Air Sealing Improvement Protocol

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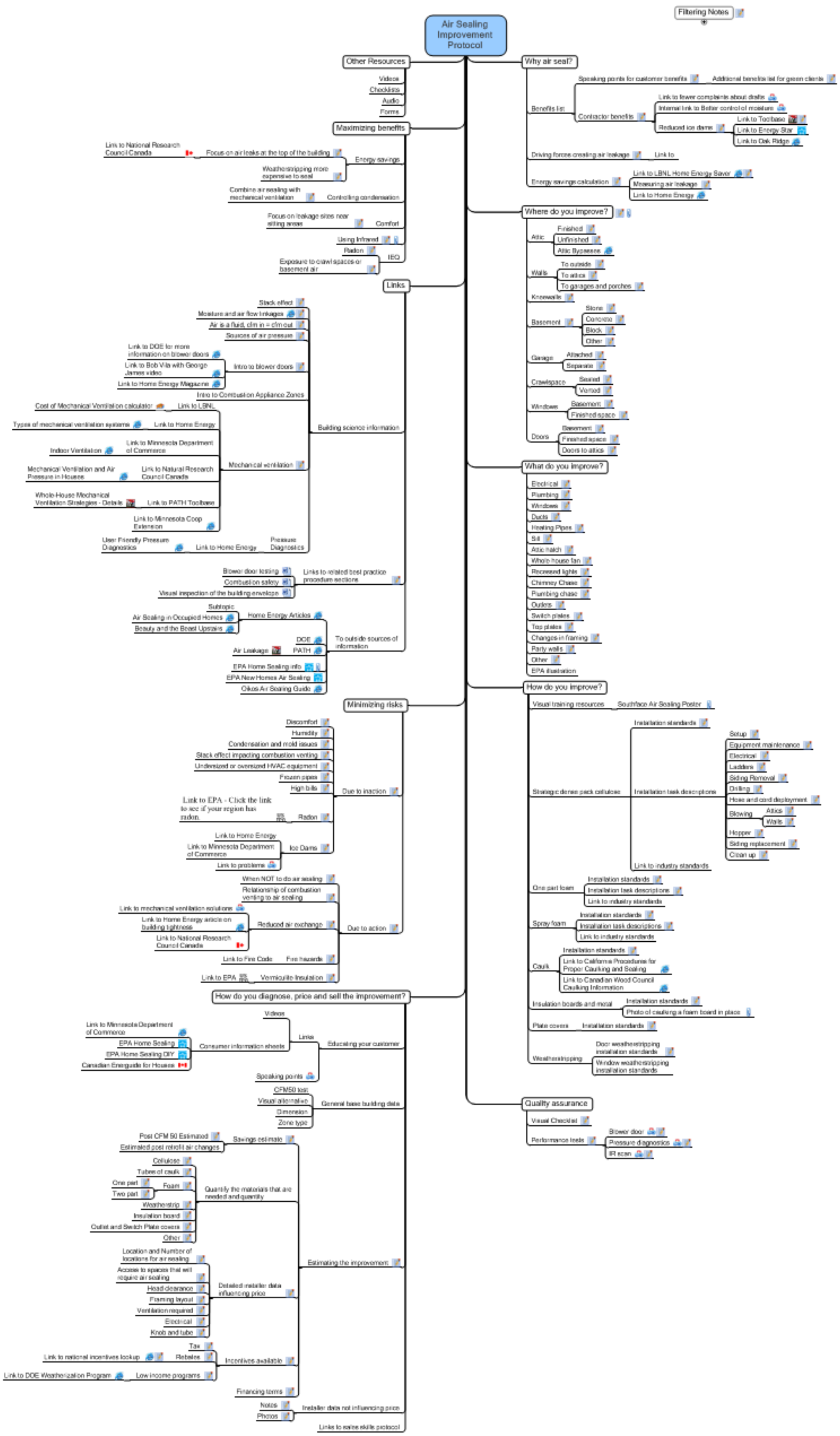

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1 Why air seal?

1.1 Benefits list

1.1.1 Speaking points for customer benefits

Sealing air leakage is usually one of the most cost-effective ways to reduce heating and cooling bills. In addition to saving money, air sealing improves comfort by reducing drafts. Dust levels are dramatically reduced, along with the impact of outside noise inside the house. Controlling air leakage from the house into the attic also reduces the possibilities of attic mold/moisture problems as well as the possibility of ice dams.

Infiltration can be as much as 30% of a home's energy bill, more in cold climates and less in mild climates.

Tight houses with poor air quality typically have a source problem, something specific is creating poor air quality. Remove the source of the problem and the air quality is greatly improved. Keeping your house leaky does not avoid these types of problems. The best solution is a tight comfortable and efficient house with the sources of poor air quality removed. Sometimes this is referred to as "Dilution is not the solution to pollution".

Controlling air leakage from a specific space, such as a damp basement or crawlspace, can improve the air quality of a house, in addition to saving energy.

If you want additional air quality, simple mechanical ventilation systems will provide a consistent source of fresh air for less cost than relying on air leakage. The mechanical ventilation system, sometimes as simple as a very quiet bathroom fan, can provide a constant amount of fresh air, instead of relying on the inside-outside temperature difference to drive a widely varying amount of air leakage. You don't want too much air in the winter and too little air in the summer. You want the right amount of fresh air, year round.

1.1.1.1 Additional benefits list for green clients

Air sealing can improve health of building occupants by reducing dust and controlling the entry of contaminants into the building. For example, crawlspaces and basements may contain mold. Air entering into the building that passes through these spaces can pick up the contaminants.

Energy use has impacts on the environment through greenhouse gas production and through the pollutants, such as mercury and nitrous oxides that are produced from power generation and other sources of combustion.

1.1.2 Contractor benefits

Higher customer satisfaction, fewer draft-related callbacks, and more referrals – because a well-sealed house will be more comfortable than a poorly sealed house. and attic moisture. A well-sealed building needs less heating and cooling capacity, reducing installation costs for these appliances.

1.1.2.1 Link to fewer complaints about drafts

See also: Stack effect

1.1.2.2 Internal link to Better control of moisture

See also: Moisture and air flow linkages

1.1.2.3 Reduced ice dams

Attic air sealing also reduces callbacks and expenses related to ice dams.

1.1.2.3.1 Link to Toolbase

See document: tertiaryT.asp
ToolBase

Energy Star

Oak Ridge

1.1.2.3.2 Link to Energy Star

See document: index.cfm

1.1.2.3.3 Link to Oak Ridge

See document: ice_dam.html

1.2 Driving forces creating air leakage

Tightly sealing the building at the “attic plane” can dramatically slow the loss of heated air during the heating season, and reduce drafts throughout the building. This is because heated air tends to rise and leak out of upper levels of the building, and outdoor air is drawn into lower levels of the building. This "stack effect" is a principal cause of air leakage. [insert picture]

Air leakage can also be driven by wind, a more intermittent effect than the stack effect and by fans, such as exhaust fans or furnace fans blowing through leaky duct work. Isolation of supply air registers from return air grilles can also create air leakage.

