



COMMONWEALTH SUSTAINABILITY WORKS

540/219-8912 / PO Box 633, Culpeper, Virginia 22701
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Energy Audit Report: May 4, 2010

- Audit performed and report prepared by Andrew Grigsby, HERS #9004, BPI #10114

SUMMARY:

Your house is sturdy and well-built – but lacks sufficient insulation and efficient heating/cooling. Basic air-sealing is a cheap and effective first step towards increased comfort and lower energy costs. Next, you need an affordable way to make heat in the winter – baseboard electric is very inefficient. I recommend a new heat pump – located in a conditioned crawlspace. The attic needs air-sealing and increased insulation. It would be great to add insulation to the walls somehow – but I don't see an affordable way to make that happen at this point. The remaining improvements are fairly minor: water heater insulation, efficient light bulbs, etc.

TEST RESULTS:

Blower Door Test (depressurization)

Test Date	April 27, 2010
Building Volume	11060cf
House to Outside Pressure	-50pa
Blower Door Ring	open
Fan Flow	3650cfm50
ACH50	19.8
ACHnatural	.99 (N=20)

This measurement of the draftiness of the entire house showed the house performing poorly: 19.8 air changes per hour at the standard testing pressure of 50 pascals – or .99 air changes per hour under normal conditions. A lower score indicates a tighter house. This is well above the target score (.35ACHnatural) for a non-mechanically ventilated house.

This indicates that during cold months, the house loses a great deal of its heat through the many drafts throughout the house. Even if the wind is not blowing through these holes, natural convective currents form, causing warm air to exit out of holes in the ceiling to be replaced by cold air entering the holes down low. Many of these air-leaks can be corrected with low-cost caulk and canned foam.

There is no need to worry that air-sealing work will cause the house to be so tight as to require mechanical ventilation. However, if extensive air-sealing is performed, a follow-up blower door test is recommended.

EFFICIENCY RECOMMENDATIONS (presented in order of cost-effectiveness):

1. First, stop the drafts. Stopping simple air leaks provides significant energy savings with little effort. A penetration through the drywall or subfloor is an opportunity for a draft that compromises health, durability, and efficiency.
 - a. Seal around bath fans: remove cover and caulk metal housing to drywall.
 - b. If the attic-based air handler and duct system will not be used, the supply and return vents should be covered over to make air-tight – either from the living space or the attic.



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- c. Seal around plumbing penetrations: use foam or caulk to fill gaps where pipes disappear into drywall or the floor of kitchen/bath cabinets
- d. Use pre-cut foam gaskets to seal behind electrical outlets and switchplates
- e. Repair/replace worn weatherstripping around doors.
- f. Seal baseboards to floor with a tiny bead of caulk.
- g. Fill any gaps in plaster/drywall: at baseboard, at ceiling/wall intersections, behind/adjacent to baseboard heaters, etc.
- h. Fill old chimney flues with a small garbage bag stuffed with fiberglass insulation.



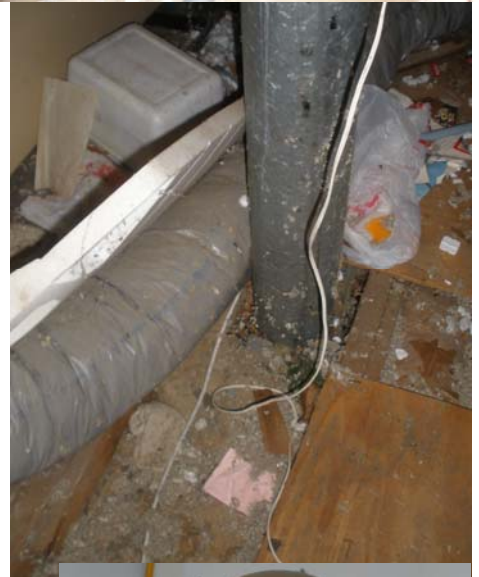
2. Install a high-efficiency heat pump:
 - a. Baseboard electric heat is about the least affordable heating option for this climate – especially for a nearly un-insulated house. A high-efficiency heat pump that provides heating and cooling would be the most cost-effective option. The only challenge is installation.
 - b. While there is currently an air handler and duct work in the attic, the unfinished crawlspace provides a much better location. This area easily can be made conditioned space. Ductwork to the north rooms could be run through a dropped soffit adjacent to the wall between the kitchen and dining room.
3. Close and condition the crawlspace.
 - a. Remove stored items temporarily
 - b. Excavate dirt and provide support to piers and foundation walls as needed. Excavate to create flat, usable floor space.



