4.0 sq ft	20”
3.5	7.0 sq ft	4.66 sq ft	20”
4.0	8.0 sq ft	5.33 sq ft	20”
5.0	10.0 sq ft	6.66 sq ft	2- 18”

Duct Insulation [3]

Insulate supply ducts that run through unconditioned areas outside of the thermal boundary, such as crawl spaces, attics, and attached garages with a minimum of R-8 vinyl- or foil-faced duct insulation. Do not insulate ducts that run through conditioned areas unless they cause overheating in winter or condensation in summer.

Insulation Installation Best Practices

- Always perform necessary duct sealing before insulating ducts
- Insulation should cover all exposed supply ducts, without significant areas of bare duct left uninsulated.
- Insulation should be fastened by mechanical means such as stick pins, twine, or plastic straps. Tape can be effective for covering joints in the insulation to prevent air convection, but tape will usually fail if expected to resist the force of the insulation's compression or weight.
- Insulation must have a vapor barrier that is overlapped and sealed air tight.

Improving Airflow [3]

Inadequate airflow is a common cause of comfort complaints. The airflow capacity of the air handler may be evaluated in relationship to the capacity of the air conditioner. For combustion furnaces, there should be 150 CFM of airflow for each 10,000 Btuh of output. Central air conditioners and heat pumps should deliver 400 CFM of airflow per ton of cooling capacity. In Texas, almost all AC's have only about one half of the return grille face area and the return ducts are likewise undersized.

Table 6.7 Recommended Airflow in CFM

Furnace Output kBtu/hr							
	30	40	50	60	70	80	90
CFM	450	600	750	900	1050	1200	1350
AC or Heat Pump Cooling Capacity (tons)							
	1	1.5	2	2.5	3	4	5
CFM	400	600	800	1000	1200	1600	2000

When the air handler is on, there should be a strong flow of air out of each supply register, providing its balancing damper is open. Low airflow may mean that a branch is blocked or separated, or that return air is not sufficient. When low airflow is a problem, consider the following obvious improvements.

- Clean or change filter. Add more return grille area and more or larger ducts.
- Clean furnace blower.
- Clean air-conditioning or heat pump coil. (If the blower is dirty, the coil is probably also dirty.)
- Increase blower speed.
- Lubricate blower motor, and check tension on drive belt.

- Repair or replace bent, damaged, or restricted registers.

Consider the following improvements in response to customer complaints, conditions observed during a thorough duct inspection and measurements such as the temperature rise across the heat exchanger or high static pressure (higher than recommended by furnace manufacturer).

- Make sure that the fan control is adjusted to the optimum fan on/off temperatures and functioning so that the furnace fan is cycling at the desired temperatures.
- Remove obstructions to registers and ducts such as rugs, furniture, and objects placed in ducts, like children's toys and water pans for humidification.
- Remove kinks from flex duct, shorten longer than necessary flex duct sections and replace collapsed flex duct and fiber duct board.
- Extend supply and return ducts as needed to provide heated air throughout the building, especially into additions to the building.
- Add retrofit crossover ducts.
- Install registers and grilles where missing. Do not install return air grilles in crawl spaces.
- Seal significant supply and return leaks.

Flex Duct Problems [10]

Duct Improvements to Increase Airflow [3]

Consider the following improvements in response to customer complaints and conditions you observe during a thorough duct inspection. Unbalanced airflow through ducts can pressurize or depressurize rooms, leading to increased air leakage through the building shell.

Consider the following duct changes to increase system airflow and reduce the imbalance between supply and return:

- Clean dirty filters and modify system to allow easier filter changing.
- Remove obstructions to registers and ducts such as rugs, furniture, and objects placed inside ducts, like children's toys and water pans for humidification.

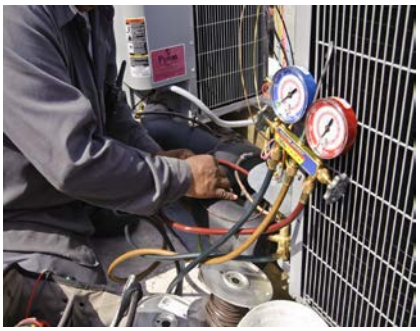
✓ GOOD TO KNOW

HOT, HUMID CLIMATE

When the air handling unit is placed in the garage in a hot and humid climate, many negative consequences can occur. Accelerated rusting in the ferrous heat exchanger and increased evaporator coil sweating are both more likely due to the humid environment and both can shorten the life expectancy of the heating and cooling system. Air leakage can introduce the home to outdoor irritants, automobile exhaust, and toxic fumes from substances stored in the garage. Ductwork creates an unfiltered pathway for hot, moist air, and/or pollen-laden outside air to enter the home.[15]

- Remove kinks from flex duct, and replace collapsed flex duct and fiberglass duct board.
- Inspect the blower for dirt. Clean the blower if necessary.
- If the blower is dirty, an air conditioning coil, if present, is probably also dirty**.**
- Install a transfer grille or jump duct between the bedroom and main body of house to improve airflow.
- Install registers and grilles where missing. Enlarge the return grille face area to the following ratio:
  - **Non-filter grilles** provide one gross square foot of grille face area for each 300 CFM of system airflow assuming 400 CFM/ton.
  - **Filter grilles** provide one gross sq ft of grille face area for each 200 CFM of system airflow assuming 400 CFM/ton.

Measuring and Evaluating System Airflow [3]



Cooling efficiency is more dependent on airflow than heating efficiency. Also, refrigerant charge and airflow are interdependent and are best checked during the cooling season. Most refrigerant charging methods will not be accurate if the airflow across the evaporator coil is off by more than 10%.

The correct airflow for a heat pump or air conditioner is usually expressed in cubic feet per minute per ton of cooling capacity (one ton equals 12,000 Btus per hour). When the heat pump or air conditioner is operating in the cooling mode, the acceptable airflow rate is 400 CFM ±20% according to most manufacturers.

One EPA-sponsored report noted that 70% of over 400 homes tested had less than 350 CFM per ton with an average of 327 CFM per ton. Correcting airflow would save an average of 8% of cooling energy according to the report.

Airflow is often measured both before and after duct sealing because duct sealing may change the measured airflow. Tighter ducts may be more restrictive because duct leaks provide pressure relief through additional inlet and outlet areas, which is lost when they are sealed.

✓ GOOD TO KNOW

TEXAS CLIMATES

- In dry climates, you may increase performance and efficiency by increasing airflow to 480 CFM per ton if noise and comfort allow.
- In wet climates, the recommended airflow per ton may be somewhat less than 400 CFM per ton to facilitate dehumidification by keeping the coil cooler and air moving slower across the coil.
- In humid climates, 320-360 CFM per ton will enhance humidity removal and comfort. [3]

Technicians use a number of different airflow measuring techniques, depending on their equipment, training, and preferences. The type of air handler and ducts is also a factor when choosing an airflow measuring method.

The most accurate and reliable methods for measuring system airflow are the duct blower method and the flow plate method. Measuring return airflow with a flow hood is also an accurate, quick, and reliable method if the flow hood is properly calibrated and used according to manufacturer's instructions. There are also a couple of airflow indicators, which are measurements of static pressure and temperature change across the indoor coil. These measurements won't give an accurate measurement of airflow, but they are used to detect inadequate airflow.

Airflow and Blower Speed [3]

A blower in the air handler can have as many as five speeds. The first step in measuring airflow by any of the methods described here is to make sure that the blower is operating at one of the higher speeds, normally reserved for cooling. (Heating typically uses a lower speed.) Sometimes cooling is assigned a lower blower speed by mistake, so checking which blower speed is paired with cooling is a necessary preparatory step to airflow testing. If the blower speed isn't obvious when looking at the air handler terminal block, clamp an ammeter around the color of wire corresponding to one of the higher speeds to determine which blower speed is energized while cooling. It is not necessary to operate the compressor and condenser fan in order to measure airflow.

Chapter 7: Baseloads

Table of Contents

Water Heaters

Replacing an existing gas water heater that typically uses 250 or more therms per year with a new gas water heater that uses as little as 175 therms per year will save 75 therms, which can repay the initial investment in four to nine years at today's gas costs.

Any replacement gas water heater should meet new ENERGY STAR® ratings, which as of 2010, have an energy ratio (ER) of .67 or higher, and an insulation value of at least R-10.[2] Check the Recovery Efficiency and Energy Factor of the unit to assure these guidelines.

STANDARDS

WATER HEATER

Item	Materials	Criteria/Requirements
Water Heaters	▪ Replace when the unit achieves an SIR of 1 or better in the Audit as an energy saving measure. ▪ Or use other funding source	▪ Replace with high efficiency Energy Star rated units ▪ Replace with same size units, except where recommended by licensed professional ▪ Installation must meet all local codes. - Must have a T&P valve - Discharge pipe should: • be made of rigid metal pipe or approved high temperature plastic pipe • terminate 6" above the floor or outside the dwelling - Insulation must not obstruct draft diverter, pressure relief valve, thermostats, hi-limit switch, plumbing pipes, or element/thermostat access plates - Set temperature to 120°F with clients' approval - If an older automatic dishwasher without its own water-heating booster is present, set to 130°F - Inspect faucets and repair any hot water leaks

ER - Energy Ratio EER - Energy Efficiency Rating COP - Coefficient of Performance

* All natural gas and/or propane fueled heaters must be checked to assure proper orifices have been installed to prevent cross fueling.

NOTE: According to "PART 3280" of the Manufactured Home Construction and Safety Standards, Subpart H - Heating, Cooling and Fuel Burning Systems.