Combustion appliances that use chimneys can also create air leakage by exhausting out air that needs replacement. This includes fireplaces and wood stoves.

1.2.1 Link to

1.3 Energy savings calculation

In general, air sealing is one of the most cost- effective measures available, with payback times of 5 years or less for many "improvement measures." In addition, it can save money by preventing maintenance problems such as freezing pipes, ice dams and roof rot.

1.3.1 Link to LBNL Home Energy Saver

See document: hes.lbl.gov
Air sealing is just one component of all the energy savings opportunities in a house. To accurately calculate air sealing savings, you need to take into account the weather where the house is located and other energy uses. Use this link to analyze the total building energy use including savings from air sealing.

1.3.2 Measuring air leakage

Use a blower to estimate the amount of air leakage in a home. Then use software to calculate the potential energy savings from reducing that air leakage. Use the blower door again to make sure you have accomplished the savings that you predicted.

1.3.3 Link to Home Energy

See document: 940111.html

2 Where do you improve?

See attachment(s): pic18633.jpg
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2.1 Attic

2.1.1 Finished

You may have to move existing attic insulation to do proper sealing.

Seal the following critical framing junctions with rigid material, caulked or foamed at the edges:

Floor/kneewall transitions (block and seal floor joists below kneewall) [insert picture]

Wall/ceiling transitions (on slopes, dormers and gable ends) [insert picture]

Slopes to flat ceiling transitions. [insert picture]

Also, seal electrical, HVAC and plumbing penetrations, wall top-plates, recessed light fixtures, and fans. Built-in drawers or cabinets should be enclosed and sealed from the attic side.

2.1.2 Unfinished

The best time to seal an attic is prior to installation of the insulation, but for purposes of retrofit air sealing, the following locations should be addressed.

Large openings (flue, duct, and plumbing chases). These should be sealed with rigid material (sheetrock, plywood, foam board, etc.) caulked or foamed at the edges. Note: Always maintain required clearances between flues/chimneys and combustible materials. For sealing around flues, use sheet metal or foil-faced fiberglass ductboard and high-temperature caulk. [insert picture]

Soffits - such as those frequently found above kitchen cabinets and in bathrooms - should be sealed off from the living space. [insert picture]

Interior walls sometimes open to attic, like in split-level designs. These should be blocked at the lower top plate and enclosed from the attic side with insulation sheeting materials. [insert picture]

Plumbing and wiring penetrations (easily sealed with one-part foam).

Junctions between sheetrock and wall top-plates should be blocked with insulation sheeting material and sealed whenever possible. [insert picture]

Recessed light fixtures. Only IC (“insulation contact”) rated fixtures should be sealed. The best way to seal these is by building sealed boxes from fire-rated materials such as sheetrock or ductboard. [insert pictures]

2.1.3 Attic Bypasses

See document: Attic_Bypasses_110602012529_AtticBypass.pdf

2.2 Walls

2.2.1 To outside

Bottom plates and rim joists should be sealed to the subfloor with caulk or construction adhesive.

If building a new addition, install an air infiltration barrier under the siding. This can be an insulated board material such as styrofoam or a housewrap/drainage plane such as Tyvek. Seal seams in infiltration barrier with tape. [insert picture] (Air infiltration barriers are not necessary with SIP or ICF construction).

Whenever possible, gaps between window/door jambs and rough openings should be sealed with caulk, one-part foam, or other materials in accordance with manufacturer's instructions.

Hose bibs, fan termination points, electrical boxes and weatherheads that penetrate the exterior air infiltration barrier should be sealed with housewrap tape or silicone caulk. [insert picture]

Electrical boxes should be sealed to sheetrock with caulk or sheetrock compound. Foam gaskets can be installed inside outlets to further reduce air infiltration. [insert picture]

2.2.2 To attics

Walls adjoining unconditioned attics should be enclosed with foam board, sheetrock, or sheathing. Gaps in the board material should be sealed.

2.2.3 To garages and porches

Porch walls Walls and floors adjoining unheated porches should be treated as exterior walls. Continuous sheathing and air barrier should be installed even in areas hidden by porch roofs which may not be sided. [insert picture]

Garage walls and ceilings: Sealing garages from the living space is particularly important to prevent infiltration of automobile exhaust into the living space. Walls and floors adjoining garages should be sheetrocked in accordance with fire codes. All penetrations (wiring, gas piping, should be sealed with appropriate materials). All joist cavities that cross a wall between garage and living space should be blocked with rigid material. [insert picture] Special attention should be paid to sealing any ductwork passing through the garage.

2.3 Kneewalls

The kneewall is a critical region for sealing in finished attics, and story-and-a-half style houses such as saltboxes and capes. The cavity behind the kneewall can be considered "conditioned" or "unconditioned" space, depending on how it is insulated.

For kneewall cavities that are to be heated / cooled:

Seal exterior top plates and rim joists adjoining the kneewall cavity. [insert picture]

Enclose the rafter slopes with rigid materials; seal seams in the rigid materials. [insert picture]

For kneewall cavities that are NOT to be heated / cooled:

Seal all penetrations of the ceiling below the cavity (see unfinished attics).

Block and seal the floor/kneewall transition. Insert rigid blocking between the joists and caulk in place. [insert picture]

Seal any pentetrations into kneewall (mainly electrical boxes). Weatherstrip kneewall access doors.

2.4 Basement

Basement air sealing should only be undertaken by contractors who are comfortable assessing houses for potential moisture problems and who are willing to undertake combustion safety tests, such as those established by the Building Performance Institute, to ensure air sealing does not create issues with moisture or backdrafting of combustion equipment.

The following locations should be sealed with caulk or foam. [insert picture] Where local codes permit exposed foam board or 2-part foam on band joists, these materials can double as insulation and air sealing materials. Foam board should always be sealed in place with caulk or foam.

Gaps between top of foundation wall and sill plate. [insert picture]

Gaps between sill plate, band joist, and subfloor. [insert picture]

Gas and oil pipe penetrations, hose bibs, electrical weatherheads. [insert picture]

Fan and dryer vents.

Sidewall vents (use noncombustible materials and observe required clearance for non-zero clearance flues). [insert picture]

Window frames.

2.4.1 Stone

Stone foundations are often very leaky. Attempts to seal gaps in the stonework with expanding foam are often unsuccessful and unsightly. The best approach to reducing air leakage through stone walls is to repair deteriorated mortar.

2.4.2 Concrete

Poured concrete construction is inherently tight. Most air leaks will be associated with windows and doors, sill plates, and the band joist.

2.4.3 Block

Most air leaks will be associated with windows and doors, sill plates, and the band joist. If the sill plate is undersized and the top layer of block is unfilled hollow-core, then air can leak around the sill plate. This problem can be easily addressed with expanding foam.

Concrete block walls can also provide pathways for soil gas entry. For example, the open cells at the top of block walls should be covered and sealed. Another location for soil gas infiltration is where drain lines, etc. penetrate the block walls.