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- c. Install a vapor barrier over the bare earth: 10mil plastic sheeting adhered to the foundation wall and piers. If the crawlspace is to be used extensively for storage, pour a thin (2") concrete slab over the sheeting where needed.
 - d. Insulate the foundation walls with encapsulated fiberglass blankets – R-10 minimum. Insulate the band joist at the perimeter of the house with spray foam – R-20 minimum.
 - e. Provide conditioned air to this space as needed.
4. Re-insulate the attic:
- a. Temporarily remove stored items.
 - b. Remove old HVAC equipment.
 - c. Seal with caulk, canned foam, and drywall all penetrations in the attic floor. Cover over old HVAC registers, seal around pipes, wires, the chimney, etc.
 - d. Use 2x6 lumber to build a floor joist system over the existing joists, oriented perpendicular. Use this framing to create a box around the opening for the stairs.
 - e. Construct an insulated, sealing cover for the stairs: 6" of foamboard with plywood and weatherstripping.
 - f. Blow in additional cellulose insulation, ½" above the new joists.
 - g. Replace the plywood floor.
5. Improve water heater operation
- a. Insulate all visible hot water pipes with foam sleeves. Insulate the cold water pipes also to keep them from sweating in summer. Insulation should be applied carefully to evenly cover the entire pipe. Gaps in coverage of as little as 3% can reduce effectiveness by 50%.
 - b. Add an insulation jacket (encapsulated fiberglass) to the water heater.
6. Continue replacing windows and doors with insulated models. Seek U-values of less than .35 for windows and R-Values of greater than 4 for doors. Install carefully with low-expansion foam, not fiberglass around the jambs/frames.





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7. Repair gutters.

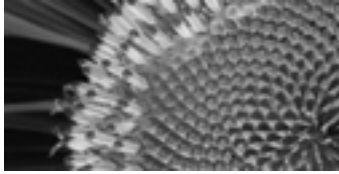


TAX INCENTIVES:

All of these improvements qualify for up to \$1500 in Federal tax credits – calculated as 30% of materials cost – see http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US43F&re=1&ee=1.

MISCELLANEOUS EFFICIENCY SUGGESTIONS

1. Always turn off un-used electronic equipment (printers, scanners, copiers, laptop chargers, battery chargers, etc.). See http://en.wikipedia.org/wiki/Phantom_load. If it has a light on – it is using electricity – perhaps needlessly. This is easy if connect everything to a surge-protection power-strip.
2. Use proper power management with computers. Set them to go to “sleep” and power off when not in use. In Windows, go to start; control panel; performance and maintenance; power options. See also http://www.eere.energy.gov/consumer/your_home/appliances/index.cfm/mytopic=10070).
3. For more good ideas, see the *Consumer Guide to Home Energy Savings* published by The American Council for an Energy Efficient Economy - <http://www.aceee.org/store/proddetail.cfm?CFID=569382&CFTOKEN=28344766&ItemID=367&CategoryID=3>