Hot Water Pipe Insulation [3]

STANDARDS

PIPE INSULATION

Item	Materials	Criteria/Requirements
Acceptable Materials	All types	▪ Minimum life expectancy of 10 years ▪ Must be capable of continuous operation at 180° F ▪ Must have a flame spread rating of 150 or less and a smoke density of 50 or less ▪ Conforms to 10 CFR 440 Appendix A ▪ Minimum thickness of 3/4" ▪ Heat tape or strap insulation not allowed ▪ Must fit pipe diameter ▪ Insulate both inlet and outlet water heater pipes under continuous water pressure
Coverage	Allowable materials	▪ Insulate the first 6' of both hot and cold water pipes

Item	Materials	Criteria/Requirements
		▪ Cover elbows, unions and other fittings to same thickness as pipe ▪ Elbows should be 45° mitered to form fit all performed insulation ▪ Keep pipe insulation at least 6" away from flue pipe ▪ Interior diameter of pipe insulation sleeve should match exterior diameter of pipe
Installation	All materials	▪ Insulation must be firmly secured (but not compressed) using tape, plastic ties or metal sleeves
	Tape	▪ Must have flame spread rating of 25 or less ▪ Duct tape is not allowed
	Ties	▪ Must be installed so as not to slip and not to compress insulation ▪ Place 1" from the ends and at all joints; other ties should be spaced closely enough to secure the insulation
	Sleeves	▪ Only metal ▪ Use only where insulation requires protection ▪ Must not compress insulation
	Slits	▪ On vertical pipes, slits may be taped and joints (where two sections of insulation meet) may be taped or strapped ▪ On horizontal pipes, slits must face down and must not be taped (to allow condensation to discharge)

Water Heating Measures [2]

General Specifications for Water Heaters

- Confirm that the water heater has a pressure and temperature (p/t) relief valve and a safety discharge pipe.
- Discharge pipe should terminate 6" above the floor or outside the dwelling as specified by local codes.
- If a water heater is located in an area where a person could be exposed to a released p/t relief valve, a discharge pipe must be installed.
- Adjust water temperature with clients' approval to 115°-120°F.
- If the home has an older automatic dishwasher without its own water-heating booster, set the thermostat to 140°F.
- Shut off power to electric water heaters before opening the access panels.
- Inspect faucets for hot water leaks and repair leaks if needed.
- Follow local code for your area.

NONFEASIBLE CRITERIA

WATER HEATER PIPE INSULATION

Do Not:

- Insulate leaking pipes
- Insulate gas pipes
- Cover:
  - pressure and temperature (p/t) relief valves
  - valve handles
  - control and safety devices
  - p/t drain lines

Water Heater Insulation

STANDARDS

WATER HEATER: Location

Item	Materials	Criteria/Requirements
All water heaters	N/A	▪ Must be in protected area (not exposed to weather) ▪ Must have minimum 3" clearance on sides and back, and 6" from front ▪ Insulate even, if located in conditioned area

ASHRAE STANDARDS
This unit meets or exceeds minimum ASHRAE Standards 90-75 (or 90-80).
Do not install additional insulation on this unit

Water heaters bearing this tag or a similar tag, shall not receive additional insulation. If no tag is present, insulate.

★ STANDARDS

WATER HEATER: Allowable Materials

Item	Materials	Criteria/Requirements
Allowable Materials	Blankets	▪ Conform to 10 CFR 440 Appendix A
	High temperature blankets	▪ Conform to 10 CFR 440 Appendix A
	Fiber blankets	▪ Must be mineral fiber only
	All blankets	▪ Minimum R-10 ▪ Maximum 25 flame spread rating
	Tape	▪ Duct tape not allowed ▪ Maximum 25 flame spread rating ▪ **Tape only is not acceptable,** must also use straps or retainers

STANDARDS

WATER HEATER: Insulation Pre-Installation

Item	Materials	Criteria/Requirements
Items to check prior to installing insulation	All water heaters	▪ Water heater is in working order ▪ If an operable relief valve exists with no drain line, you may install a drain line following local codes ▪ Is water heater protected from the weather? If not, you may build a protective enclosure (this is repair material) ▪ Does an operable pressure relief valve exist? If a pressure relief is plugged or does not exist, you must unplug the valve or install a relief valve before you insulate the water heater (Install by local). *Note: This action is required only if the water heater is addressed. If you are not going to install a pressure relief valve, you must advise the client of the possible dangers of the situation and suggest they have it corrected*
	Gas (or propane/butane)	▪ If no vent pipe exists, or if the vent pipe is incorrectly installed, correct the problem before insulating the water heater ▪ When installing a vent pipe, it must be double walled and vented to the outside atmosphere. *Note: A 3" clearance between the vent pipe and the blanket or tape must be maintained.* ▪ If there is no burner access door, appliance valve, or inadequate combustion air, correct the problem before installing insulation ▪ If there is incomplete combustion, as indicated by smoke or soot on the outside of the heater, correct the problem before installing insulation
	Electric	▪ If hazardous wiring exists, you must correct the problem before insulating the unit

Gas- and Propane-Fired Water Heater Insulation [3]

Keep insulation at least 2" away from the burner or gas valve. The insulation needs to be a cut away at least 3" from burner access door, gas valve, and drain. Do not insulate the tops of gas- or propane-fired water heaters.

Electric Water Heater Insulation [3]

- Generally speaking, if the water heater was manufactured after 2004, it does not need additional insulation. The required insulation for these units was also increased in 2012.
- Set both upper and lower thermostat to keep water at 120°F before insulating water heater.
- Insulation may cover the top of the water heater if the insulation will not obstruct the pressure relief valve.
- Access plates should be marked on the insulation facing to locate heating elements and their thermostats.

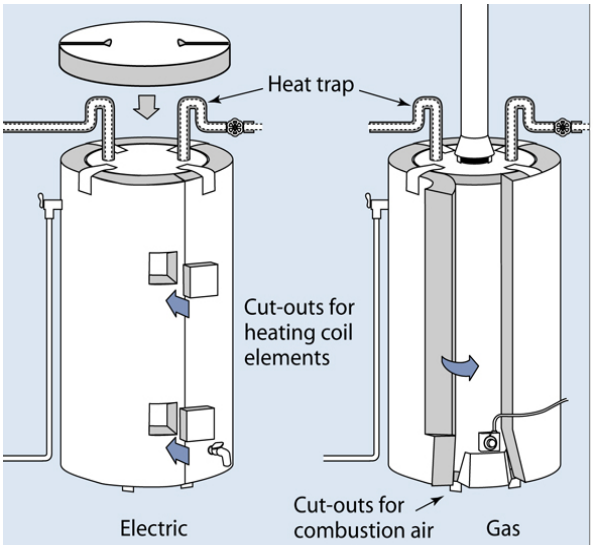
NONFEASIBLE CRITERIA

WATER HEATER INSULATION

Do Not Insulate:

- When water heater label gives specific instructions not to insulate;
- The water heater is already insulated to R-10;
- Water heater is leaking;
- Has less than 3" clearance on sides and back and 6" on front; and/or
- Unprotected units.

Diagram 7.1 Water Heater Tank Insulation



★ STANDARDS

WATER HEATER: Insulation

Item	Materials	Criteria/Requirements
Insulation Installation Requirements	All water heater blankets	▪ Must install 3 retainers (straps, not tape) as follows: - One retainer within 3" of the top; - One retainer in the middle; and - One retainer as close to the bottom as is feasible without covering the panels. ▪ If gas, the top and side seams must be sealed with tape ▪ All retainers must be installed so as to prevent blanket from slipping, but not so tight as to compress the insulation ▪ Safety instructions must not be covered. Before installing the blanket, mark the blanket where the safety instructions will be located. After the blanket is properly installed, cut around the safety instructions and then tape the loose insulation edges to the water heater ▪ Water heaters should be re-insulated to at least R-10 with an external insulation blanket ▪ Do not cover: - Drain valves (retain 1" clearance) - End of drain line from pressure relief valve - Access plates
	Gas water heaters	▪ Do not cover: - Access doors, vents, thermostat and controls - Appliance valve ▪ Blanket must be at least 3" from access doors and vents ▪ Do not insulate top of water heater ▪ **Do not** over tighten the middle strap as it will reduce blanket R-value
	Electric water heaters	▪ Do not: - Cover the upper or lower thermostats - Over-tightening middle strap will reduce the R-value of the blanket.

STANDARDS

WATER HEATER: Ventilation

Item	Materials	Criteria/Requirements
Gas Water Heater Ventilation	Gas water heaters	▪ Gas water heaters located in conditioned spaces opening into a sleeping area must have outside combustion air. Local codes must be followed in meeting this requirement ▪ Units located inside a conditioned space with outside combustion air shall be treated as if located in an unconditioned space. The water heater closet door shall be weatherstripped. If no door is present, install a hollow core door and weatherstrip.
Vent Pipes	Electric and gas water heaters	▪ Pressure relief (pop off) valves must be operable and must be vented to the outside where feasible
	Gas water heaters	▪ Must be vented to outside using double wall pipe ▪ Vents must extend at least 2' above the highest point where they pass through the roof and at least 2' higher than any portion of the building within 10' unless a vent cap is attached to and terminates the vent above the roof ▪ Vents are to be constructed so that no horizontal or negative runs or 90° angles are present ▪ Gas water heaters located in conditioned areas must have a metal collar installed and attached to the ceiling and sealed with silicone

Adjust water temperature between 115°F and 120°F with clients' approval, unless the client has an older automatic dishwasher without its own water heating booster. In this case the maximum setting is 130°F.

STANDARDS

WATER HEATER: Temperature Setting

Item	Materials	Criteria/Requirements
Setting Water Heater Temperature	All units (gas & electric)	▪ **Use manufacturer recommended settings** ▪ Recommend that the client set the thermostat to low or medium ▪ Advise clients of energy savings from setting the thermostat to low or medium ▪ Educate clients on hazards of high temperature setting

Shower Heads and Faucet Aerators [34]

Fix Leaks

You can significantly reduce hot water use by simply repairing leaks in fixtures - faucets and showerheads - or pipes. A leak of one drip per second can cost $1 per month.