2.4.4 Other

If the house is a split level, they often have exposed kneewalls in the basement or the crawlspace. You may not want to improve anything but the lid, major breeches, and the kneewalls.

2.5 Garage

2.5.1 Attached

Sealing garages from the living space is particularly important to prevent infiltration of automobile exhaust into the living space. Walls and floors that are adjoining garages should be sheetrocked in accordance with fire codes. All penetrations (wiring, gas piping) should be sealed with appropriate materials. All joist cavities that cross a wall between garage and living space should be blocked with rigid material. [insert picture] Special attention should be paid to sealing any ductwork passing through the garage.

2.5.2 Separate

A garage unconnected to a living space will typically not require sealing. If it is a heated or cooled space, treat it as a separate building.

2.6 Crawlspace

2.6.1 Sealed

Sealed crawlspaces with adequate moisture control can be treated as "mini-basements."

2.6.2 Vented

One approach that has produced good results is to take steps to manage crawlspace moisture (install vapor barriers, etc.), then to seal crawlspace vents, converting the crawlspace to an unvented condition. This approach should only be undertaken when the contractor is confident that moisture issues have been addressed. Unvented crawlspaces are still not allowed in some areas due to local building codes.

If a crawlspace is kept in a vented condition, it is important to seal all piping, wiring, HVAC, and other penetrations between the crawlspace and the living space. Any ductwork in the crawlspace should also be tightly sealed. Preferably, the floor joists in the crawlspace should be enclosed with plywood or some other rigid material to further reduce airflow and to prevent wildlife from damaging the insulation.

2.7 Windows

2.7.1 Basement

The frames of new or existing basement windows should sealed to masonry walls with caulk or foam. When the frames of existing windows are sound, repairs to glazing and hardware can provide significant air leakage reduction at minimal cost.

2.7.2 Finished space

Air leakage through or around existing double-hung windows can often be reduced by installing or adjusting sash locks, installing storm windows, and caulking window trim. Whenever possible, full replacement windows and inserts should be installed, caulked, and flashed in accordance with manufacturer's instructions.

2.8 Doors

2.8.1 Basement

The pressure/thermal boundary should typically be established at the door in the plane of the basement wall, not the the exterior bulkhead. In older houses, basement doors are often non-standard sized, site-built, and excessively leaky. The first step in making these doors weathertight is to straighten and secure the frame of the door to the opening, which may require masonry fasteners. If a threshold is not present, one made of aluminum or pressure-treated wood should be installed.

The door frame can then be sealed to the wall with expanding foam. If the existing door is to be used, it can be insulated with foam board; if not, a new door can be fabricated by sandwiching 1" foam board between two thin sheets of plywood, with a 1" wood border. New hinges and barrel bolts can ensure that the door closes tightly against the frame.

2.8.2 Finished space

Air leakage of existing doors can often be reduced significantly at minimal cost. Care must be taken to ensure that homeowners are able to open and close doors freely after weatherstripping.

Ensure that the knob and lockset are tightly installed.

Remove any old, loose, or damaged weatherstripping.

Adjust the strike plate so that the door latches tightly with minimal play.

If significant air leakage is still present:

Install a high-quality weatherstripping (vinyl bulb with wood/metal backing, secured with nails or screws) to seal leaks at sides and top of door.

Install threshold, sweep, or bottom shoe to seal leaks at bottom of door.

2.8.3 Doors to attics

Doors to walk-up attics and kneewall cavities can be weatherstripped. Small lift-up ceiling hatches ("scuttles") are often relatively airtight, provided that the scuttle board makes good contact with the trim boards holding it in place. A thick layer of foam board insulates and gives weight to the scuttle, and prevents rattling in windy conditions.

Pull-down attic stairs are usually quite leaky. The plywood "door" itself is often warped, and the springs do not provide tight closure. The best approach is to build or purchase a lightweight removable insulated cover (typically made of foam board) that fits over the stairs in the attic. To work well, this should make good contact with the attic floor; the gap between the ceiling sheetrock and the plywood floor should be blocked with wood or other material.

3 What do you improve?

3.1 Electrical

Seal electrical penetrations of exterior walls (including the main weatherhead and boxes for outdoor lights) with caulk and weatherproof (tyvek) tape.

Seal electrical penetrations between conditioned spaces and attics (including holes in top plates, ceiling boxes, etc.) with caulk or expanding foam.

Seal IC-rated recessed light fixtures with sealed boxes made of sheetrock, ductboard, or other non-flammable material, and then sealed to the ceiling.

Seal indoor electrical boxes or exterior walls with caulk and gaskets.

3.2 Plumbing

Seal around vent stacks at the level of the attic floor with expanding foam or caulk.

Caulk hose bibs where they pass through the band joist or exterior wall.

In older houses, seal plumbing chases at the basement ceiling to yield some benefit.

3.3 Windows

Air leakage through or around existing double-hung windows can often be reduced by installing or adjusting sash locks, installing storm windows, and caulking window trim. Whenever possible, full replacement windows and inserts should be installed, caulked, and flashed in accordance with manufacturer's instructions.

3.4 Ducts

Duct shaft connections should be sealed with mastic. As they move through walls between non-conditioned and conditioned space, any infiltration points should be sealed with rigid material (sheetrock, plywood, foam board, etc.) that is caulked or foamed at the edges.

3.5 Heating Pipes

As they move through walls between non-conditioned and conditioned spce, infiltration should be sealed with caulk or foam. Note: Always maintain required clearances between flues/chimneys and combustible materials.

3.6 Sill

The following locations should be sealed with caulk or 1-part foam. (Where local codes permit exposed foam board or 2-part foam on band joists, these materials can double as insulation and air sealing materials. Foam board should be sealed in place with caulk or foam.)

Gaps between top of foundation wall and sill plate.

Gaps between sill plate, band joist, and subfloor.

Gas and oil pipe penetrations, hose bibs, electrical weatherheads.

Fan and dryer vents.

Sidewall vents (use noncombustible materials and observe required clearance for non-zero clearance flues).

Window frames.

3.7 Attic hatch

Doors to walk-up attics and kneewall cavities can be weatherstripped. Small lift-up ceiling hatches ("scuttles") are often relatively airtight, provided that the scuttle board makes good contact with the trim boards holding it in place. A thick layer of foam board insulates and gives weight to the scuttle, and prevents rattling in windy conditions.

Hook and eye securing mechanisms can have a significant impact to minimize air leakage.

Pull-down attic stairs are usually quite leaky. The plywood "door" itself is often warped, and the springs do not provide tight closure. The best approach is to build or purchase a lightweight removable insulated cover (typically made of foam board) that fits over the stairs in the attic. To work well, this should make good contact with the attic floor; the gap between the ceiling sheetrock and the plywood floor should be blocked with wood or other material.

3.8 Whole house fan

The louvered covers of whole-house fans are usually very leaky. These are typically sealed from the attic by building a plywood or foam board box around the fan assembly. The box must be tightly sealed at to the attic floor; be sure to instruct the homeowner that the fan cover must be removed each summer and put back in place each winter.

