Level 3 Protocol: Insulation Installation

1.0 Background

Insulation of the building envelope reduces the conductive losses and gains by improving the envelope's resistance to heat flow. This greatly improves comfort, while reducing the energy demand and the size of appliances required for space conditioning. The effectiveness of insulation is greatly dependent on the quality of the installation.

Manufacturer's rated R-values refer to the insulation values under "best case" conditions, meaning that the coverage is complete and without voids, the material has been installed to the proper density, and that the insulation is installed with proper and integral air and vapor barriers in place. Any deviation from these installation standards will adversely affect the performance (R-value) of the material.

Insulation can be added to an existing building envelope by filling the framing cavities (floor, ceiling and wall) or by installing an additional layer of insulation, usually a rigid board type, adjacent to the frame of the envelope. Insulation should be selected for its ability to completely cover or fill the area of installation and to provide the optimum U-value for the most reasonable cost. It must also be installed in accordance with all fire, electrical and safety regulations. Personal protection equipment is required when installing blown insulation, fiberglass and cellulose or any fiberglass rolls, batts or boards. In addition, a fitted respirator and eye protection are required for the installation of these products, while gloves and coveralls are recommended.

2.0 Tools and Materials

Infrared scanner, blower door test equipment, diagnostic smoke generator, HEPA vacuum cleaner, personal protection equipment including respirators, gloves, eye protection, protective coveralls, and boot covers, heavy mil trash bags (see Level 1 Protocol for description of these tools).

3.0 Procedures

3.1 Determine the requirements and location for vapor barrier placement, with installed insulation

Vapor barriers are intended to restrict the movement of moisture into the insulation and building frame through diffusion (see Level 1 Protocol). In most climates, the vapor barrier belongs on the conditioned side of the envelope to deter household moisture from migrating into the building envelope. In climates where the outdoor air is humid, the barrier would best be located on the exterior of the wall frame. In the case of ventilated attics, the vapor barrier belongs on the conditioned side of the ceiling. Where floors are insulated, the vapor barrier belongs on the conditioned side of the floor. An integral vapor barrier is less of a concern in areas where the average yearly climate is dry and when indoor moisture is properly controlled.

- Vapor barriers are best installed at the time of construction or remodeling. Establishing a vapor barrier in an existing building – where one previous doesn't exist – has limited success due to the difficulty in assuring the continuous nature of the barrier.

- Vapor barriers can be constructed of an impermeable construction material, such as a foil faced insulation, polystyrene insulation board, or impermeable paint on the surface of an airtight drywall system, or paper such as in paper-faced fiberglass batts. Most building materials are given a perm rating by ASHRAE and most vapor barriers have a rating of less than 1 perm. Vapor barriers are only effective when envelopes are properly air sealed. Transfer of moisture carried by airflow is greater than that transported by diffusion through the envelope.

  NOTE: A vapor barrier serves a different purpose than a capillary break. Controlling moisture migration into the building frame - from wherever the frame comes into contact with the foundation or the earth - requires an interruption (capillary break) in the wicking action of the earth to masonry to wood. This is usually a material such as “Water and Ice Shield”, a water repellent mat or “Sill Seal” (a water repellent soft closed cell foam that is installed during construction between the masonry and wood).

- Air seal the envelope to prevent moisture movement from the interior to the exterior. This is especially important in areas of high moisture, such as kitchens, bath and laundry areas. Plumbing and electrical penetrations into floors, walls and ceilings should be sealed with approved materials and techniques. Ducts that extend outside of the living space may serve as a route of moisture migration and must be air sealed (see Air Sealing protocols).

Install vapor barriers in areas of potentially high moisture generation, i.e. kitchens bath and laundry areas. For drywall or similar material, low perm paint as the primer or finish coats can be an effective vapor barrier. For situations where the interior finish has not been installed, an airtight drywall system painted with low perm paint is recommended.