Install Low-Flow Fixtures

Federal regulations mandate that new showerhead flow rates can not exceed more than 2.5 gallons per minute (gpm) at a water pressure of 80 pounds per square inch (psi). New faucet flow rates can not exceed 2.5 gpm at 80 psi or 2.2 gpm at 60 psi. Quality, low-flow fixtures are available for around $10 to $20 each and achieve water savings of 25%–60%.[4] Shower heads are now available with rates of 1.5 gpm or lower.

Showerheads

Most families use more hot water in the shower than for any other use. A low flow shower head reduces this consumption. [2]

For maximum water efficiency, select a shower head with a flow rate of less than 2.5 gpm. There are two basic types of low flow showerheads: aerating and laminar flow. Aerating showerheads mix air with water, forming a misty spray. Laminar flow showerheads form individual streams of water. For a humid climate, you might want to use a laminar flow showerhead because it won't create as much steam and moisture as an aerating version.

NONFEASIBLE CRITERIA

SHOWER HEAD

Do Not Install:

- When shower arm is not accessible
- When shower arm and head are one piece
- When shower arm is damaged and shower head cannot be removed
- Client refusal due to higher quality existing shower head

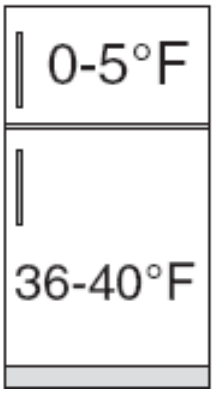
Faucets

Aerators are inexpensive to replace and they can be one of the most cost effective water conservation measures. For maximum water efficiency, purchase aerators that have flow rates of no more than 1.0 gpm. Some aerators even come with shut-off valves that allow you to stop the flow of water without affecting the temperature.

Use caution in removing the existing shower head from old, fragile plumbing systems. Do not attempt to remove the neck that connects the shower head to the fitting inside the wall. Instead, replace just the showerhead itself. [2]

Refrigerators

Over the past decade, many refrigerator manufacturers have improved the energy efficiency of their products by a factor of three or more. Refrigerators manufactured after 1993 present lower peak loads to the grid and have much higher power factors than those manufactured in previous decades. Accordingly, replacing energy wasteful refrigerators with new units can be very cost-effective, even when the older, wasteful units are still functional.



Refrigerator Settings

- Adjust refrigerator and freezer dials to achieve the temperature range shown.
- Turn the Energy Saver switch to the “On” position if not needed, and explain its operation to the occupants.
  - When the Energy Saver switch is in the “On” position, it saves energy by switching off the door heaters that reduce condensation in humid weather. These heaters are not needed in dry climates.

Refrigerator replacement programs save electric energy, lower peak demands, improve power quality, and help the environment. They also serve lower income customers in a most visible and welcome way. [14]

The quickest way to reduce the consumption of many refrigerators and freezers is to adjust the set-points. The refrigerator temperature should be 36-40°F and the freezer should be 0–5°F for optimal energy efficiency. Try the higher end of these temperature ranges to see if these settings are acceptable to the client. If they aren't, instruct the customer to reduce the temperature setting gradually until it is at an acceptable level. [2]

Verify that the new refrigerator will fit in the existing location. Many older homes have undergone multiple renovations over the years that have changed the size of the doors and pathways needed for the removal and installation of refrigerators. Before the replacement refrigerator arrives, measure door openings and pathways to assure the old refrigerator can be removed from the premises and the new refrigerator can be brought into the home.

Disposal of Old Refrigerators

Refrigerators that are replaced should be taken to a facility licensed to reclaim their refrigerant. No refrigerator that is taken out of service should be returned to service by sale, barter, or for free. [2]

Lighting

Most homes have six to 12 lamps that burn for more than two hours per day. These should be considered for retrofit by more efficient compact fluorescent lamps (CFLs). This easy retrofit has as good an economic return as any weatherization measure.

Explain the benefits to the client, and encourage them to purchase additional CFLs if possible. Point out that the long life of these lamps makes them economical, despite their higher initial cost. [2]

Clients are often hesitant to replace their existing incandescent bulbs with CFLs because they envision them as not providing enough light. Today's CFL products come in various shapes, sizes, and colors.

Choosing the Right CFL

The work order will advise the wattage necessary. Choose ENERGY STAR® qualified bulbs. They will last longer.

✓ GOOD TO KNOW

COMPACT FLOURESCENT LAMPS (CFLs)

An ENERGY STAR® qualified light bulb:

- Can save more than $40 in electricity costs over its lifetime;
- Uses about 75% less energy than standard incandescent bulbs and lasts at least six times longer; and
- Produces about 75% less heat, so it's safer to operate and can cut energy costs associated with home cooling. [7]

If every American home replaced just one light bulb with a light bulb that has earned the ENERGY STAR®, we would save enough energy to:

- Light 3 million homes for a year,
- Save about $600 million in annual energy costs, and
- Prevent 9 billion pounds of greenhouse gas emissions per year, equivalent to those from about 800,000 cars.[35]

CFLs may be used to replace most household lamps. However, there are a few special conditions to know:

- **Dimmers** need a special dimmable CFL.
- **Three-way socket** require a special three-way CFL.
- **Electronic control -** be sure to **c**heck with the manufacturer of the photocell, motion sensor, or timer.

★ STANDARDS

FLUORESCENT LAMPS AND FIXTURES

Item	Materials	Criteria/Requirements
Acceptable Materials	Compact fluorescent lamps	▪ Conforms to 10 CFR 440, Appendix A ▪ Install in all fixtures used for 4 or more hours per day. ▪ Choose products that have a reputation for reliability, with the highest lumens per Watt, and with the longest life expectancy.
	Fluorescent lighting fixtures	▪ Conforms to 10 CFR 440, Appendix A

Table 7.1 How to Choose the Right ENERGY STAR® Qualified Bulbs [36]

		Table/Floor Lamp	Pendant Fixtures	Ceiling Fixtures	Ceiling Fans	Wall Sconces	Recessed Cans	Track Lighting	Outdoor Covered	Outdoor Flood
										
Spiral		✓		✓	✓	✓			✓	
Covered A-shaped		✓	✓		✓				✓	
Globe			✓							
Tube		✓		✓		✓			✓	
Candle					✓	✓			✓	
Indoor Reflector					✓		✓	✓		
Outdoor Reflector										✓

Color also plays a role in lighting. Today, many bulbs are categorized by warm or cool color. The color temperature is measured by the Kelvin scale. Cooler colors provide better light for reading and working.

The Color Rendering Index (CRI) compares a light source to that of natural sunlight. This index ranges from 0 to 100, with 100 being that of sunlight. Most compact fluorescent bulbs have a CRI of 65-88.

The best light is from a cool bulb with a high CRI.

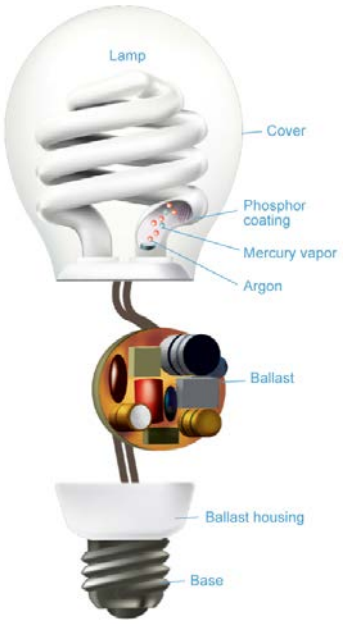
Table 7.2 What Color Would Work Best for Your Use [36]

With CFLs you have options for your white light. Light color is measured on the Kelvin (K) scale. As you see below, lower numbers mean the light appears yellowish and high numbers mean the light is whiter or bluer.

Warm White, Soft White Standard color of incandescent bulbs.		**Cool White, Bright White** Good for kitchens and work spaces		**Natural or Daylight** Good for reading	
2700K	3000K	3500K	4100K	5000K	6500K

Clean Up and Disposal of CFLs [37]

Parts of a CFL



If you break a CFL when working, use proper disposal procedures to reduce exposure to mercury vapor from a broken bulb.

1. Before cleanup
   a. Have people and pets leave the room.
   b. Air out the room for 5-10 minutes by opening a window or door to the outdoor environment.
   c. Shut off the central forced air heating/air conditioning (H&AC) system, if there is one.
   d. Collect materials needed to clean up broken bulb.
2. During cleanup
   a. Be thorough in collecting broken glass and visible powder.
   b. Place cleanup materials in a sealable container.
3. After cleanup
   a. Promptly place all bulb debris and cleanup materials outdoors in a trash container or protected area until materials can be disposed of properly. Avoid leaving any bulb fragments or cleanup materials indoors.
   b. For several hours, continue to air out the room where the bulb was broken, and leave the H&AC system off.

Chapter 8: Health & Safety

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Carbon Monoxide (CO) [2]

Carbon monoxide (CO) is released by combustion appliances, automobiles, and cigarettes as a product of incomplete combustion. CO is the largest cause of injury and death in the United States from gas poisoning, resulting in more than 500 deaths per year. Many more people are injured by high concentrations of the gas, or temporarily sickened by lower concentrations of five to 50 parts per million (ppm).

The symptoms of low level CO exposure are similar to the flu, and may go unnoticed. CO blocks the oxygen carrying capacity of the blood's hemoglobin, which carries vital oxygen to the tissues. At low concentrations (five to 50 ppm), CO reduces nerve reaction time and causes mild drowsiness, nausea, and headaches. Higher concentrations (50 to 3,000 ppm) lead to severe headaches, vomiting, and even death if the high concentration persists. The effects of CO poisoning are usually reversible, except for exposure to very high levels, which can cause brain damage.

