Level 1 Protocol: Air Sealing Home Improvement

1.0 Why Air Seal?
Cost: Sealing air leakage can be one of the most cost-effective ways to reduce heating and cooling bills. Infiltration can be as much as 30% of a home's energy bill, more in cold climates and less in mild climates.

Comfort: Air sealing may improve comfort by reducing drafts, reduce dust levels as well as minimize the impact of outside noise within the house.

Durability: Controlling air leakage from the house into the attic may also minimize attic mold/moisture condensation and formation of ice dams.

Profit: Becoming a competent contractor in the detection and sealing of air leakage pathways can create a niche in the market place where the practitioner gets a name as a unique contractor known for quality work.

2.0 What is Air Sealing?
A certain amount of fresh air entering a home is required for ventilation of the home by building code. Ventilation can occur through planned openings in the structure such as opened windows, ventilation systems, vent grills, etc. Air movement or "leakage" through openings not intended for this purpose, however, is not desired. Openings such as unsealed gaps between window frames and rough framing, holes for wiring and plumbing penetrations, gaps between sheathing and framing, etc. all can allow substantial amounts of air to enter or leave the building. Cold or warm air entering the building is called infiltration and leaving the building is exfiltration. Building and ventilation design strategies do not take into account infiltration and exfiltration.

The goal of air sealing to realize the benefits mentioned in the "Why Air Seal" section through the sealing of these unintended avenues for air flow. The air sealing contractor will find and seal these areas of infiltration and exfiltration and then monitor the effectiveness of these activities.

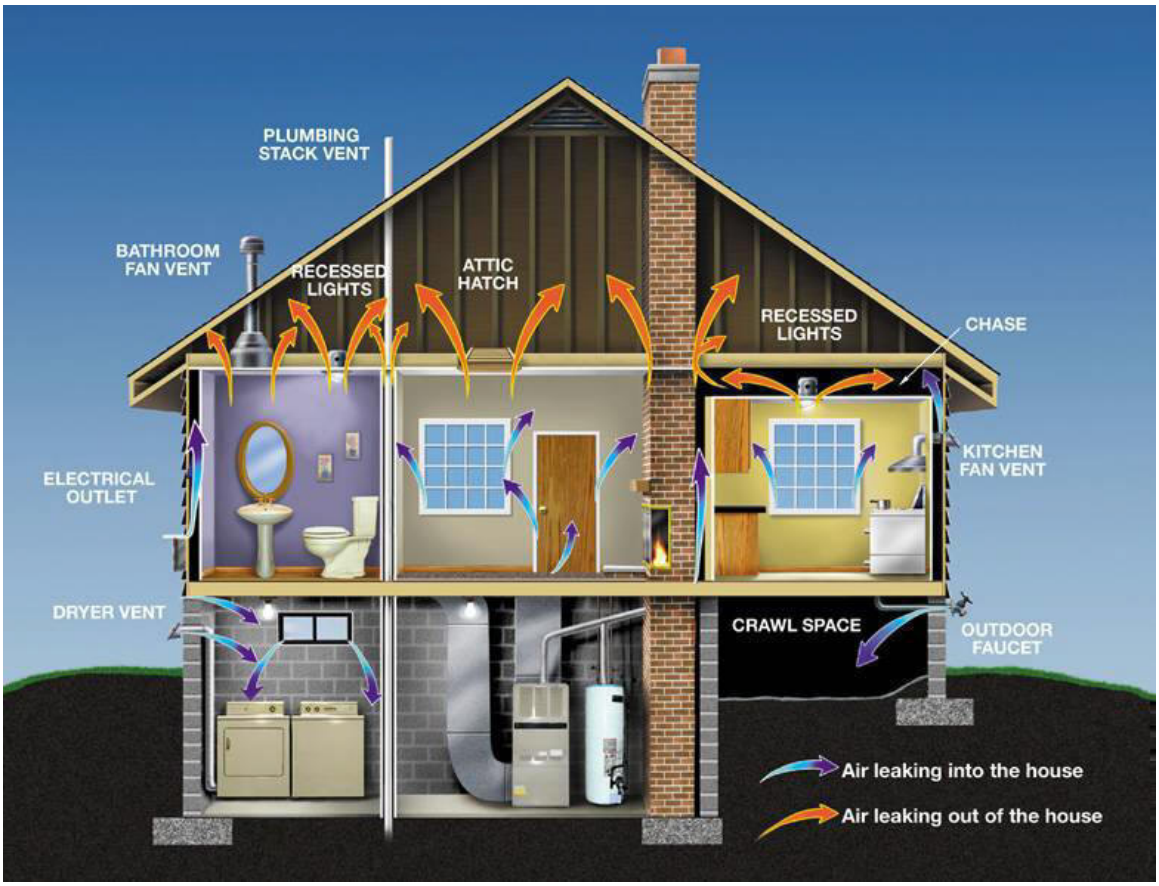
3.0 How Air Moves
Air moves from one side of a building to another based on pathways and pressure differences. A hole with no pressure difference will not experience infiltration or exfiltration. Natural sources of pressure include wind and the effect caused by warm air rising called "stack effect". Stack effect comes about because warm air is less dense than cool air and will ascend. Chimneys work based on the principle of stack effect. Air movement in the reverse direction is also possible through this phenomenon. Cool air, being more dense, will settle. An example of this situation is the flow of cool air during a winter day down a chimney connected to a fireplace that is not being used. Some customers may complain about the difficulty of getting their fireplace to properly draft due to this downdraft of cool air.