3.9 Recessed lights

Recessed light fixtures should be replced with sealed fistures whwnever possible. Otherwise, only IC ("insulation contact") rated fixtures should be sealed. The best way to seal these is by building sealed boxes from fire-rated materials such as sheetrock or ductboard and covering the fistures in the attic floor.

3.10 Chimney Chase

Flue and chimney chases should be sealed at the attic plane with rigid, non-combustible material such as sheet metal or foil-faced fiberglass ductboard. Use high-temperature caulk to seal the ductboard or metal to the flue pipe or chimney. If insulating the attic with cellulose, wrap the flue pipe in unfaced fiberglass batting, secured with wires, to prevent cellulose from coming in contact with the chimney

3.11 Plumbing chase

Plumbing vents passing through top plates into the attic should be sealed with caulk or one-part foam. Larger chases and plumbing walls lacking top plates should be sealed with foam board and one-part foam.

3.12 Outlets

Inexpensive insulating "inserts" can be installed behind electrical outlets to minimize air leakage from inner wall cavities.

3.13 Switch plates

Inexpensive insulating "inserts" can be installed behind switch plates to minimize air leakage from inner wall cavities.

3.14 Top plates

The top plates of stud walls frequently leak where the sheet rock or plaster meets the top plate.

3.15 Changes in framing

Changes in framing frequently result in a path for air to leave the heated space. This includes interior soffiting such as required by a drop in ceiling height.

3.16 Party walls

The block or other fire resistant wall separating two apartments can have leakage in the interior of the wall or where the framing ties into the wall.

3.17 Other

Where two different materials meet there is often an air leak. An example of two different materials meeting is sheet rock up against a brick fireplace.

3.18 EPA illustration

4 How do you improve?

4.1 Visual training resources

4.1.1 Southface Air Sealing Poster

See attachment(s): Southface air-seal poster.pdf

4.2 Strategic dense pack cellulose

4.2.1 Installation standards

When properly installed, cellulose insulation can be a cost- effective way to seal hard-to-reach air leaks in floors, porch ceilings and other building cavities.

In order to act as a durable air barrier, cellulose must be blown into an enclosed cavity at high density (> 3.5 lbs/cubic foot). Sites for strategic dense-packing should be chosen to align with and complete existing thermal boundaries. In some cases creative approaches have been used to contain cellulose at the building perimeter--for example, for a leaky band joist between a first and second floor, kitchen trash bags can be inserted into drill holes and packed full of cellulose.

Cellulose installation density can be most easily determined by calculating the volume of a space and determining by count the number of bags necessary to fill the space. An alternative method uses a weighed core sample.

These techniques support the use of cellulose as an air sealing approach.

4.2.2 Installation task descriptions

4.2.2.1 Setup

Taking a few extra minutes to plan and setup may greatly increase job efficiency. Planning parking, access, materials staging, etc. cuts down on install time and increases productivity. Walking through the house with the customer provides a chance to discuss customer concerns, as well as to assess and document pre-existing cracks in sheetrock, moisture damage, etc. prior to beginning of work.

4.2.2.2 Equipment maintenance

A well-stocked, organized vehicle and properly maintained equipment increase productivity, projects professionalism, and decreases job costs due to broken equipment and damaged materials. Sheet goods, fasteners, caulk, blower hoses, cords, and lighting should be stored in secure, convenient bins, shelves, or hooks. A regular schedule of calibrating equipment is also necessary..

4.2.2.3 Electrical

Areas to be insulated should be checked for electrical hazards, including open electrical boxes, damaged or frayed wires, knob-and- tube or other antiquated wiring, etc. Contractor equipment (lights, saws, blowers, etc.) should also be inspected regularly for damaged wiring. Any wiring damaged during drilling or other preparation should be repaired prior to insulation work.

Electrically-powered insulation blowers should only be plugged into house circuits in good condition and suitable for the required amperage. Crew members dealing with insulation blower should be trained in electrical safety.

Steps should also be taken to minimize static buildup on insulation hoses.

4.2.2.4 Ladders

Ladders should be stored, transported, and used in accordance with manufacturer's instructions and OSHA standards.

4.2.2.5 Siding Removal

Siding removal should be done carefully to minimize damage. Aluminum and vinyl siding can be un-seamed with an appropriate siding tool. Wood clapboards can be carefully pried off, loosening the course of siding above the one to be removed to access nail heads. Cedar shakes can be pried off or cut and snapped with a utility knive. An assortment of ply bars, side cutters, etc. is useful during siding removal. For houses built prior to 1978, lead-safe practices should be used.

4.2.2.6 Drilling

For high density cellulose insulation, drill holes should be 2.5", ideally about 2' up an 8' wall. To maximize efficiency and minimize damage, an effort should be made to determine where studs are placed within the wall cavities.

4.2.2.7 Hose and cord deployment

Orderly cord and hose deployment increases work efficiency and decreases likelihood of damage to property as well as tripping injuries. Hoses should be coiled and strapped or wound on reels when not in use; no more hose or cord should be deployed than is necessary to reach the work area. Take care to protect door and window trim, stairs, wall corners, etc. from abrasion by the hose.

4.2.2.8 Blowing

4.2.2.8.1 Attics

Prior to open attic blows, all necessary preparation (air sealing, installation of vent chutes, installation of baffles to prevent spillage, etc.) should be completed. The attic should be blown to the desired pre-settled depth in accordance with insulation manufacturer's coverage charts; coverage should be verified with bag counts. Depth markers or flagging on trusses may help crews to maintain even coverage; the attic crew member should start at the far end of the attic and work their way back toward the hatch.

4.2.2.8.2 Walls

Considerable practice is required to achieve consistent good results with high-density sidewall insulation. The main cellulose hose is connected via series a reducers and smaller diameter hoses to a flexible vinyl sidewall tube approx. 9' long and 1" or 1.25" in diameter. The tube is inserted into the wall cavity; the hose is used to probe for blockage as well as to help pack the insulation to the desired density. A rag or scrap of fiberglass is used to allow air to escape from the cavity while keeping insulation in. Cellulose insulation should be packed to a minimum density of 3.5 lbs/cubic ft. At this density, it is difficult to push one's finger into the insulation. Practice is needed to develop the forearm strength, coordination of blower controls, and "feel" to achieve efficient dense-packing with minimal material waste.

4.2.2.9 Hopper

Open-blow operations with a medium to large volume blower may require one person feeding the hopper full time. For dense-pack work, particularly with larger machines, a crew member can alternate between feeding the hopper and other activities (blowing insulation, air sealing, clean-up. Hopper extensions, either factory made or homebuilt, can allow loading more bails at a time, freeing up crew for other activities.

4.2.2.10 Siding replacement

Siding should be restored, as closely as possible, to original condition. Aluminum/vinyl siding should be completely zipped; dings in aluminum siding should be straightened. Nail holes in clapboard should be caulked or puttied; drill holes in siding, if any, should be repaired with countersunk wooden plugs and outdoor wood putty. Clapboard severely cracked during removal should be replaced.