Sources of Carbon Monoxide [2, 21]

CO is a common problem in low income housing, affecting 20% or more of residential buildings in some regions. Offending appliances include: poorly performing unvented gas space heaters, kerosene space heaters, back drafting vented space heaters, gas ranges, leaky wood stoves, and automobiles idling in attached garages or near the home.

CO is usually caused by one of the following:

- **Overfiring** is caused when too much heat is generated within the fire chamber, which will lead to warping, buckling, and general damage to the stove and its internal components. High heating efficiencies on closed appliances can only be attained by controlling the supply of air to the fire chamber (operating the air control correctly). It is not recommended to leave the air control fully open, except when helping the chimney/flue heat up initially. A fully open air control will lead to more heat being sent straight up the chimney rather than into the room, which reduces efficiency. The biggest problem with leaving the air control fully open is "overfiring".
- **Backdrafting** occurs when a naturally vented appliance loses the chimney effect, which carries dangerous combustion by-products up the flue. Backdrafting can occur with furnaces, fireplaces, woodstoves, and water heaters when air pressure in the house is lower than outside air pressure. Backdrafting may occur when wind speed is too low to create the Venturi effect at the top of the chimney. Running a furnace, clothes dryer, bathroom exhaust fans, or a kitchen exhaust fan can cause negative indoor air pressure that leads to backdrafting, as they move air out of the house, which must be replaced from the outside. If the doors and windows are all closed and very tight, the replacement air may come down a chimney and can cause backdrafting of combustion appliances.

- **Flame interference** occurs when moving air or an object blocks combustion, such as a pan over a gas burner on a range top.
- **Inadequate combustion air** occurs whenever there is a lack of fresh air supply that provides the oxygen for the combustion process.
- **Misalignment of the burner**

Look for an even blue flame. [22]

Spotting Carbon Monoxide [38]

Combustion equipment

Examination of combustion appliances prior to the installation of blower door driven weatherization is essential. Reducing the amount of natural air change in a home by sealing sources of infiltration and exfiltration can jeopardize the health of the occupants, especially if the home contains a combustion appliance which is not operating safely. Consider, for example, a malfunctioning appliance which is introducing an unsafe level of CO into the conditioned space. This type of hazard must be identified and corrected prior to reducing the amount of natural ventilation in the home by the installation of infiltration reduction measures. Infiltration reduction measures encompass all duct and shell sealing activities, including window and door replacements, cooler and air conditioner covers, and caulking and weatherstripping.

Because it is vital to protect indoor air quality, safety inspections must be performed on all combustion appliances present within the home and in adjacent locations. The goal is to identify and eliminate any hazardous conditions. The combustion appliance safety inspections are geared to detect such hazards as:

- A cracked heat exchanger or other combustion chamber defect
- Backdrafting and spillage of combustion products
- Excessive CO
- Gas leaks
- Improper, disconnected, or otherwise faulty flue and vent systems
- Inadequate combustion air
- Inadequate draft
- Rollout and other burner-related abnormalities

Problems associated with combustion appliances must be corrected before infiltration reduction measures may be installed. With supervisor approval, the weatherization crew may be able to make routine minor repairs. However, more serious defects and most operational adjustments require a qualified technician or licensed contractor to perform the modifications necessary to make the system both safe and efficient.

The important first step in the weatherization sequence is to check the appliances for evidence of safety hazards.

★ STANDARDS

CARBON MONOXIDE

Item	CO Action Level	Criteria/Requirements
Ambient Air	35 parts per million ***If greater than 35ppm CO is detected, weatherization measures shall not be installed until the CO problem has been corrected***	▪ Test at initial assessment ▪ Test at final inspection ▪ If above maximum level, test all combustion appliances to determine cause ▪ If cause cannot be determined, calibrate equipment and re-test ▪ If still indeterminable, refer to local gas company
Cook Stove Top Burners Cook Stove Ovens	25ppm/burner or greater 150ppm or greater	▪ Test all vented combustion appliances at initial assessment and final inspection ▪ If above maximum levels of CO: - must abate by clean and tune - If leverage funds cannot be utilized, WALK AWAY**
Fuel-Fired Furnace Fuel-Fired Water Heater	100ppm or greater 100ppm or greater	▪ Test all vented combustion appliances at initial assessment and final inspection ▪ If above maximum levels of CO, must abate by: - clean and tune - replacement ▪ Contact trained personnel or licensed HVAC contractor - If abatement cannot be accomplished due to fund limitations, refer/leverage/or WALK AWAY**
Unvented Space Heaters	25ppm or greater	▪ Primary unvented space heaters must be removed and replaced with a vented fuel furnace. ▪ Secondary unvented space heaters must have operating oxygen depletion sensor system and meet the following guidelines: - Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bathroom: • Has an input rating that does not exceed 6,000 Btu/hour; • Is equipped with an oxygen-depletion sensing safety shut-off system; and • The bathroom meets required volume criteria to provide adequate combustion air. ▪ Where approved by the authority having jurisdiction, one listed wall-mounted space heater in a bedroom: - Has an input rating that does not exceed 10,000 Btu/hour; - Is equipped with an oxygen depletion sensing safety shut-off system; and - The bedroom meets required volume criteria to provide adequate combustion air. ▪ Shall require the enforcement of minimum ventilation guidelines as determined by the greater of: - 15 cubic feet per minute (CFM) per person, - 15 CFM per bedroom plus one [(# of bedrooms + 1) x 15 CFM], or - .35 air changes per hour. ▪ The above minimum ventilation guidelines are natural ventilation rates, not with the house depressurized to -50 Pascal with a blower door.
Flue	100ppm or greater	▪ Test all vented combustion appliances at initial assessment and final inspection

* When the CO measurement on any appliance exceeds the prescribed safe level, weatherization measures shall not be installed until the appliance has been serviced by a qualified technician and declared safe. Weatherization may proceed if CO does not exceed the prescribed level.

** It is not the intent of this policy to walk away from a unit just because a high level of carbon monoxide exists. Every effort should be made to abate the existing problem. Should funds be limited, subgrantees should refer the client to another entity that can help, or attempt to find leverage funds to cover cost. All abatement procedures should be performed by trained personnel or licensed HVAC contractors. Clients should always be informed of the existence of high levels of CO and advised to take precautions until abatement can be performed. In case of a WALK AWAY, a client MUST BE INFORMED IN WRITING.

Note: Carbon Monoxide testing is to be performed with a combustion analyzer or a Department approved sensing device. CO detectors are not suitable testing devices and are not to be used. Sensing device must have a range from 0-2,000 ppm; accuracy ± 5% of readout; readout resolution = 1 ppm adjustable to 0; pump draw up to 3/4" of water; and an attachable probe for flue test to be considered for approval.

STANDARDS

CARBON MONOXIDE DETECTORS

Item	Materials	Criteria/Requirements
Carbon Monoxide Detector	**CO Detectors**	Per R315.2 and R315.3 (IRC) ▪ Existing dwellings that have attached garages or dwellings, within which fuel-fired appliances exist, CO alarms shall be provided. - Detectors should always be installed when un-vented space heaters are in use ▪ Detectors must meet Standard UL 2034 and shall be installed in accordance with the above and the manufacturer's installation instructions.
Where to install		▪ A CO alarm should also be installed when combustion appliances are in use. ▪ CO alarms should be installed in all homes with unvented space heaters and in all homes where backdrafting could occur in a furnace, space heater, wood stove, fireplace, or water heater. ▪ Always install CO alarms according to the manufacturer's instructions.

Carbon Monoxide Alarm Placement [2]

A carbon monoxide alarm should be installed near any combustion appliance. Customers should be educated about the purpose and features of the alarms and what to do if an alarm sounds an alert.

CO Alarm Installation Specifications

- CO alarms should be installed in all homes with unvented space heaters and in all homes where backdrafting could occur in a furnace, space heater, wood stove, fireplace, or water heater.
- Always install CO alarms according to the manufacturer's instructions.

NONFEASIBLE CRITERIA

CO Detectors

Do Not Install:

- In a room that may get too hot or cold for alarm to function properly;
- Within 5' of a combustion appliance, vent, or chimney;
- Within 5' of a storage area for vapor-producing chemicals;
- Within 12" of exterior doors and windows;
- Within a furnace closet or room;
- With an electrical connection to a switched circuit; and/or
- With a connection to a ground-fault interrupter circuit (GFCI).

Smoke Alarms

A properly installed and maintained smoke alarm is the only thing in a home that can alert occupants to a fire 24 hours a day, seven days a week. Whether awake or asleep, a working smoke alarm is constantly on alert, scanning the air for fire and smoke.

According to the National Fire Protection Association (NFPA), almost two-thirds of home fire deaths resulted from fires in properties without working smoke alarms. A working smoke alarm significantly increases chances of surviving a deadly home fire. [42]

Smoke Alarm Placement [2]

All homes should have at least one smoke alarm on each level, including one near the combustion zone and at least one near the bedrooms. Customers should be educated about the purpose and features of the alarms and what to do if an alarm sounds an alert.

NONFEASIBLE CRITERIA

Smoke Alarms

Do Not Install:

- In a home that already has a functioning smoke alarm;
- Within 12" of exterior doors and windows;
- With an electrical connection to a switched circuit; and/or
- With a connection to a ground-fault interrupter circuit (GFCI).

STANDARDS

SMOKE ALARM

Item	Materials	Criteria/Requirements
Smoke Alarm	Smoke Alarm	Per R314.1 (IRC): ▪ All smoke alarms shall be listed in accordance with UL 217 and installed in accordance with the provisions of this code and the household fire warning equipment provisions of NFPA 72. Per R314.4 (IRC) Power Source: ▪ EXCEPTIONS: Smoke alarms shall be **permitted to be battery operated** when installed in buildings without commercial power.
Where to Install	Smoke Alarm	▪ Ceiling-mounted smoke alarms must be mounted at least 6" from any wall. ▪ Wall-mounted smoke alarms must be installed at least 6" but less than 18" from the ceilings. ▪ All homes should have at least one smoke alarm on each level, including one near the combustion zone and at least one near the bedrooms. ▪ They should always be installed according to applicable local codes or ordinances.