3.2 Insulate sidewalls with high-density cellulose.

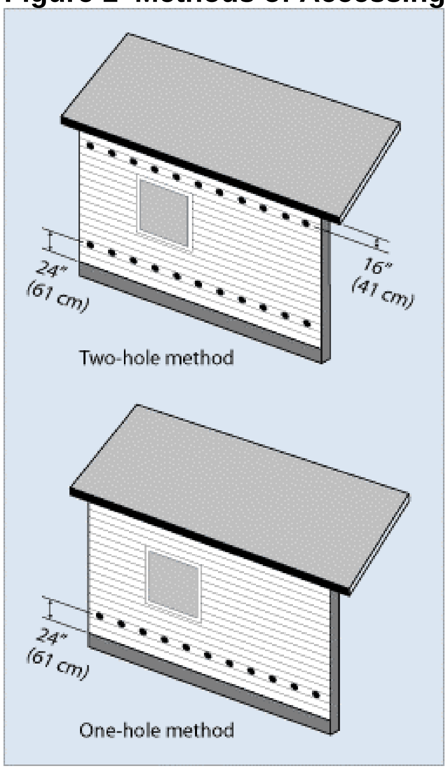
Insulating frame walls with high-density cellulose can offers a combination of benefits including energy efficiency, comfort and sound control. Properly installed high-density cellulose can provide uniform insulation coverage to all areas of the wall, including corners and along the edges of the building frame often difficult to insulate with batt insulation. In addition, high-density (3.5 pounds per cubic foot) cellulose is the preferred approach to air sealing the building frame (see Air Sealing protocols). At this density, a 4-inch wall cavity will require 1.2 pounds of insulation per square foot, and a 6-inch wall cavity will require about 1.75 pounds per cubic foot. An injection-type installation (using a hose that is inserted into the wall cavity) is preferred over an injection cone (inserted perpendicular to the wall cavity through the siding/sheathing) because air pressure is maintained and the material is more effectively delivered to the area to be insulated.

- Inspect all sidewalls with an infrared scanner from inside the building. This will help identify the frame type, fire stops, existing insulation, ductwork, etc… Capturing this image with digital photography can provide a clear roadmap to the insulation installer.
- Inspect the wall cavities for ductwork or passages used for air handling. If these cavities are to be insulated, provisions must be made to re-direct the air supply and returns so they remain operable.
- Identify any live knob and tube or aluminum wiring that may exist in wall cavities. It is not permissible to insulate over knob and tube or aluminum wiring as this creates a

potential fire hazard. Substandard wiring must be replaced before the wall cavity is insulated.

- Determine a method for accessing wall cavities. One common approach includes the removal of the exterior siding and then drilling into the sheathing. Occasionally the wall cavities can be accessed from the attic such as with balloon framed construction. If the exterior cladding is stucco or brick, access from the conditioned space though drywall or kick molding might be advised.

Figure 1 Methods of Accessing Wall Cavities



Source: U.S. Dept. of Energy Energy Efficiency and Renewable Energy

- Evaluate the lead content of any paint on the siding that will be disturbed. If the paint tests positive for lead, or if no testing has been performed, use lead-safe work practices.
  - Lay out plastic ground covers to collect lead dusts and debris.
  - Use sprayers to wet any painted surface prior to handling. Work while things are wet.
  - HEPA vacuums are used for all cleanup.
  - Personal protection equipment includes respirators, gloves, eye protection, protective coveralls, and boot covers.
  - All dust, damaged siding, disposable personal protection and gear should be double-bagged in heavy mil trash bags and properly disposed.

Remove siding by unlocking vinyl and aluminum with a zip tool to reveal the hidden nailing strip at the top of each piece of siding. Gently pull the nails from one course of siding with a thin pry bar. Remove the siding to expose the sheathing.

- When deciding upon siding courses to be removed, select a section that runs under the windows. This will minimize the amount of siding required to be removed to provide comprehensive insulation.
- For wood clapboard siding, gently pry the nails from two courses of siding with a thin flat bar and a nail puller. This will completely loosen one course of siding, which can be removed to reveal the sheathing.
- Shake siding can be easily removed by scoring the shake at the shadow line near the top of the shake, with a utility knife. Gently lift the shake from the bottom until the shake snaps at the knife score.
- Drill a 2¼ or 2½ inch hole through the sheathing. If there are no firestops or blockers in the wall system, then an 8 or 10-foot wall cavity can be insulated through just one hole, by injection blowing. When drilling this sheathing, it is important to not force the drill bit past the sheathing, or the electrical wiring in the wall cavity may be damaged by the drill bit. Through the drilled hole, probe horizontally with a tape measure or wire probe to determine the location of the next wall stud and the appropriate location for the next hole to be drilled.

Assemble the insulation blowing machine and hoses required to reach the wall cavities. Total hose length should be kept less than 100 linear feet and laid out in a straight line, to improve air pressure and minimize plugging of the hose or nozzle with insulation material.