4.2.2.11 Clean up

Maintaining a clean, orderly job site, inside and outside the house, increases customer satisfaction and decreases material waste and tool loss. Cleanup time and effort can be greatly reduced by prior arrangement with customers to clear work areas, good planning of hose/cord access, and use of dropcloths, tarps, and plastic sheeting to contain mess.

Every crew should keep a fully stocked set of cleanup materials, including a working wet-dry vacuum (for outdoor/truck use), HEPA vacuum (for indoor use), contractor-grade trash bags, brooms, dustpans, mop, bucket, rags, paper towels, and citrus or ammonia- based cleaning spray.

Indoor areas made dusty with insulation should be HEPA-vacuumed; outdoor areas should be swept, vacuumed, or raked.

4.2.3 Link to industry standards

4.3 One part foam

4.3.1 Installation standards

One-part polyurethane foam is an extremely useful and versatile air sealing material. It is known to many homeowners as the messy and difficult-to-use cans with straw applicators; contractor-grade steel or plastic “gun” applicators are now widely available and offer cleaner, more controller application. The gun can be adjusted to apply beads of foam ¼” to about 2” wide, making it useful for air sealing top plates, electrical and plumbing penetrations, gaps around basement windows, and many other air leaks. For larger gaps, expanding foam can be used to seal the edges of rigid materials such as foam board. One part foam is flammable and should not be used around to seal around chimneys or flues. For aesthetic reasons, one part foam should not be used in finished spaces or left exposed on the exterior of the house.

4.3.2 Installation task descriptions

To ensure good consistency and adhesion, cans of foam should be kept warm and brought indoors in good weather. Gloves and long sleeves should be worn to avoid contact with skin. To maximize foam gun life and performance, follow manufacturer's instructions concerning cleaning and storage. To avoid waste, the smallest bead necessary to seal the gap should be used. For gaps larger than about 2", rigid blocking materials should be used. Care should be applied when applying foam around window and door rough openings to avoid warping the frames.

An air sealing crew member should work their way systematically through an attic, applying foam to all potential leakage sites (top plates, etc.). Crew should also work their way systematically around basements and crawlspaces sealing leaks around the band joists, window frames, etc.

Permeable surfaces such as carpets and drapes should be protected from foam. Foam accidentally sprayed on cement floors or walls should be allowed to cure thoroughly, at which point it can be removed with a minimum of mess; any residue can be scraped up with a putty knife or razor blade.

4.3.3 Link to industry standards

4.4 Spray foam

4.4.1 Installation standards

Two-part polyurethane foam is an expensive material but used strategically it can produce excellent air leakage reduction while reducing labor costs. The work area should be prepared and cleared of obstacles so that the crew member can move rapidly from one joist bay to the next so that the foam doesn't cure in the nozzle. Protect windows, furniture, and other items that would be damaged by oversprayed foam. Practice is required to achieve full coverage with minimal overspray and overly thick application.

Check local codes to see if exposed polyurethane foam is permitted on band joists in your area or if a fire barrier such as sheetrock is required. Also check materials MSDS for recommended ventilation and personal protection requirements.

Permeable surfaces such as carpets and drapes should be protected from foam. Foam accidentally sprayed on cement floors or walls should be allowed to cure thoroughly, at which point it can be removed with a minimum of mess; any residue can be scraped up with a putty knife or razor blade.

4.4.2 Installation task descriptions

A typical application for foam would be sealing and insulating a leaky band joist. Other applications include sealing module seams, top plates, and other attic bypasses and insulating crawlspace walls. Trial and error is the place to start learning how to apply spray foam. A thick but consistent "bead" is best.

4.4.3 Link to industry standards

4.5 Caulk

4.5.1 Installation standards

Select a caulk appropriate to the application. Silicone caulks are, in general, more flexible, can span wider gaps, and are more appropriate to outdoor applications; they are not paintable, give off stronger odors, and are more difficult to clean. High temperature silicone should be used for sealing around chimney chases and high-temperature sidewall terminations. Acrylic and latex caulks are easier to clean, less odorous, and are paintable; they are generally preferred for indoor applications and gaps less than 3/8". For wider gaps, backer rods can reduce the amount of caulk needed and reduce cracking and the caulk flexes and dries.

Caulk should be applied to clean surfaces (free of dust and debris). The tube should be cut at an angle; the size of the cut will determine the thickness of the bead. In general, "pushing" the caulk gun away from you provides better penetration into a crack than pulling the gun; wetted fingertips or implements can also be used to shape and "tool" the caulk into the crack. For interior caulking, take care to protect carpets, curtains, and other permeable surfaces, and keep a clean rag and warm water ready to clean up fingerprints and smears.

4.5.2 Link to California Procedures for Proper Caulking and Sealing

See document: caulking_sealing.html

4.5.3 Link to Canadian Wood Council Caulking Information

See document: caulks.php

4.6 Insulation boards and metal

4.6.1 Installation standards

Rigid materials are used in a wide range of insulating and air sealing applications. Extruded polystyrene and high-density expanded polystyrene are preferred for foundation and ground-contact applications. Because polystyrene has slight vapor permeability, it is preferred for exterior wall insulation in cold and mixed climates. Foil-faced polyisocyanurate provides high R-value per inch and is more resistant to breakage; it works well for enclosure of vertical surfaces in attics and kneewalls. It also works well as an interior sheathings.

Foam boards should be attached securely to substrates with cap nails, furring strips, or washer screws; in foundation wall applications adhesive can be used but should be reinforced with a mechanical fastening system. Enclosures built of foam board (for example, over pull-down attic stairs or around built-in drawers in a kneewall) should be reinforced with frame material as needed. Seams and junctions in foam board should be sealed with builders tape, caulk, or foam.

Foam boards are flammable and should not be used where high heat is an issue, for example around recessed light fixtures and flue pipes. Codes require that foam board exposed in basements and living space be covered with a fire barrier such as sheetrock; check with local officials for their interpretation of this rule in relation to crawlspaces.

For high temperature applications, sheet metal or foil-faced duct board can be used.

4.6.2 Photo of caulking a foam board in place

See attachment(s): Caulking a foam board in place.JPG

4.7 Plate covers

4.7.1 Installation standards

Inexpensive insulating "inserts" can be installed behind electrical outlets to minimize air leakage from inner wall cavities. In new construction or remodeling, electrical outlets on exterior walls should be sealed to prevent air infiltration. One approach is to seal knockouts in the box with caulk or putty, then caulk the edges of the box to the sheet rock (or interior foam board, if present). Another approach in new construction is to enclose electrical boxes in airtight pans. These pans have broad flanges that can be taped to polyethylene vapor barriers or foam sheathing where appropriate.

4.8 Weatherstripping

4.8.1 Door weatherstripping installation standards

Air leakage of existing doors can often be reduced significantly at minimal cost. Care must be taken to ensure that homeowners are able to open and close doors freely after weatherstripping. Remember that wood doors may shrink and swell seasonally with changing temperature and humidity.

Ensure that the knob and lockset are tightly installed.

Remove any old, loose, or damaged weatherstripping.

Adjust the strike plate so that the door latches tightly with minimal play.