Excess Moisture [2]

Moisture causes billions of dollars worth of property damage and high energy bills each year in American homes. Water damages building materials by dissolving glues and mortar, corroding metal, and nurturing pests like mildew, mold, and dust mites. These pests, in turn, cause many cases of respiratory distress.

Water reduces the thermal resistance of insulation and other building materials. High humidity also increases air conditioning costs because the air conditioner must remove the moisture from the air to improve comfort.

The most common sources of moisture are leaky roofs and damp foundations. Other critical moisture ranges or decorative fireplaces. Climate is also a major contributor to moisture problems. The more rain,

extreme temperatures, and humid weather a region has, the more its homes are vulnerable to moisture problems.

For solving moisture problems, find the source and fix it. Next, install air and vapor barriers to prevent water vapor from migrating through building cavities. Relatively airtight homes may need technical ventilation to remove accumulating water vapor.

STANDARDS

EXCESS MOISTURE

Item	Materials	Criteria/Requirements
Walls (interior)	Moisture creating substances	▪ Check unit for tightness. "Loosen" unit to upper range of DAE ▪ Check unit for "cold walls". Bypass air in wall cavity will cause moisture buildup. Remedy by insulating cold wall
Crawl Space	Standing water	▪ Check for standing water under unit or outside sweating wall ▪ Check for leaking plumbing or poor drainage ▪ Repair plumbing/Refer (always take care of the moisture source before making repairs) ▪ Provide ventilation ▪ Dam up skirting to prevent water running under unit
Attic	Wet insulation (wet framing, spots on ceiling, etc.)	▪ Check roof for leaks ▪ Provide adequate venting

Solutions to Moisture Problems

Water moves easily as a liquid or vapor from the ground through porous building materials like concrete and wood. A high groundwater table can channel moisture into a home faster than anything short of a big roof leak. The most common moisture source is water vapor rising through the soil or liquid water moving up through the soil by capillary action. To prevent this, all crawl spaces should have ground moisture barriers.

A ground moisture barrier is simply a piece of heavy plastic sheeting laid on the ground. Black or clear heavy plastic film works well, but tough cross linked polyethylene is more durable. The edges should be sealed to the foundation walls with urethane adhesive and/or mechanical fasteners. The seams should be sealed as well. Plastic vapor barriers should not come in contact with wood members, to avoid moisture accumulation and wood decay.

Avoid excessive watering around the home's perimeter. Watering lawns and plants close to the house can dampen its foundation. In wet climates, keep shrubbery away from the foundation, to allow wind circulation near the foundation.

Preventing moisture problems is the best way to guarantee a building's durability and its occupant's respiratory health. Besides the all important source reduction strategies listed above, consider the following additional moisture solutions.

- Install or improve air barriers and vapor barriers to prevent air leakage and vapor diffusion from transporting moisture into building cavities.
- Add insulation to the walls, floor, and ceiling of a home to keep the indoor surfaces warmer and less prone to condensation. During cold weather, well insulated homes can tolerate higher humidity without condensation than can damage poorly insulated homes.
- Ventilate the home with drier outdoor air to dilute the more humid indoor air. However, passive ventilation is only effective when the outdoor air is drier than the inside air.

Electrical Safety [22]

Electrical safety is a basic housing need affecting home weatherization and repair. All electrical work must be performed by qualified personnel. Clues of electrical issues may include:

- Tripped circuit breakers or blown fuses;
- Warm tools, wires or cords;
- Wire connections not in junction boxes;
- Ground fault circuit interrupter (GFCI) that shuts off a circuit; and/or
- Worn or frayed insulation around wire or connection.

★ STANDARDS

ELECTRICAL

Item	Materials	Criteria/Requirements
Electrical Wiring		▪ Visually inspect fuse box/breaker panel, junction boxes, switches, outlets, fixtures, and appliances.
Electrical Systems		▪ All home electrical systems should be grounded, either to a grounding rod or to a water pipe that has an uninterrupted electrical connection to the ground.
Breakers		▪ #14 copper or #12 aluminum wiring should be protected by a fuse or breaker rated for no more than 15 amps. ▪ #12 copper or #10 aluminum should be protected by a fuse or breaker rated at no more than 20 amps.
Wiring splices		▪ Wiring splices should be enclosed in metal or plastic electrical boxes, fitted with cover plates.
Fuses	S-type	▪ S-type fuses should be installed where appropriate to prevent occupants from installing oversized fuses.
Plates	All types	▪ Cracked or missing plates must be replaced ▪ Holes or gaps around electrical boxes must be sealed ▪ It is best to seal electrical penetrations at the top or bottom plates of the house; if that is not possible, then fire resistant, cut to fit gaskets may be installed. ▪ Oversized plates with a gasket may be used if necessary to achieve seal.

Worker Electrical Safety [22]

Electrical burn. [22]

On average, one worker is electrocuted every day. Be aware of your surroundings, use safe work practices, and maintain safe equipment. Serious injuries may occur when touching electrical wiring or equipment that is improperly used or not maintained. Electric shock can also cause secondary injuries, such as falling from elevated locations when experiencing a shock. Inadequate wiring can cause a hazard when a conductor is too small to safely carry the current of the tool.

Safe Work Practices

Buy quality GFCI's. [22]

- Keep work areas clear
- Replace tools or extension cords that have frayed wiring or a missing grounding prong
  - Do not strain electrical cords or plugs, which may cause fraying or damage.
  - Always remove a plug from the outlet - do not pull it from a distance
- Use a GFCI for all tools
- Assure safety guards are on and working properly on equipment
- Use the right personal protection equipment (PPE) and clothing when operating machinery. Loose clothing may get caught and cause serious injuries.
- Use bulb protection for work lights
- Use good judgment when working near power lines.
- When performing electrical work use "Lockout/Tagout" procedures for that circuit
- Designate a competent person to conduct periodic inspections of tools and equipment
- Know ladder and scaffold set up and safety
- Use fall protection when working 6' or more above ground:
  - Guardrails
  - Lanyards
  - Personal fall arrest system (PFAS)
  - Safety net

Lead

Lead Paint [22, 39]

Technicians may either assume the presence of lead paint or test to detect lead paint. Lead paint was commonly used in homes built before it was outlawed in 1978. Weatherization activities that could disturb lead paint and create lead dust include the following:

- Glazing, weatherstripping, or replacing windows
- Weatherstripping, repairing, or replacing doors
- Drilling holes in the interior of the home for installing insulation
- Removing trim or cutting through walls or ceilings to seal air leaks, install ducts, replace windows, etc.
- Removing siding for installing insulation.

[22]

U.S. Environmental Protection Agency (EPA) Renovate, Repair, Painting Program Rule (RRP rule):

> "EPA regulations now mandate that any contractor or maintenance staff, from plumbers to electricians to painters, who disturbs more than 6 sq ft of lead paint, replaces windows or does any demolition while working in a pre-1978 home, school or day-care center, must now be Lead-Safe Certified and trained in lead-safe work practices. If not, you could face tens of thousands of dollars in fines. These regulations are now the standard of care for the industry and complying with them will reduce your chance of being involved in potentially expensive lawsuits."

Lead-safe weatherization, as specified by the RRP, is required when workers will disturb painted surfaces by cutting, scraping, drilling, or perform other dust-creating activities. There are only two exceptions to performing the RRP procedures:

1. The home is tested and found to contain no lead-based paint in the disturbed areas.
2. The weatherization job involves no disturbance of paint.

Sources of Lead

Lead has many properties which have made it useful to man throughout time, including but not limited to:

- Ammunition
- Batteries
- Cable Coverings
- Caulking
- Ceramics
- Folk Remedies
- Food/Beverage Containers
- Gasoline Additives
- Paint
- Pesticides
- Pewter
- Plumbing
- Solder

Other uses include pottery used for food, house wares (plastics, wiring, etc.), home remedies food, imported candy, water, toys, soil, jewelry, decorative goods, and hobbies.

Lead Hazards

Normal wear and tear on a home can produce lead dust, which is the most common source of lead poisoning. Deteriorating paint may produce dust and flakes. In weatherization activities lead-based house paint is a major safety concern. Disturbing intact lead-based paint during remodeling, renovation, and maintenance can create a lead hazard. Always use lead safe work practices when lead is suspect or a home has tested positive.

Health Effects [22, 39]

Lead can be very toxic. Unlike some other metals which serve some purpose in the body, lead has no beneficial use. While the body can tolerate a certain amount of lead, just about every major body organ can be damaged if too much lead enters the body. Lead enters the body through inhalation of lead dust or ingestion of dust, soil or paint chips. It is especially hazardous to children. Children exposed to lead may have loss of intelligence, behavioral difficulties, and problems in school. Lead poisoning symptoms often imitate other common problems, such as headache, poor appetite, dizziness, insomnia, reproductive difficulties, hyperactivity, numbness, weakness, or nausea.

- **Acute:** Short term, high-level exposure affects the central nervous system and the gastrointestinal system.
- **Chronic:** Long term, low-level exposures affect bone marrow, blood, peripheral nervous systems, kidneys, and the reproductive system.

Lead Protection [22, 40]

Protecting the Customer

When engaging in activities that generate lead dust, take the following precautions.

- Confine your work area within the home to the smallest possible floor area. Seal this area off carefully with floor-to-ceiling barriers made of disposable plastic sheeting, sealed at floor and ceiling with tape. Cover furniture and flooring in the work area with disposable plastic sheeting.
- Post signs warning people not to enter the work area.
- Spray water on the painted surfaces to keep dust out of the air during drilling, cutting, or scraping painted surfaces.