- All hose connections should be airtight to maintain maximum pressure. The primary hose, which is usually 2 - 3 inches in diameter, transitions to the 2 ½-inch diameter injection hose (and 1¼-inch fill tubes) by way of a smooth metal reducer.
- The injection hose is usually a 6 to 8-foot, clear polypropylene hose with enough flexibility to be inserted into the wall but enough rigidity to maintain its shape throughout the application process. Use a thicker walled fill tube for warm weather and a thin wall tube for cold weather.
- Cutting the tip of the injection hose on a diagonal will help make insertion into the wall and past obstructions easier.
- During the installation, it is important to provide the right amount of air pressure and material to prevent the plugging at the reducer. Most insulation blowing machines have air pressure controls and material feed controls. The settings will be dependent on many factors including humidity, height material must be delivered, physical properties of the insulation, and the power of the blower.
- Provide power to the machine by using properly grounded house current or a portable generator. When using house current, distribute the load to separate circuits for each power cord. If the machine has a powered agitator and two blowers, then three house circuits should be utilized. All power to the insulation machine should be provided through ground fault interrupters particularly during damp or wet conditions.
- Select cellulose material that is only borate treated. It should be treated for control of flame and fire retardency and to prevent insect infestation. Borate-treated insulation is

less corrosive to metals than other treatments such as aluminum sulfate. Always select Class 1 cellulose that has the UL approval label on each bag.

- Install cellulose into the wall cavities by inserting the injection hose into the cavity with a twisting motion, until the hose is fully inserted. The hose serves as a probe, and if it cannot be inserted the full height of the wall due to an obstruction, then another hole be drilled into the wall cavity may be needed. The installer operates the blowing machine by way of a power control switch. As the cavity fills from the top down, move the hose slowly from the wall. Once the cavity above the hole has been filled, insert the hose into the cavity below the hole to complete the fill. Measure the amount of cellulose or count the bags used to fill the first 100 square feet of sidewall and compare it to the density standard of 3.5 pounds per cubic foot (1 pound per square foot for a 4" wall cavity). If the amount of material used is less than the standard, increase the air pressure for better compaction. If during the installation, the hose should continue to plug, reduce the amount of material until a balance between the air pressure, material flow and density is reached.
- Insulate the second floor band joist. This building envelope and exterior sidewall component cannot be accessed from the same holes used to insulate either the first or second floor sidewalls. Insulating band joists require removing the exterior siding at the band joist area, or accessing the joist cavity from within the building either through the first floor ceiling or the second story floor. This area is often a major air leakage point in the building envelope which can be sealed through properly installed high-density cellulose insulation.
- Complete the installation by plugging the holes in the sheathing with tapered wooden plugs to fit the drilled holes and reinstall the siding. Vinyl and aluminum siding should snap lock back in place once siding has been re-nailed into position.
- Inspect high-density sidewall insulation by depressurizing the building to 50 pascals with the blower door, and search for air leakage sites with diagnostic smoke. If a temperature difference exists between the outside and conditioned space, perform an infrared inspection after the house has been depressurized with the blower door.
- Use HEPA vacuum cleaners for cleanup.

3.3 Insulate floor and foundation areas

Establishing a thermal boundary around the foundation wall (or around the slab on grade) provides for "earth- coupling" of the building that can have energy and comfort advantages. When insulated to the proper depth below grade, an earth-coupled foundation can provide a winter heat source to the building and a summer heat sink that helps moderate extremes in outdoor air temperature. In cold climates where frost is expected, the foundation insulation should extend from the top of the foundation wall to below the typical frost depths. In climates without frost, the foundation insulation should extend from the top of the foundation, to two feet below the grade level. Extruded polystyrene is ideal foundation insulation because it can be placed on either the interior surface of the foundation or the exterior surface. This product is not affected by water or moisture. However, if this material is used on the exterior of the foundation, it requires covering to protect it from the sun's ultra-violet light. Be sure to consult local building codes as some municipalities prohibit foam products in soil contact due to termite concerns.

Figure 2 Extruded Polystyrene as Foundation Insulation

Framed floor insulation is usually installed between the joists of floors over unconditioned spaces, i.e. basements, garages and crawl spaces. Rigid foam insulation can be used, but fiberglass batts are the most commonly used insulation material. A supporting system of wire mesh fastened to the bottom of the floor joists is used to keep the fiberglass batts in place. This application does not take advantage of the principles of earth-coupling, but is often used because it is inexpensive and easy to install.