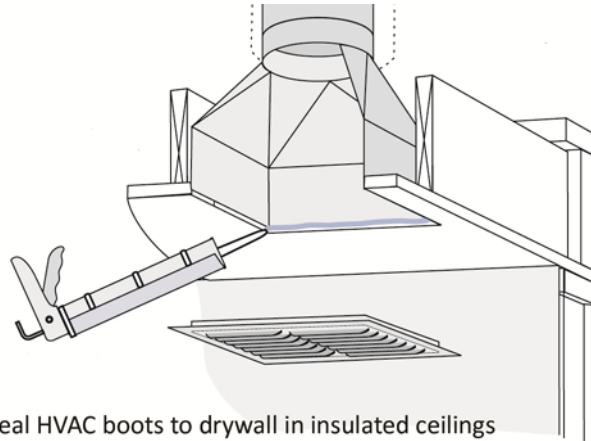


CONSTRUCTION DETAILS

INTERIOR AIR SEALING

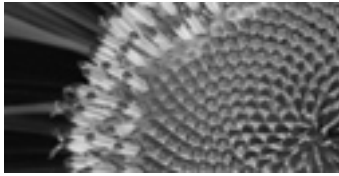
Draftiness – known in the business as “unintended infiltration” – typically is the primary cause of excessive home power use.

1. **All penetrations in ceilings should be sealed** to keep warm interior air from escaping to the attic. Start with the bath fans. Remove the covers and fill the gap between the metal housing and the drywall. Do the same with all HVAC registers – both supply and return.
2. **Seal electric outlets and switches in exterior walls.** Use pre-cut foam gaskets available at most hardware stores. The goal is to eliminate airflow from interior space into the wall. Again, to be thorough, do the interior wall switches as well. These connect to framing which connects to outside air leaks.
3. **Doors:** All exterior doors should close and seal tightly. Worn or non-functional weather-stripping, sweeps and thresholds should be replaced. This is not a difficult job, but must be done carefully to be effective. Adjust the position of the weather-stripping and sweeps to make good contact – blocking drafts while allowing for easy function of the door. Cheap, stick-on foam strips rarely last long. Rigid, nail-on varieties are superior to stick on if the application allows. The best weather-stripping devices are silicon held in place by a “foot” embedded in a kerf-cut. See http://www.conservationtechnology.com/building_weatherseals.html.
4. **Foam and caulk around plumbing penetrations.** Canned foam with a straw applicator allows the insulation to penetrate into walls – which minimizes freezing in winter. Recommended for all penetrations into or through exterior walls or floors.
5. **Windows:**
 - Adjust sashes to enable proper function and tight closure.
 - Storm windows should be caulked on the top and both sides – not the bottom.
 - Double-hung windows should close tightly – with the lock pulling the sashes together.
 - Consider insulated blinds or curtains. These can easily triple the R-Value of older windows. Google “thermal blinds”.
 - If you ever remove the interior trim, seal any gaps around the window framing with low expansion canned foam.
 - When replacing windows, seek U-Values below .35.



More air-sealing tips and details at

- http://www.southface.org/web/resources&services/publications/technical_bulletins/AS-Airsealing%2000-767.pdf
- <http://www.nrel.gov/docs/fy01osti/28039.pdf>.