- Use a dust-containment system with a high-efficiency particulate air (HEPA) vacuum when drilling holes indoors.
- Clean up as you work. Vacuum affected areas with a HEPA vacuum and wet mop these surfaces daily. Don't use the customer's cleaning tools or leave the customer with lead dust to clean up.
- Cleaning must be verified by a Certified Lead Renovator (CLR) using a white disposable wipe compared to a card provided by the EPA.

Eye protection

Protecting Yourself

- Wear a tight fitting respirator to protect yourself from breathing dust or other pollutants.
- Avoid taking lead dust home on clothing, shoes, or tools. Wear coveralls, gloves, and boot covers while in the work area, and remove them to avoid tracking dirt from the work area to other parts of the house.
- Wash face and hands frequently and wash thoroughly before eating, drinking, smoking, and leaving for the day.

Hand protection

Personal Protective Equipment (PPE)

- Disposable coveralls
- Disposable non-latex gloves
- Disposable foot covers
- Eye protection
- Hearing protection
- Leather or canvas work gloves
- N-100 respirators
- Disposable waste bags
- Duct tape
- Hand washing facilities and hand soap

Foot protection [22]

Ear protection- canal caps

Asbestos [22, 38]

Asbestos is classified as a known carcinogen. Workers who encounter asbestos in the workplace must be trained to recognize and avoid it.

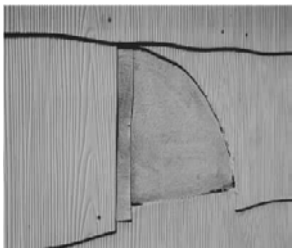
Asbestos fibers do not evaporate into air or dissolve in water. They have no odor or smell and do not migrate through soil. Asbestos absorbs sound and resists heat, electricity and chemical damage. These

properties made asbestos a popular building product in the late 1800's. At least 5,000 different products have been manufactured from asbestos.

Sources of Asbestos

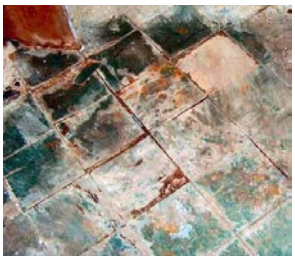
- Thermal and acoustic insulation-heat barrier around stove and smoke pipes, behind the walls of heaters and light fixtures, and around steam and hot water pipes. Used in fire doors and welding curtains.
- Asbestos-concrete
- Electrical
- Fireproofing - fire dampers in fire partitions, insulated ductwork where it passes through combustible materials.
- Gasket, packaging, and filler
- Paper products
- Plastic Products - vinyl floor tiles
- Roofing materials
- Siding - trade name "Transite"
- Textiles

Asbestos pegboard and pipe wrap



Transite (asbestos) siding

Transite roofing tiles



Asbestos 9" x 9" floor tiles [22]

Health Effects

Asbestos becomes harmful when it is disturbed, becomes airborne, and is inhaled. Various weatherization activities can cause asbestos to become airborne, such as sawing, drilling, nailing, cutting, bumping, tearing, and sweeping. Friable means that the product can be crushed by hand pressure into tiny sharp fibers too small to be seen, or into a powder making it harmful. Dose related exposure (the more you breathe) may cause:

- Asbestosis- scarring of the lungs
- Lung Cancer
- Other Cancers, such as cancer of the digestive system

Non-dose related (a onetime encounter) may cause cancer of the lung or stomach lining, known as Mesothelioma. The period of time between a person's exposure to asbestos fibers and the development of mesothelioma is referred to as its latency period. For asbestos, this is between 10 and 40 years. [22]

STANDARDS

ASBESTOS

Item	Materials	Criteria/Requirements
Asbestos - In Siding, Walls, Ceilings, Floor tile Adhesive	Transite siding, acoustical ceiling tiles	▪ Inspect exterior wall surface and subsurface for asbestos siding prior to drilling or cutting. ▪ All precautions must be taken not to damage siding. Asbestos siding should never be cut or drilled. It is recommended, where possible, to insulate through the home's interior to completely avoid disturbing or removing the asbestos siding on the exterior of the home.
Asbestos - On Pipes, Furnaces, Other Small Covered Surfaces	Combustion pipes, furnaces, ductwork	▪ Assume asbestos is present in covering materials. Encapsulation is allowed by **an AHERA asbestos control professional** and should be conducted prior to blower door testing. Removal may be allowed **by an AHERA asbestos control professional** on a case by case basis.
Asbestos - In Vermiculite	Vermiculite Insulation	▪ When vermiculite is present, unless testing determines otherwise, take precautionary measures as if it contains asbestos, such as not using blower door tests and using personal air monitoring while in attics. Encapsulation by an appropriately trained asbestos control professional is allowed. Removal is not allowed.
Whenever Asbestos is Suspected		▪ If the asbestos containing material is in good condition-- DO NOT disturb it. ▪ If the asbestos containing material (ACM) is damaged, i.e., raveling, frayed, breaking apart, immediately isolate the area(s). For, example, separate the work area in question for occupied portions of the building using appropriate containment practices and do not disturb. ▪ For suspected ACM that is damaged or that must be disturbed as part of the retrofit activity, contact an asbestos professional for abatement or repair. Only a licensed or trained professional may abate, repair or remove ACM. The extent of containment may warrant a deferral. ▪ Notify the client of the ACM, document, and use deferral standards. ▪ Do not dust, sweep, or vacuum debris that may contain asbestos. ▪ Never saw, sand, scrape, or drill holes in asbestos materials or use abrasive pads or brushes. ▪ Do not track material that could contain asbestos through the house. ▪ Follow EPA and OSHA regulations regarding the safe handling of asbestos to ensure worker and client safety.

NOTE: Check with agency as to allowable abatement activities.

Radon

Radon is a naturally occurring radioactive gas produced by the breakdown of uranium in soil, rock, and water. Because the air pressure inside a home is usually lower than pressure in the soil around a home's foundation, a home acts like a vacuum, drawing radon in through foundation cracks and other openings.

Radon also may be present in well water and can be released into the air in a home when water is used for showering and other household uses. In most cases, radon entering the home through water is a small risk compared with radon entering a home from the soil. Although building materials rarely cause radon problems by themselves, in a small number of homes, the building materials, such as granite and certain concrete products, can give off radon. In the United States, radon gas in soils is the principal source of elevated radon levels in homes. [41]

The EPA believes that any home with a radon concentration above 4 picocuries per liter (pCi/l) of air should be modified to reduce the concentration.

Since radon comes through the soil, mitigation strategies include:

- Installing a plastic ground barrier and carefully sealing the seams
- Sealing the walls and floor of a basement
- Ventilating the crawl space or basement to dilute radon
- Depressurizing the ground underneath the concrete slab. [23]

Diagram 8.1 Radon Map of Texas

What the Colors Mean

Red - Zone 1 - Highest Potential
Counties have a predicted average indoor radon screening level greater than 4pCi/L (picocuries per liter). A curie is a unit quantity of any radioactive nuclide in which 3.7×10^{10} disintegrations occur per second.

- A pico equals one trillionth (10^{-12}) part of; very small. Thus a picocurie is one trillionth of a curie.
- A picogram is one trillionth of a gram.

Orange - Zone 2 - Moderate Potential
Counties have a predicted average indoor radon screening level between 2 and 4 pCi/L.

Yellow - Zone 3 - Low Potential
Counties have a predicted average indoor radon screening level less than 2 pCi/L.

All of Texas falls in the Orange-Zone 2 and Yellow-Zone 3 categories.

As the map above indicates, high concentrations of radon are not prevalent in Texas. Radon shall be addressed on a case-by-case basis. [23]

Volatile Organic Compounds (VOCs)

Volatile organic compounds (VOCs) are emitted as gases from certain solids or liquids. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Concentrations of many VOCs are consistently higher indoors (up to 10 times higher) than outdoors. VOCs are emitted by a wide array of products numbering in the thousands. Examples include paints and lacquers; paint strippers; cleaning supplies; pesticides; building materials and furnishings; office equipment such as

copiers and printers, correction fluids and carbonless copy paper; and graphics and craft materials, including glues and adhesives, permanent markers, and photographic solutions. [22]

Guidance WPN 11-6

Removal of pollutants is allowed if they pose a risk to workers. It is recommended to ask the client to remove or properly discard these products. If the pollutant poses a risk and removal cannot be performed or is not allowed by the client, the unit must be deferred. Removal of pollutants, not necessary to perform weatherization, is not allowed; i.e., cleaning out of old paint cans or oil out of garages.

Sources of VOCs

VOCs may be found in household products, such as paints, paint strippers, and other solvents; wood preservatives; aerosol sprays; cleansers and disinfectants; moth repellents and air fresheners; stored fuels and automotive products; hobby supplies; dry-cleaned clothing. [22, 38]

Storage of VOCs in the HVAC closet allows VOC vapors to potentially infiltrate the home via supply ducts. It also robs precious combustion air.

Health Effects

The ability of organic chemicals to cause health effects varies greatly from those that are highly toxic, to those with no known health effect. As with other pollutants, the extent and nature of the health effect will depend on many factors, including level of exposure and length of time exposed. Eye and respiratory tract irritation, headaches, dizziness, visual disorders, and memory impairment are among the immediate symptoms that some people have experienced soon after exposure to some organics. At present, not much is known about what health effects occur from the levels of organics usually found in homes. Many organic compounds are known to cause cancer in animals; some are suspected of causing, or are known to cause, cancer in humans. [23]

Steps to Reduce VOCs

Increase ventilation when using products that emit VOCs. Meet or exceed any label precautions. Do not store opened containers of unused paints and similar materials within the home. Formaldehyde, one of the best known VOCs, is one of the few indoor air pollutants that can be readily measured. Identify, and if possible, remove the source. If not possible to remove, reduce exposure by using a sealant on all exposed surfaces of paneling and other furnishings. Use integrated pest management techniques to reduce the need for pesticides. [38]

Appendix A: Glossary of Acronyms and Terms

AC – air conditioner

ACCA - Air Conditioning Contractors of America

ACH - air changes per hour

ACI – Air Conditioning & Refrigeration Institute

ACM – asbestos containing material

ACS - alternative compliance supplement

AEHS – an environmental, health, and safety consulting firm

AHERA - Asbestos Hazard Emergency Response Act

Air barrier - building materials that block random air movement through building cavities, such as drywall. It is impermeable to airflow.