3.3.1 Foundations:

- Air seal the foundation connection to the sill plate, and any other obvious air leakage paths through the foundation/crawl space wall.
- Insulate the interior or exterior of the foundation wall with 2 inches of extruded polystyrene (R-10). Use adhesive designed for polystyrene (Dow PL-200) to affix the insulation directly to the masonry foundation. When insulating the exterior of a slab on grade, adhesive is not required, as the backfilled earth prevents any movement of the installed insulation. If exterior insulation should be finished with a covering to protect it from ultra-violet light, consider a mason’s lath and mortar finish.
- If the region is termite prone, select another method of insulating the above grade foundation; either insulating the interior of the foundation wall or insulating the floor between the crawl space and conditioned living space. This will leave the exterior of the building exposed for termite inspection.
- Cover earth floors of a crawl space with a heavy mil polyethylene tarp, weighted in place and overlapped at the seams, to prohibit the evaporation of moisture from the earth to the crawl space area.

3.3.2 Framed floors:

- Air seal any bypasses in the floor between the conditioned space and the basement/ crawl space area, i.e. plumbing, duct, electrical or framing.
- Insulate all ductwork and water lines within the crawl space area. If freezing temperatures are anticipated, drain traps should be insulated/isolated to prevent freezing.

- Install heavy mil polyethylene sheeting over any earthen floor of a crawl space to prevent the evaporation of moisture from the earth to the crawl space area. Overlap any seams and weight the sheeting in place with stones, gravel or other inorganic material.
- Install insulation to the full depth of the floor joists; 6-inch fiberglass batts for a 6-inch floor joist, 10-inch batt for a 10-inch joist. When installing faced fiberglass batts, the facing should be positioned to the conditioned floor of the building. Friction fit the batts to temporarily hold them in place
- Support the insulation with rolls of 2- inch wire mesh; run perpendicular to the floor joists and stapled in place to the bottom of the floor joist. This will give good support to the settled floor insulation.
- Floors of bonus rooms (living space above garages) benefit greatly from the installation of high density cellulose, even if the floor has been previously insulated with fiberglass batts. The high density cellulose helps to provide an airtight barrier between the garage, which can be the source of carbon monoxide, volatile organic compounds, and the living space. High density cellulose in this floor area greatly reduces airflow through the building frame – a common occurrence in this type of construction. Installation can be accomplished with an injection hose through the garage ceiling. Density should be in the range of 3.5 pounds per cubic foot, or about 2.25 pounds per square foot in an 8 inch floor joist. All penetrations in the garage ceiling must be plugged and sealed as this ceiling serves as a fire barrier between the garage and the living space.

4.0 References and Suggested Reading

http://www.toolbase.org/secondaryT.asp?CategoryID=1025 — Insulation Materials standards, installation techniques and tools

http://www.pathnet.org/si.asp?id=399 — Walls Systems Partnership for Advancing Technology in Housing

http://www.pathnet.org/si.asp?id=482 — Roof Systems Partnership for Advancing Technology in Housing

http://www.pathnet.org/si.asp?id=481 — Foundation Systems Partnership for Advancing Technology in Housing

http://www.buildinggreen.com/features/ins/insulation.html — Environmental Building News: Insulation Guide

Builder's Guide; Chapter 12 "Insulation" Building Science Corp., Westford, MA

http://www.scespc.com/manualsandforms/Rcp-v2a2000.pdf — "Residential Contractor Program 2000R", Chapter 10 "Walls" Southern California Gas Co, Southern California Edison Co.

http://www.epa.gov/lead/rrpamph.pdf — "Reducing Lead Hazards When Remodeling Your Home" EPA

http://www.housingzone.com/probuilder/article/CA467409.html — HousingZone.com; Insulating Attics for Performance

http://www.greenbuilder.com/general/articles/AAS.atticcool.html — GreenBuilder.com; Don't Let Your Roof Take the Heat http://www.weatherization.org/floorandfoundationinsulation.htm — Department of Energy — Energy Topics; Floor and Foundation Insulation

http://www.pathnet.org/si.asp?id=481 — Foundation Systems — Partnership for Advancing Technology in Housing

ASHRAE Fundamentals, Chapter 20 "Thermal Insulation and Water Vapor Retarders"

http://www.pathnet.org/si.asp?id=441 — Moisture and moisture control – Partnership for Advancing Technology in Housing