If significant air leakage is still present:

Install a high-quality weatherstripping (vinyl bulb with wood/metal backing, secured with nails or screws) to seal leaks at sides and top of door.

Install threshold, sweep, or bottom shoe to seal leaks at bottom of door.

4.8.2 Window weatherstripping installation standards

5 Quality assurance

5.1 Visual Checklist

Locations

Electrical

Plumbing

Windows

Ducts

Heating pipes

Sill

Attic hatch

Whole house fan

Recessed lights

Chimney chase

Plumbing chase

Party wall

Top plates

Changes in framing

Outlets

Switch plates

Treatments

Weatherstripping

Caulk

One part foam

Spray foam

Outlet and switch plate covers

Insulation boards and metal

Quality

Effectiveness

Durability

Appearance

5.2 Performance tests

The recommended process is to test into and out of a building. Testing in will help you find leaks and tell you how hard to look for them. Testing out will tell you if you have been successful and if you need to supply additional sources of mechanical ventilation.

5.2.1 Blower door

See also: Blower door testing
The air flow at 50 Pascals of air pressure (CFM 50) is a benchmark used by many standards and can be used to compare leakage between buildings.

Leakage can also be characterized by the leakage per square foot of surface area, at a pressure of 50 Pascals.

Other blower door tests that measure flow at a range of pressures may provide more accuracy, if that is required.

5.2.2 Pressure diagnostics

See also: Pressure Diagnostics
Pressure diagnostics allow you to determine approximitaly how connected a transition space, for example an attic, is to the inside or outside. If the attic has been air sealed, it should have no connection to the inside.

5.2.3 IR scan

See also: Using Infrared
Infrared inspections of air sealing work provide rapid qualitative or visual feedback.

6 How do you diagnose, price and sell the improvement?

6.1 Educating your customer

6.1.1 Links

6.1.1.1 Videos

6.1.1.2 Consumer information sheets

6.1.1.2.1 Link to Minnesota Department of Commerce

See document: Attic_Bypasses_110602012529_AtticBypass.pdf

6.1.1.2.2 EPA Home Sealing

See document: Home_Sealing_Brochure04.pdf

6.1.1.2.3 EPA Home Sealing DIY

See document: DIY_COLOR_100_dpi.pdf

6.1.1.2.4 Canadian Energuide for Houses

See document: airleakage.pdf

6.1.2 Speaking points

See also: Speaking points for customer benefits

6.2 General base building data

6.2.1 CFM50 test

6.2.2 Visual alternative

6.2.3 Dimension

6.2.4 Zone type

6.3 Estimating the improvement

What data do you need to make a good estimate? How do you present this to a customer so that you sell the job? What information will help your installation crew do the best job?

6.3.1 Savings estimate

What information is needed to estimate the energy savings? Are there other non-energy financial savings?

6.3.1.1 Post CFM 50 Estimated

Benchmark your blower door number against other houses and the proposed workscope. If you are doing sidewall insulation that has an air sealing impact, such as dense pack cellulose, take that into consideration.

6.3.1.2 Estimated post retrofit air changes

6.3.2 Quantify the materials that are needed and quantity

6.3.2.1 Cellulose

Bags per square foot based for a specific wall or attic insulation depth, for example 4" for a typical retrofit wall or 12" for a retrofit attic. High density cellulose is installed at 3.5 pounds per cubic foot. This figure can be used when using cellulose to air seal a large cavity.

6.3.2.2 Tubes of caulk

Coverage depends greatly on hole size and speed of application.

6.3.2.3 Foam

Coverage is per board foot or a one inch deep one square foot piece of foam. Foam tends to be overused since it applies very quickly.

6.3.2.3.1 One part

Estimate per linear foot.

6.3.2.3.2 Two part

Estimate spray foam from coverage. there tends to be a lot of overspray and expansion so materials use may be higher than expected. There is a labor to materials trade off that should be accounted for. Spray foam is fast to apply, but may cost more than other materials. Have crews track their usage to maintain control over materials costs.

6.3.2.4 Weatherstrip

Weatherstripping selection should be done carefully and take into account durability as well as ease of installation. Weatherstripping installed on frequently used openings should be more durable. Pricing can be by linear foot or by piece, for the sweep at the base of a door for example.

6.3.2.5 Insulation board

Board is priced per square foot for various insulation values. Be clear on the purpose of the board. If the board is to be used primarily for sealing purposes, and other insulation will cover the board, use an easy to cut board. If the board is to insulate as well as air seal, pick a board with an insulation value closer to the insulation value of the other surfaces in the same space.

6.3.2.6 Outlet and Switch Plate covers

Plate covers are priced per item. Labor can vary depending on the amount and placement of furniture that must be moved to reach the outlets.

6.3.2.7 Other

Other air sealing materials include sheet metal for use in areas requiring heat resistance, plastic bags filled with fiberglass insulation used to stuff holes, and other creative materials appropriate for totally stopping air movement.

6.3.3 Detailed installer data influencing price

The following information should be collected by the estimator at the time of the initial inspection so that a proper estimate can be made and crews can come to the job properly prepared and well informed about the scope of the project.

6.3.3.1 Location and Number of locations for air sealing

The data collection system used should record the types of surfaces requiring treatment. this count of holes can be used to create a per hole estimate to do the required air sealing. Check your estimate for all holes against a common sense level of effort.

6.3.3.2 Access to spaces that will require air sealing

Gaining access to a space can increase the cost of your bid. A space may require a hole to be cut to allow access and the hole resealed for fitted with a reopenable door.

6.3.3.3 Head clearance

A requirement to fit crew into small spaces can also affect pricing. Crawlspaces and low sloping roofs are frequently hard to access due to space limitations.

6.3.3.4 Framing layout

Balloon framing will make air sealing more difficult. The balloon framing allows for more connections between holes, meaning that the air sealing work needs to be comprehensive to be effective.

Contemporary houses or houses with lots of remodeling done to them may have framing details that are hard to seal effectively.

6.3.3.5 Ventilation required

Attics and crawlspaces require ventilation to be within most building codes. Sometimes removable ventilation caps are used to help seal up crawlspaces for the winter and still meet the code requirement for ventilation in a crawlspace.

The building code for attics typically require ventilation installed as part of an insulation job. Air sealing can help this ventilation system be much more effective.

6.3.3.6 Electrical

Do any of your tools require access to line voltage?

6.3.3.7 Knob and tube

Know and tube wiring can make air sealing an attic a very cautious process. Replacement of the wiring should be considered.

6.3.4 Incentives available

Are there incentives available for this improvement from a state agency, from a utility or from state or federal tax credits or deductions.

6.3.4.1 Tax

Discussion of tax`deductions vs tax credits.

6.3.4.2 Rebates

Types of incentives.

6.3.4.2.1 Link to national incentives lookup

See document: index.cfm
The link will take you to the DSIRE online database of energy efficiency and renewable energy incentives. This database covers all 50 states and the federal government.