AL - air leakage

AFUE - annual fuel utilization efficiency - a measure of how efficient an appliance is in the energy in its fuel over the course of a typical year. It accounts for chimney, jacket and cycling losses.

ANSI – American National Standards Institute

ASHAE - American Society of Heating and Air-Conditioning Engineers

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASHVE - American Society of Heating and Ventilating Engineers

ASRE - American Society of Refrigerating Engineers

Backdrafting - continuous spillage from a combustion appliance that occurs when exhaust air is drawn back into the home along with dangerous combustion gases.

Backer Rod - a polyethylene foam rope used to fill in larger cracks before caulking.

Baffle - a flow-directing panel, such as an attic baffle used to prevent insulation from covering the soffit vent, or a flue baffle used to redirect the flow of flue gases.

Blocking - materials used to prohibit building components from resulting in safety issues, such as a sheet metal barrier to prevent insulation from touching a heat source, or plywood or batt insulation used to prevent blown insulation for coming in contact with knob and tube wiring.

Blower - the fan part of an HVAC system that looks like a squirrel cage, used to move air.

Blower Door - a device used to measure air infiltration or exfiltration in a building depending upon if it is used to depressurize or pressurize a building in reference with the outside.

Boot - a transition device used to connect a section of duct to the register

British Thermal Unit (BTU) - the amount of energy needed to heat one pound of water one degree Fahrenheit.

Btu/h - British thermal units per hour.

Building cavities - spaces between the interior and exterior sheeting of ceilings, walls and floors.

Burner - a mechanical device that burns a gas or liquid fuel into a flame in a controlled manner.

Bypass - a conduit for air travel within a building cavity.

CABO – Council of American Building Officials

Caulk - a flexible compound used for sealing cracks and joints.

Capillary Action - the ability of water to move against gravity through small tubes or spaces within building materials.

Carbon Dioxide - a naturally occurring chemical compound that results from complete combustion.

Carbon Monoxide - a colorless, odorless, and tasteless gas that is slightly lighter than air. It is a poisonous by-product of incomplete combustion.

Cellulose - a plant fiber used for insulation material. It is treated with a fire-retardant and typically made from old newspaper or wood waste.

CFL - compact fluorescent lamp

CFM - cubic feet per minute

CFR - Code of Federal Regulations

CFS - cubic feet per second

Chimney Effect - see *Stack Effect*.

Circuit Breaker - an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit.

CLR - Certified Lead Renovator

CO - carbon monoxide

COP - coefficient of performance (see description below)

Coefficient of Performance (COP) - a heat pump or air conditioners efficiency at adding or removing heat.

Color Rendering Index (CRI) - a quantitative measure of a light source's ability in comparison with natural sunlight, ranging from 0 to 100.

Color Temperature - the measurement in degrees Kelvin of the warmness or coolness of a light source.

Combustible - a substance that can be burned to provide heat or power or a substance that can be consumed to produce energy such as fuel.

Combustion Air - air that provides oxygen for a substance to burn.

Combustion Analyzer - a device used to measure the efficiency of a combustion appliance by quantitatively measuring the products of combustion.

Compressor - a mechanical device that receives the cool, low-pressure gas from the evaporator and squeezes the fluid increasing its energy and temperature. This fluid leaves the compressor as a hot, high pressure gas that flows into the condenser.

Condenser - this outside component contains metal fins that act like a radiator in a car that help the heat dissipate. The temperature of the gas becomes much cooler, changing the gas back to a high pressure liquid.

Conditioned spaces are the indoor areas that are heated and cooled.

Conduction - the transfer of energy (heat) between solids.

Convection - the transfer of energy (heat) through a fluid such as air or liquid.

Cooling Load - the rate at which heat is removed from conditioned space for the hottest and most humid levels expected.

Cost Effective - a measure that is of good value, where the benefits and usage are worth at least what is paid for the labor and materials of replacement. Most frequently referred to as a Savings-to-Investment Ration (SIR) of 1 or better.

CRI - Color Rendering Index (see description above)

Cubic Feet per Minute (CFM) - a standard measurement of airflow that has a volume of one foot wide, one foot deep and one foot high.

Damper - a device installed near a fan that only allows air to flow in one direction.

Depressurization - causing a lower pressure in one zone in reference to another zone.

Dilution Device - a draft diverter on a combustion appliance.

Distribution System - as series of ducts or pipes used to disperse energy; such as cooling, heat, or water.

DOE – U.S. Department of Energy

Draft - flue pressure that carries combustion gases out of the building.

Draft Diverter - a device that gathers exhaust gases from a combustion appliance to safely vent to outside the building and restrains these gases from re-entering the combustion appliance zone.

Draft Inducer - a fan that assists in moving air and gases out of a combustion appliance and up the flue or chimney.

Duct Blower - a device used to measure air flow and air leakage of a duct system.

Efficiency - the ratio between output and input.

Energy - a quantity of work or heat

Energy Consumption - the amount of energy used by the occupant(s) for heating, cooling, appliances, and general household use.

Energy Efficiency Ratio (EER) - a measure of an air conditioner or heat-pumps ability to work. EER= BtuH/watts.

EER - energy efficiency rating / energy efficiency ratio (see description above)

Energy Factor - indicates a water heater's overall energy efficiency based on the amount of hot water produced per unit of fuel consumed over a typical day. The higher the energy factor, the more efficient the water heater.

Energy-Recovery or Enthalpy-Recovery Ventilator (ERV) - a central heat exchanger that transfers a certain amount of water vapor along with heat energy.

EPA – U.S. Environmental Protection Agency

ER - energy ratio

ERV – energy recovery or enthalpy recovery ventilators

Evaporator Coil - this coil looks like a series of pipes that absorb heat when air passes through their system. Within this device hot gas is cooled and turned back into a liquid, which is then sent back to the compressor.

Expansion Device - a valve that regulates refrigerant flow to the evaporator.

Exfiltration - movement of air, gases, or moisture from inside a building to outside the building.

Fan Control - a thermostat, on a furnace or air conditioner that senses when the blower needs to turn on or off.

Fenestration - window or door openings in the shell of a building.

Fiberglass - a material made from a plastic matrix reinforced by fibers of glass, used for insulation.

Fill tube - a plastic or metal tube used to blow in insulation.

Fin Comb - a device used to straighten and clean out condenser fins.

Fire Barrier - vertical or horizontal building materials that will resist fire for one to four hours.

FLA - full load amp

Flashing - thin continuous pieces of sheet metal or other impervious material installed to prevent the passage of water into a structure at roof penetrations or walls.

Flue - a duct, pipe, or chimney that conveys combustion gases.

Footing - a component of building that transfers weight from the structure to the ground.

Gasket - an elastic material or mechanical seal that fills the space between two materials.

Glazing - a putty-like compound used to hold glass in place and seals out the weather; pertaining to windows.

GFCI – ground fault circuit interrupter

GPM - gallons per minute

H&AC - heating/air conditioning system

Heat Gains - heat that accumulates in a building.

Heat Loss - heat that escapes through the building shell.

Heat Pump - is an air conditioner that can be switched to perform both heating and cooling by removing heat. In the summer it removes from the building to the outside. In the winter it removes heat from outside into the building.

Heat Recovery Ventilator (HRV) - a central ventilator that controls heat transfer.

Heating Load - the rate at which heat is needed by conditioned space for the coldest day.

Heating Seasonal Performance Factor (HSPF) - the total space heating required during the heating season, expressed in Btu, divided by the total electrical energy consumed by the heat pump system during the same season, expressed in watt-hours. Specifically used to express the efficiency of an air source heat pump.

HEPA – High Efficiency Particulate Air

HRV – heat recovery ventilators

HVAC - heating, ventilation, and air conditioning

Hydronic - the use of water as the heat-transfer medium in heating and cooling systems.

IAQ - indoor air quality

IC - Insulation Contact

IECC - International Energy Conservation Code

IFGC – International Fuel Gas Code

Infiltration - movement of air, gases, or moisture from outside a building to inside the building.

Insulated Glass - glass panes that are separated by an air or other gas filled space to reduce the transfer of heat.

Insulation - a material added to a structure to improve energy efficiency and comfort that has a relatively high thermal resistance.

Intermediate Zone - an area located between the conditioned space and outdoors, such as an attic or crawlspace.

Internal Gains - heat generated from appliances or general household activities; such as cooking, bathing, or exercise.

IR - infrared

IRC - International Residential Code

Jamb - the vertical side members of an opening, doorway or window.

Joist - framing members that support the floor or ceiling of a structure.

K&T - knob-and-tube

Kilowatt (kW) - is a unit of energy equal to 1000 watt hours.

Kilowatt-hour (kWh) - is a unit of energy equal to 3412 Btu's.

Lamp - a light bulb.

Latent Heat - is the heat lost or gained by something when it changes state; such as, a liquid to a gas.

Low-e (low emissivity) - is the quality of a surface to resist the flow of radiant heat or thermal energy.

Mastic - a substance used to seal cracks or seams in a building; such as duct mastic for sealing plenums and ducts.

MERV - minimum efficiency reporting value

Metering Device - an instrument used to measure the flow of liquid refrigerant or electricity through the system.

MHEA – Manufactured Home Energy Audit

Minimum Ventilation Requirement (MVR) - the blower door measured air-leakage CFM value that below which would require mechanical ventilation. Previously known as Building Tightness Limit (BTL).