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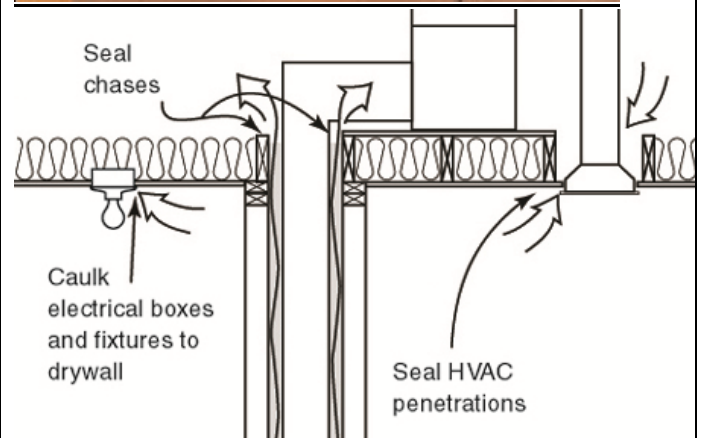
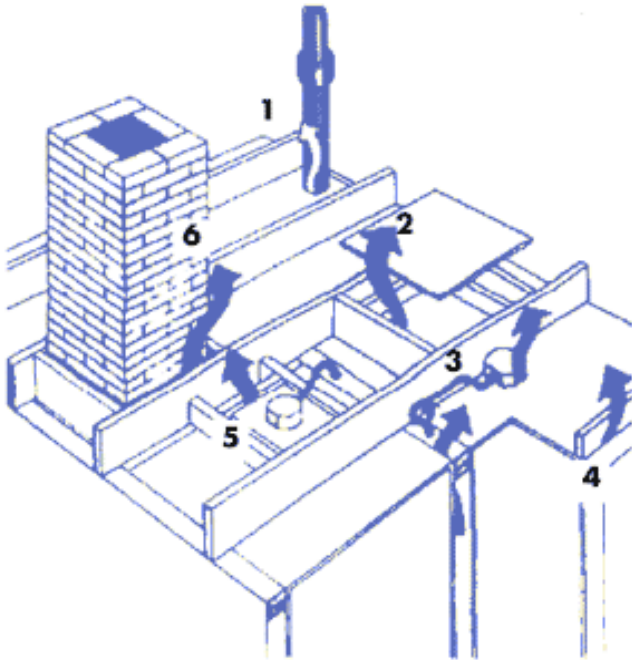
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IN THE ATTIC

Everyone knows warm air rises and we should insulate our attics, but most attics are not properly insulated. Careful air-sealing is equally important – and is even more rare. Use temporary walk-boards to make prep work easier and safer.

SEAL THE ATTIC FLOOR (for un-conditioned attics.)

Pull back the existing insulation and seal all electrical and plumbing penetrations where wires and pipes enter the attic from below. Use canned foam or caulk to fill holes in framing or drywall. Chases around ductwork should be filled and sealed. Chases around chimneys and stove pipes should be shielded from contact with insulation with non-combustible material (metal flashing) and sealed with fire-proof caulking.





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RAISE FLOORS AND WALKWAYS TO ACCOMMODATE THICKER INSULATION

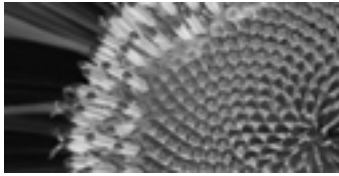
In unconditioned attics, if the existing joists (or bottom members of the trusses) at the attic floor are less than 10 inches tall, add a new joist system over the existing to create enough room for adequate insulation between the ceiling below and the floor of the attic storage. Be certain that the joists or bottom truss members are strong enough to handle the weight of a floor and stored items. Install 2x6 or 2x8 lumber on edge perpendicular to the existing floor joists and deck with plywood.



ATTIC STAIRS

If the attic is not conditioned, this is a door to the outside and should be air-sealed and insulated – either by building a cap above the existing stairs or by buying a new set that includes an insulated, sealing door. Insulated attic stairs manufactured by Fakro, Rainbow Attic Stair, Calvert USA, Rintal, and Battic Door. Pre-fabricated caps for existing stairs are also available. See <http://www.batticdoor.com/atticstairinsulator.html>





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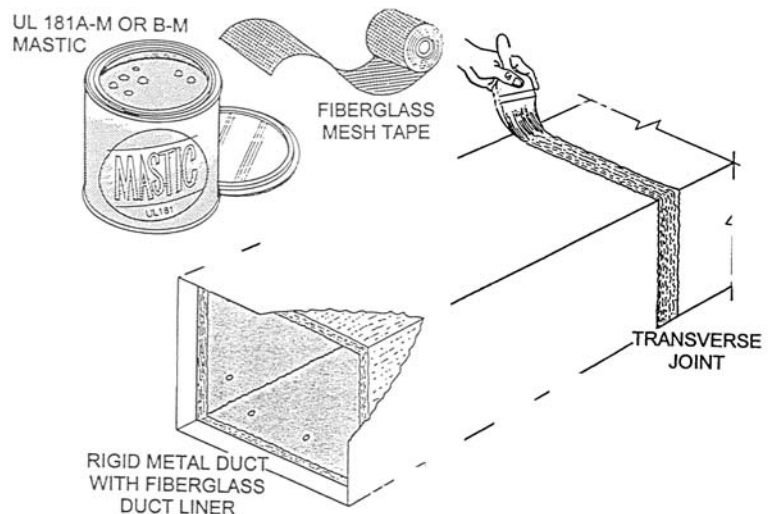
INSULATE ATTIC FLOORS TO R-50, MINIMUM