6.3.4.3 Low income programs

The federal government offer low income families assistance in weatherizing their house through the Low Income Weatherization Assistance Program. Some utilities offer similar or complimentary programs.

6.3.4.3.1 Link to DOE Weatherization Program

See document: apply.html

6.3.5 Financing terms

Is this improvement eligible for financing?

6.4 Installer data not influencing price

6.4.1 Notes

Good notes taken at the time of an inspection can be very helpful to an installer.

6.4.2 Photos

Digital photography has made it easy to get pictures at the time of an estimate that you can pass on to an installer. Be sure to provide a commentary so the installer knows where the picture is in the building. Create a folder on your computer that has all the information for one building including pictures.

6.5 Links to sales skills protocol

7 Minimizing risks

7.1 Due to inaction

Uncontrolled air leakage can cause a wide range of problems. If you are doing work on a building and you do not know how to reduce air leakage you risk a wide range of performance problems. Taking control of air leakage reduces your risk from these problems.

7.1.1 Discomfort

Failure to properly air seal a building will result in the continuation of discomfort problems. Correcting the problem may involve air sealing at sites other than the sites of the comfort problems.

7.1.2 Humidity

Leaky homes can be excessively dry in the winter. Air escaping from the house carries with it moisture. Cold air entering the house is heated by the house. The moisture carrying ability of the cold fresh air is increased when it is heated, making the air dry.

7.1.3 Condensation and mold issues

Unintentional leakage of air into building cavities and assemblies may result in damage from condensation and mold. Air movement is one of the primary transport mechanisms for moisture.

7.1.4 Stack effect impacting combustion venting

Excessive depressurization of the basement due to stack effect may lead to backdrafting of combustion.

7.1.5 Undersized or oversized HVAC equipment

If you do not know how leaky a building is, how do you know how big to make the heating equipment? Heating contractors will tend to put in larger equipment that costs more and uses more energy, just to be safe. If you know a house is tight, and especially if you measure the air leakage, you can reduce the HVAC equipment size and save money on installation, on operation and have occupants that appreciate a quiet and comfortable house.

7.1.6 Frozen pipes

Cold air blowing on pipes is a major cause of frozen pipes.

7.1.7 High bills

Failure to properly air seal a building will result in continued high energy costs.

7.1.8 Radon

Radon is a cancer-causing, radioactive gas that occurs in various regions of the country. You can't see, smell, or taste radon. But it may be a problem with or without air sealing. Radon test kits are available at low cost and are worth the expense.

7.1.8.1 Link to EPA - Click the link to see if your region has radon.

See document: zonemap.html

7.1.9 Ice Dams

Ice dams result from heat entering the attic and melting snow that is lying on a roof when the outside air is cold enough to refreeze the melted water as it reaches the edge of the roof. [Picture] Though the effect is frequently attributed to poor attic insulation, high rates of air leakage, even through the attic insulation is frequently the source of the problem. Adding additional attic ventilation will not reduce the air leakage rate. Air sealing is often the best solution.

7.1.9.1 Link to Home Energy

7.1.9.2 Link to Minnesota Department of Commerce

7.1.9.3 Link to problems

See also: Reduced ice dams

7.2 Due to action

When undertaking air sealing, be careful of these things. These things may already be hazards without doing any air sealing, but may be aggravated if not addressed before or during air sealing.

7.2.1 When NOT to do air sealing

When moisture might be an issue. Look for any signs of mildew, mold or structural rotting. If moisture is causing a problem then take control of the moisture source before air sealing.

If there are gas appliances, carbon Monoxide might be an issue. In general. a carbon monoxide detector should be installed as part of any air sealing effort.

Heating equipment may have an issue. If there are any signs of backdrafting or inefficient combustion, have it tested by an HVAC technician.

Unvented space heaters will be used at any time over the year.

If there is a whole house fan that is used regularly. Customers need to be educated to the risk associated with whole house exhaust fans and combustion equipment

Rodents or insect infestations might be an issue. Be sure to figure this out first if there might be a problem.

Houses on slabs are traditionally tighter (air sealing just the attic might even cause a problem with lack of ventilation). Often areas of slab around plumbing pipes are boxed out to that the plumber has enough space to modify the pipe location in the dirt. These need to be covered and sealed. Also, the joint between the slab floor and foundation wall needs polyurethane or silicone caulk to reduce soil gases.

7.2.2 Relationship of combustion venting to air sealing

The relationship between the combustion zone and the living space is a primary datapoint.

Always install a carbon monoxide detector as part of any air sealing effort.

Is the combustion equipment in a zone with an air handler - with leaky ducts?

Isolating and sealing the combustion zone from the living space should be a priority – in southern climates, this reduces humid summer air into the living space.

Is a combustion air vent necessary? For a standard water heater, you need a 6- inch vent? 1 square inch per 1000 Btu's.

7.2.3 Reduced air exchange

Sealing up a building will reduce the amount of air entering the building. The best way to determine if you have done enough and not too much sealing is to do a blower door test. Another option is to seal up a building as much as possible and then supply fresh air via a mechanical ventilation system.

7.2.3.1 Link to mechanical ventilation solutions

See also: Mechanical ventilation

7.2.3.2 Link to Home Energy article on building tightness

See document: 930309.html

7.2.3.3 Link to National Research Council Canada

See document: 14_e.html

7.2.4 Fire hazards

Recessed lighting fixtures and chases around chimneys are the typical air sealing locations where special precautions should be taken.

Recessed lighting fixtures can be sealed using a sealed sheet rock box built around the fixture and sealed to the attic ceiling. Or older fixtures can be replaced with sealed fixtures. Consider switching the light bulbs to compact florescent bulbs. They use less energy and produce considerably less waste heat.

Chimney chases can be sealed using metal to bridge the gap from the chimney to the framing and sealed with caulking resistant to high temperatures.

7.2.4.1 Link to Fire Code

7.2.5 Vermiculite Insulation

Vermiculite insulation can contain asbestos. For more information on handling vermiculite, follow the link for information from the US EPA.

7.2.5.1 Link to EPA

See document: insulation.html

8 Links

8.1 Building science information

8.1.1 Stack effect

The “stack effect” occurs when there are leaks in the top and bottom of a home, so that warm air flows out the top and cold air is then drawn in through the bottom. [insert picture]
A tight home “envelope” (walls, floors and roof) is one of the most important aspects of an energy-efficient home.

8.1.2 Moisture and air flow linkages

See document: 951108.html
Air flow is the primary way that moisture moves through a building. tests have shown that putting a hole in a wall, such as an electrical outlet, allows ten times as much moisture to go through the wall. So stop the air movement and you stop almost all (roughly 90%) of the moisture movement.

8.1.3 Air is a fluid, cfm in = cfm out

If a cubic foot of air is leaking into a house, an identical cubic foot of air is leaking out [insert picture], except that the air leaking out is now warmed up and carrying moisture. So if you feel cold air leaking in at a door, you can be sure that hot air is leaking out. If it did not, the house would keep increasing its air pressure to the point that it would explode, We do not see houses exploding in the winter from the cold air leaking in.