MVR - minimum ventilation requirement,

National Fenestration Rating Council (NFRC) - provides accurate information to measure and compare energy performance of windows, doors and skylights.

Natural Ventilation - air movement that naturally occurs within a home, without fans.

NEAT - National Energy Auditing Tool

NFPA - National Fire Protection Association

NFRC - National Fenestration Rating Council

OSB – Oriented Strand Board

Oxygen Depletion Sensor (ODS) - detects when oxygen in the room falls below a specified level . The device shuts off the gas to the fire, rendering an unvented space heater safe.

p/t - pressure/temperature

Pascal - a standard unit of measure for air pressure.

pCi – picocuries

PFAS - Personal fall arrest system

Plenum - connects the supply or return duct to the air handler.

PPM - parts per million

PSI - pounds per square inch

PVC - polyvinyl chloride

R-value - a measure of thermal resistance. The higher the R-value the greater the resistance to heat flow.

Radiation - the transfer of energetic particles or waves through space.

Radiant Barrier - a highly reflective material that reflects (or more specifically, re-emits) radiant heat rather than absorbing it.

Radon - a radioactive, colorless, odorless gas that naturally occurs from the decay of certain rocks; such as granite.

Rafter - a sloping structural member that supports a pitched roof.

Recovery Efficiency - the ability of a water heater to heat incoming water.

Refrigerant - a chemical substance used in air conditioners. Refrigerants can change states from a liquid to a vapor. It changes to a vapor by adding heat and later changes back to a liquid by removing heat during the cooling cycle.

Register - a grill cover that fits over a duct boot.

Relative Humidity - the amount of moisture in the air compared to what the air can "hold" at that temperature. The dew point is reached when the air can no longer hold all the moisture.

Resistance - the ability of a substance or material to the conduction of energy or heat.

Retrofit - to add an energy saving measure to an existing system.

Return Air - air that circulates back to an HVAC unit to be reheated or re-cooled.

Rim Joist - the outermost joist that caps the end of the row of joists that support a floor.

RRP - RRP Rule: Renovate, Repair, Painting Program Rule (US Environmental protection Agency)

Sash - the moveable or stationary frame that holds the glass of a window.

Savings to Investment Ratio (SIR) - the life-time savings of an energy-saving measure compared to the initial cost for the materials and installation cost.

Sealed Combustion - a fuel-fired appliance that brings outside air directly into the burner and exhaust flue gases (combustion products) directly to the outside, without the need for a draft hood or damper.

Seasonal Energy Efficiency Ratio (SEER) - an air conditioner cooling output in Btu (British thermal unit) during a typical cooling-season divided by the total electric energy input in watt hours during the same period. The higher the SEER the more energy efficient it is.

SEER - seasonal energy efficiency ratio

Sensible Heat - thermal energy that results in a temperature change.

Shading Coefficient - measures the solar energy transmittance through windows.

Sheathing - A layer of boards or of other wood or fiber materials applied to the outer studs, joists, and rafters of a building to strengthen the structure.

Shell - the roof, walls, and floor/foundation that enclose a building providing safety and protection from the elements.

SHGC - Solar Heat Gain Coefficients

Short Circuit - allows a current to travel along an unintended path. A short is caused when one hot wire (black) comes in contact with another hot wire or a neutral wire (white).

Sill - the horizontal member at the bottom of a window or door opening.

SIR - savings to investment ratio

Soffit - an underside of the overhang of a roof or a ceiling enclosure above kitchen or bath cabinets.

Solar Gain - heat from the sun that increases the temperature in a space, object or structure.

Solar Heat Gain Coefficient (SHGC) - measures the fraction of solar energy transmitted and tells you how well the product blocks heat caused by sunlight. The lower the SHGC, the less solar heat the window transmits.

sone - term used to measure the loudness of a fan. The lower the number the quieter the fan.

SPF - spray polyurethane foam

Spillage - the unwanted overflow of combustion gases into a home.

Stack Effect - drafts created in a building from low infiltrating air and high exfiltrating air.

Static Pressure - Static pressure is the difference in air pressure between the suction side and pressure side of the blower; measured in Pascals.

Steady State Efficiency (SSE) - measures how efficiently a furnace converts fuel to heat, after the initial start up cycle.

Strike Plate - the protective metal plate installed in the door jamb that receives the latch or lock.

Stud - a vertical framing member of a wall.

Subfloor - the sheathing that sits between the joists and underlayment and/or flooring material.

Subcooling-when the condenser and cooling pipes force the temperature of a liquid below its saturation point at the same pressure causing it to change phases.

Superheat-when the evaporator and heat pipes force the temperature of a vapor higher than its saturation point at the same pressure causing it to change phases.

Supply Air - heated or cooled air that is forced through the ducts and out the registers.

TDHCA - Texas Department of Housing and Community Affairs

Therm - a unit of heat energy equal to 100000 British thermal units.

Thermal boundary - restricts or slows the flow of heat from conditioned and unconditioned spaces in a building. It is made up of an air barrier and insulation that is well aligned.

Thermal Break - a material of low thermal conductivity placed in an assembly to reduce or prevent the flow of thermal energy between conductive materials.

Thermal Resistance - See R-value

Threshold - A piece of wood, metal or stone placed beneath a door; a doorsill

Transmittance-the fraction of radiant energy that passes through the building material into the building.

U-value or U-factor - measures the rate of heat transfer and tells you how well a window insulates. The lower the U-factor, the greater a window's resistance to heat flow.

UI - United Inches = One width measurement inches plus one length measurement inches.

UL – Underwriters Laboratories

Unconditioned space - the outdoors or any areas in a residence that are not heated or cooled.

Vapor barrier - a material that retards the migration of water vapor.

Vent Connector - a pipe fitting that connects the appliance to the flue or chimney.

Vent Damper - an automatic device that allows natural draft during appliance operation while preventing residual conditioned air from escaping during off cycles.

Ventilation - the exchange of air to the outside or the circulation of air within the building.

Venting - a pipe, flue or chimney that removes combustion gases or moist air from a building.

Vermiculite - an asbestos containing mineral used for insulation.

Visible Transmittance (VT) - measures the amount of light the window lets through. The higher the VT, the more light you see.

VOC - volatile organic compounds (see description below)

Volatile Organic Compounds - are a large group of carbon-based chemicals that easily evaporate at room temperature. Many of hazardous to human health.

Volt - is the unit used for the apparent power in an electrical circuit.

VT - visible transmittance (see description above)

Watt - a unit of power equal to one joule of energy per second or 3.4 Btu's.

Weatherization - the energy-saving measures performed on homes to increase comfort and improve building efficiency.

WAP - Weatherization Assistance Program

Weather-Resistant Barrier - a material designed to protect against rain or water intrusion.

Weatherstripping - process used to prevent water and air from entering a building, or expensive conditioned air from exiting a building by typically installing rigid metal strips or flexible gaskets.

Weep holes - purposeful openings in building materials that allows water to drain out of a building component; such as holes drilled into the bottom of a window frame or openings in brick to prevent excessive water from entering a building shell.

WPN – Weatherization Program Notice

Zone - a space or area within a building defined by an air-barrier; such as a closet, bedroom, first floor, etc.

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Appendix C: Assistance Resources

While working with clients, you may notice that they or their home may be in need additional assistance. For example, you may notice that a resident of the home is in a wheelchair, but the home is not accessible, or the roof of the home is in need of repair. Please encourage clients in need to contact the Texas Department of Housing and Community Affairs or 2-1-1 Texas.

Texas Department of Housing and Community Affairs (TDHCA)

Visit the Texas Department of Housing and Community Affairs online at www.tdhca.state.tx.us and *click on the "Help for Texans" tab*, or call TDHCA toll free at 800-525-0657 for local provider contact information for assistance such as:

- Emergency and homeless services
- Foreclosure prevention assistance
- Homebuyer education counseling
- Homebuying assistance
- Home repair, architectural barrier removal
- Reduced rent properties
- Rent payment assistance
- Utility bill payment assistance
- Weatherization assistance

2-1-1 Texas

You may also refer clients to www.211texas.org or encourage them to dial 2-1-1 for more information on assistance that may be available locally, such as:

Need	Assistance	
Home Accessibility[1]	▪ Bathroom modification ▪ Ramp construction ▪ Kitchen modification	▪ Residential lift equipment ▪ Home barrier removal loans ▪ Home barrier removal grants
Home Repair	▪ Disaster specific home repair ▪ Home maintenance and minor repair services ▪ Home rehabilitation loans ▪ Home rehabilitation programs ▪ House painting ▪ Minor home repair programs	▪ Plumbing maintenance, repair ▪ Post disaster housing ▪ Roof maintenance, repair ▪ Septic system inspection, maintenance ▪ Subsidized home purchase ▪ Yard work
Rent	▪ Alternative dispute resolution ▪ Congregate living facilities ▪ Disaster specific rent assistance ▪ Food outlets ▪ Housing counseling ▪ Housing expense assistance ▪ Public housing ▪ Rent payment	▪ Residential housing options ▪ Rooming/boarding houses ▪ Section 8 Housing Choice Vouchers ▪ Shared housing facilities ▪ Single room occupancy housing ▪ Subsidized private rental housing ▪ Subsidized rental housing ▪ Tenant/landlord assistance
Utility Help	▪ Discounted utility services ▪ Electric service payment ▪ Gas service payment ▪ Heating fuel payment ▪ Telephone service payment	▪ Utility deposit ▪ Utility disconnection protection ▪ Utility service payment ▪ Water service payment

[1] Accessibility assistance may accommodate persons with disabilities through structural and/or physical provisions for those with mobility, vision, and/or hearing impairments.

Additional assistance may also be available through 2-1-1 Texas for needs such as:

- Child care and education
- Clothing, household, personal needs
- Disability services
- Employment
- Food, meals
- Health care
- Mental health and addictions
- Transportation
- Veteran services