For Northern Virginia, the Dept. of Energy recommends R-49. Install loose cellulose over existing insulation to at total combined depth of 14 inches. Cellulose settles to stop the convective currents that form in uncovered fiberglass. Further, cellulose is a recycled product without added formaldehyde (a known carcinogen). Professional installation is affordable, or do this yourself with a blower available for rent at most large home improvement stores.



HEATING, VENTILATION, AND AIR CONDITIONING (HVAC)

All duct work should be as air-tight as possible, particularly any that is located in unconditioned spaces. Paint over all joints and seams with mastic – a fiber-reinforced paint-on adhesive sold for less than \$20/gal. For large gaps, cover with a mesh-type drywall tape first. Mastic creates a permanent, air-tight bond. It is cheaper and easier to use than tape.





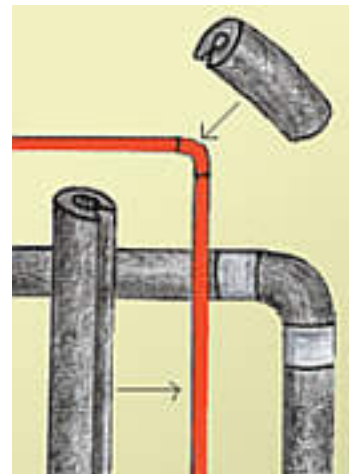
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WATER HEATING

Water heating accounts for approximately 10% of the energy use in most homes. There are a variety of ways to maximize efficiency of this system:

- **Temperature setting:** Set your water heater thermostat to 120°F. This is plenty hot for all household applications.
- **Heater insulation:** If your water heater is warm to the touch, you'll benefit from adding a "blanket" of insulation. These cost less than \$20 at most hardware stores.
- **Turn it down when you're gone:** Use the vacation setting on gas heaters – or cut off the breaker for electric heaters (unless the electric model is located in unconditioned space). It's a myth that it takes more energy to bring it back to temperature than to maintain a constant 120°.
- **Insulate water pipes:** Effective insulation covering hot water pipes improves efficiency and can raise water temperature at the faucet by 2°F – 4°F. This also helps conserve water since you won't have to wait as long for hot water at a faucet or showerhead.
- Insulate all accessible hot water pipes – including the first three feet of cold water pipe as it enters the water heater. You may also want to insulate all of the cold water lines to reduce sweating in warm weather.
- Insulating foam sleeves cost less than 30 cents per foot. Most are self-sealing – or use duct tape. For gas-fired water heaters, use 1-inch thick un-faced fiberglass pipe-wrap within 8 inches of the flue. Secure with foil tape or wire. Read a thorough article with installation instructions at http://www.leaningpinesoftware.com/hot_water_pipes.shtml. See also http://www.energysavers.gov/your_home/water_heating/index.cfm/mytopic=13060.
- **Replacing a water heater:** Plan now for what type of equipment you might install when your current system fails. Might you go solar? Solar water heating typically is the most cost-effective application of renewable energy. Would a tankless water heater make sense? If your house is often empty or you have remote faucets, this can be a money saver. How about a combined heat/hot water system? Do you have an electric system but would be better served by gas? Do you have a gas system and would be safer with electric? There are many variables based on your home and your lifestyle.