Pressure differences can also be produced as a result of the operation of mechanical equipment. Kitchen range hoods, clothes dryers, exhaust fans and forced-air distribution systems can all induce pressure differences between the house and exterior that may cause air to move in or out of the house.

When pressure is higher within the house relative to the outdoors, air will travel from the house to outdoors. When pressure within the house is lower relative to the outdoors, air will enter the house. The same volume of air entering or leaving the house will leave or enter the house, respectively, using different pathways possibly located in other areas of the structure. Air can not continually exit a house without being replaced in some fashion by air brought in. It follows that air can not be continually brought into a house without it exiting the structure. Knowing the factors causing pressure differentials and potential pathways for infiltration and exfiltration will assist contractors to diagnose and properly prescribe the cure to effectively seal the structure.

3.1 Common Air Pathways

This diagram shows common pathways used by air to enter or exit a home.



Source: EPA Energy Star

The brown arrows represent exfiltration and the blue arrows describe infiltration. As air is heated, it will rise and flow through holes or gaps between ceiling finishes and chimneys, attic hatches, recessed lights, etc. The loss of this air will cause makeup air to be drawn into the home through dryer vents, exterior outlet penetrations, and other penetrations through the foundation wall.

The air sealing contractor will identify these conditions and correct them in a manner that is economical to the client and allow the home to perform as intended.

4.0 Common Diagnostic Tools
In order to identify how a home behaves with respect to air flows, an arsenal of tools is available with varying degree of cost, complexity, and expertise required for operation.

The most basic tool is the contractor's ability to discuss issues with the homeowner. The homeowner has the most intimate knowledge of how the home has been behaving through the various seasons. Walk through the home with the homeowner and ask probing questions about comfort, drafts, HVAC equipment operation and performance, fireplace operation, energy bills, cold spots or moisture development in various parts of the home, etc. Visually investigate the home for evidence of air flow such as staining as a result of moisture/mold, darkened insulation acting as a dust filter, peeling paint, cobwebs in "enclosed" areas, and obvious gaps or daylight showing through surfaces that should be sealed.

During winter and if the roof is snow covered, evidence of exfiltration into the attic might manifest itself as stripes of melted snow between the rafters or roof trusses. The warm air leaking into the attic can melt the snow between these framing elements. Ice dams can be another indicator of this condition.

A more sophisticated tool to diagnose building tightness (the exterior walls and ceilings, sometimes called the shell or envelope) is a blower door. This device is a calibrated fan that creates a positive or negative pressure within the home with respect to the outside. Using the volume of air moved by the blower door fan at a particular pressure differential, a contractor can determine the tightness of the envelope. Ideally, air tightening activities will be performed after a blower door test in order to obtain a tightness reading before and after work has been performed.

Other tools used for tightness evaluation include infrared imaging cameras, boroscopes, and infrared digital thermometers. Infrared imaging cameras depict temperatures as different colors or shades of gray. Homes with a large temperature difference between the interior and exterior can be viewed with this camera to visually determine where temperature changes occur on wall or ceiling surfaces. These changes are indicative of air movement or insulation voids.

Boroscopes are typically fiber optic cameras inserted through small openings in walls or ceilings to inspect concealed spaces. This tool permits a visual inspection for areas commonly obscured and concealed from view.

Common thermometers measure the temperature of air. Infrared thermometers measure the temperature of surfaces. Once can get close to arriving at a surface temperature using a common, bulb-type thermometer, but the reading is only an approximation. Infrared thermometers can provide surface temperatures on a small spot in order to quickly scan a surface in order to determine cold spots. Again, a cold spot might indicate a nearby air leak.

5.0 Air Sealing Techniques
Home sealing contractors best perform their work when a house is analyzed and air sealing techniques are selected to "give the most bang for the buck". In other words, air

leaks will always exist in a house and it is not economically feasible to stop all of these leaks. Picking the low hanging fruit or attacking the problems that are easiest to address is typically the most economic route for the homeowner. Experienced contractors often have a hierarchy or a rank list of air sealing activities proposed to homeowner clients. Such a list is shown below:

1. Attack the biggest holes first. These permit the most air to enter or escape and have the greatest impact upon energy cost and occupant comfort.
2. Start with the least expensive fixes. Replace worn weather stripping, gaskets, inoperable dampers or louvers.
3. Move from the attic downward. Plugging penetrations from the living area to the attic minimizes the impact of stack effect and potential to negatively impact ventilation required for healthy indoor air quality and combustion appliances.
4. Seal interior living spaces where people spend the most time. While perhaps not addressing the most important leaks affecting energy cost, it can have a great impact upon occupant comfort.

Specific air sealing techniques by building component will be addressed in *Level 2 Protocol: Air Sealing Home Improvement.*

6.0 References and Suggested Reading

Krigger, J. and Chris Dorsi. 2004. Residential Energy: Cost Savings and Comfort for Existing Buildings. Saturn Resource Management, Inc. Helena, Mt.

Oikos, 1993. Advanced Air Sealing. Iris Communications, Inc. http://oikos.com/library/airsealing/index.html