8.1.4 Sources of air pressure

The main sources of air pressure are:

Internal pressures resulting from stack effect or hot air rising. This occurs whenever tempeatures inside a building are higher than the outside air temperature. As the temperature differences increase, such as in cold weather, the pressure difference increases. As the pressure difference increases, the flow through holes connected to the outside increases. Some holes will leak in and others will leak out depending on their placement in the building and other factors. Combustion air flow up chimneys is another example of stack effect. Remember that air can flow down chimneys if the air pressure in the house is low enough. Chimneys can also compete with each other. the large amount of air going up a fireplace chimney can sometimes create negative pressures in a house that might cause a hot water flue to backdraft or pull combustion air into the house..

External and internal wind pressures resulting from wind effects. Wind varies by location and also by exposure. Trees, bushes and other buildings can reduce the effect of wind.

Internal pressures resulting from mechanical systems such as kitchen exhaust fan, dryers, or blowers on HVAC equipment. Fans can create a powerful pressure difference in a building, while they are running, if there is not a balancing flow. This effect is often felt when entering a restaurant in the winter. If the powerful fans pulling air out of the kitchen do not have an equally powerful fan pulling air into the restaurant, then when the front door is opened, it may become the easiest place for air to enter the building. Unbalanced flows from fans can create pressures that can pull air down chimneys. Leaky ducts or supply air registers isolated from return air grilles also create air pressure differences that affect other holes through the building envelope.

[insert picture]

8.1.5 Intro to blower doors

A blower door is a large calibrated fan that hangs in a door and measures how leaky a building is. [insert picture]. The blower door measures air movement at a specific pressure. You can then make a very good guess at just how leaky the building will be on a cold winter day. Blower doors tell you how tight a building is, so you can tighten it up and know when you need to add mechanical ventilation. Blower doors can help you feel where leaks occur.

Blower doors when combined with pressure testing gauges (manometers) can help you tell if inside parts of a building are really connected to the outside.

8.1.5.1 Link to DOE for more information on blower doors

See document: mytopic=11190

8.1.5.2 Link to Bob Vila with George James video

See document: 41.html

8.1.5.3 Link to Home Energy Magazine

See document: 940110.html

8.1.6 Intro to Combustion Appliance Zones

8.1.7 Mechanical ventilation

There are a wide range of mechanical ventilation solutions available.

8.1.7.1 Link to LBNL

8.1.7.1.1 Cost of Mechanical Ventilation calculator

See document: program.html

8.1.7.2 Link to Home Energy

8.1.7.2.1 Types of mechanical ventilation systems

See document: 000511.html

8.1.7.3 Link to Minnesota Department of Commerce

8.1.7.3.1 Indoor Ventilation

See document: Indoor_Ventilation_110802042008_IndoorVent.pdf

8.1.7.4 Link to Natural Research Council Canada

8.1.7.4.1 Mechanical Ventilation and Air Pressure in Houses

See document: cbd245_e.html

8.1.7.5 Link to PATH Toolbase

8.1.7.5.1 Whole-House Mechanical Ventilation Strategies - Details

See document: techDetails.aspx

8.1.7.6 Link to Minnesota Coop Extension

See document: DK7284.html

8.1.8 Pressure Diagnostics

8.1.8.1 Link to Home Energy

8.1.8.1.1 User Friendly Pressure Diagnostics

See document: 940908.html

8.2 Links to related best practice procedure sections

These links contain more detailed information including applicable standards and best practices using performance testing tools and building science knowledge.

8.2.1 Blower door testing

See document: Performing a Blower Door Test - Procedure CA 080604_CM.doc

8.2.2 Combustion safety

See document: Inspecting Combustion Appliance Zones - Procedure 080604_CM.doc

8.2.3 Visual inspection of the building envelope

See document: Inspecting the Thermal Boundary - Procedure CA 080604_CM.doc

8.3 To outside sources of information

8.3.1 Home Energy Articles

See document: www.homeenergy.org

8.3.1.1 Subtopic

8.3.1.2 Air Sealing in Occupied Homes

See document: 951111.html

8.3.1.3 Beauty and the Beast Upstairs

See document: 950309.html

8.3.2 DOE

See document: buildings.html

8.3.3 PATH

See document: www.pathnet.org

8.3.3.1 Air Leakage

See document: tertiaryT.asp

8.3.4 EPA Home Sealing info

See document: index.cfm
See attachment(s): EPA Home Sealing DIY_COLOR_100_dpi.pdf

8.3.5 EPA New Homes Air Sealing

See document: index.cfm

8.3.6 Oikos Air Sealing Guide

See document: index.html

9 Maximizing benefits

9.1 Energy savings

9.1.1 Focus on air leaks at the top of the building

Since hot air rises, you can be most effective if you start air sealing at the top of a building. Sealing air leaks into attics also requires less special care than sealing a leaky window or door.

Basements should be next on your list.

Remember that a big hole anywhere will be leaky, but a small hole in the attic will leak more than the same sized hole at a window.

9.1.1.1 Link to National Research Council Canada

See document: cbd104_e.html

9.1.2 Weatherstripping more expensive to seal

Weatherstripping is one of the most expensive ways to do air sealing. It is more labor intensive per same hole size than caulking or sealing and the materials wear out more quickly than sealants since they are subject to movement when doors and windows open and close.

Weatherstripping a door or hatch into an attic can save energy. Even though you can't feel it from inside the house, hot air is leaking out.

Note that apartments or larger buildings may have a large percentage of the holes in the building envelope associated with operable windows.

9.2 Controlling condensation

9.2.1 Combine air sealing with mechanical ventilation

You can air seal more completely and get more energy and non energy benefits if you also provide a building with mechanical ventilation. Controlled ventilation is almost always less expensive to operate than uncontrolled infiltration.

Uncontrolled infiltration is also not a reliable source of ventilation. It provides too much fresh air when it is cold out and not enough fresh air when the weather is mild.

Ventilation systems can be installed where building occupants produce moisture. This will help control moisture levels.

9.3 Comfort

9.3.1 Focus on leakage sites near sitting areas

It often makes sense to target extra air sealing in the living space in areas where building occupants tend to sit, for food or television or to read a book. This will increase comfort and allow the occupants to be comfortable at a lower thermostat setting.

9.4 Using Infrared

See attachment(s): IR of pipe penetration.JPG
Use an Infrared (IR) camera, especially in combination with a blower door, to help you find leaks quickly. IR cameras are also very effective in helping to sell the job. The picture shows an IR image of air leakage at a pipe penetration.

9.5 IEQ

9.5.1 Radon

Isolating a basement or crawlspace from the upstairs reduces stack effect and reduces the flow of radon into the living areas of a house. This is not a replacement for a radon control system but can help reduce already low levels radon to an even lower level.

9.5.2 Exposure to crawl spaces or basement air

Unconditioned basements and crawlspaces contain all sorts of contaminants. Sealing between the basement or crawlspace and the living space reduces stack effect and limits the entry of contaminants into the living space.

10 Other Resources

10.1 Videos

10.2 Checklists

10.3 Audio

10.4 Forms