RECOMMENDED IMPROVEMENTS: IN THE CRAWLSPACE

We can better control moisture and reduce heating/cooling load by converting most crawlspaces from vented to conditioned. The one possible benefit to a vented crawlspace is mitigation of **Radon**. Most vented crawlspaces have so little ventilation and the floor is porous enough that we obtain little of this benefit. Here's what you need to know:

- Radon is an odorless, colorless gas that is the second most common cause of lung cancer in the United



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States, resulting in over 20,000 deaths per year. An estimated 1 in 15 U.S. homes has a high level of radon. For these reasons, the U.S. Surgeon General and the Environmental Protection Agency (EPA) recommend that all homes be tested for radon.

- Test for radon by acquiring an EPA-approved radon test kit (sold at hardware stores and on-line for less than \$30). Place in the crawlspace and close the vents. This will determine whether radon mitigation must be included in the designs for insulating and conditioning the crawlspace.
- Fauquier County is in Zone 2 (out of 3), indicating moderate risk for elevated radon levels. See the EPA's map of Virginia counties' radon risk at <http://www.epa.gov/radon/zonemap/virginia.htm>. See the Virginia Dept. of Health Radon Program at <http://www.vdh.virginia.gov/rad/RHP-RADON.asp>.

Fill in the vents with pieces of rigid foamboard insulation cut to fit. Use caulk or canned foam to seal the rigid foam in place. Alternatively, remove metal grilles and install masonry to match the exterior aesthetic.

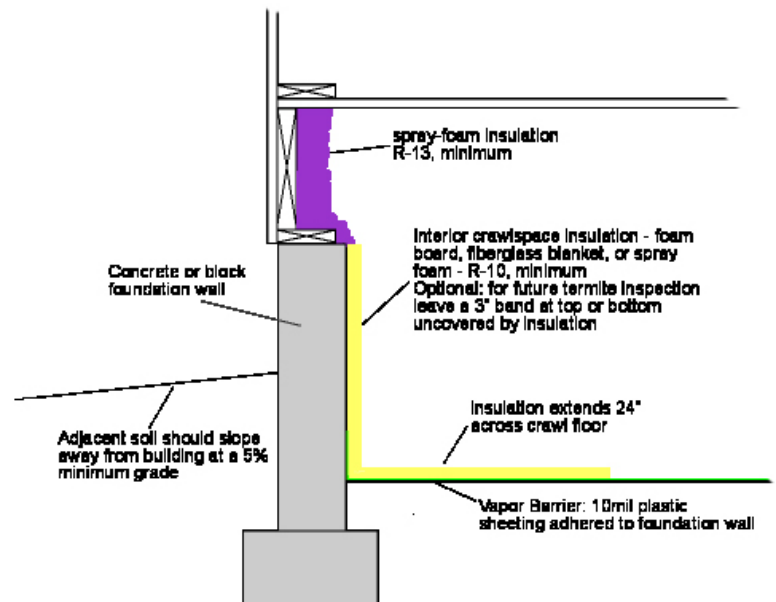
Vapor Barrier: In any crawlspace, it is this plastic sheeting on the ground that does the most to keep out unwanted moisture. Existing sheeting may be left in place. Add another layer of 6 mil. polyethylene for a complete, durable system. Seal it to the masonry foundation walls and piers with mastic. Run the sheeting up the block 6 inches to give room to apply mastic. Use the same mastic to seal joints between pieces of sheeting. These pieces should overlap 6 inches.

Insulate the band joist with spray foam.

Remove the fiberglass batts and apply foam to 3 inches thick. This provides air-sealing and excellent R-Value. Diagram below. Read an excellent article on this process at <http://www.taunton.com/finehomebuilding/how-to/articles/best-way-to-insulate-a-rim-joist-with-expandable-foam-kit.aspx?nterms=61678>. Cost for a large foam kit: \$700.

Insulate the foundation walls with encapsulated fiberglass blankets, foam board, or spray-applied foam. R-10 is sufficient. Apply to the block wall with adhesive or fasteners. The access door also needs insulation and weatherstripping.

retrofitted closed, conditioned crawlspace



Learn more at

<http://resourcecenter.pnl.gov/cocoon/morf/ResourceCenter/article/1397>
<http://www.crawlspaces.org/>