Chapter 12. Air Sealing and Insulation

Tools needed by volunteers:

Nail apron
Tape measure
Utility knife
Pencil

Tools and equipment needed:

Extension cord
Lighting
Hammer tacker stapler
Hand saw
Caulk gun
Hand stapler
Stainless steel straightedge
Stepladder
Push broom
Black felt tipped pen
Red marking crayon
Red utility knife blade disposal tube
Vacuum

Materials needed:

24" R-19 Fiberglass insulation
Staples
Air sealing tape
HVAC tape
Painter's tape
Air sealing caulk
Spray foam
Poly vapor barrier
Foamboard scrap
White trim nails
2⅜" Collated nails
3¼" Collated nails
1¼" Sheetrock screws
Tapered shims
Flat cardboard shims
OSB and 2x scrap
Garbage bag

Personal Protection Equipment:

Safety glasses (required)
Work gloves (recommended)
Dust mask (recommended)
Hearing protection (recommended)

Safety First! Review the Safety Checklist before performing tasks in this chapter.

12.1. BUILDING SCIENCE FACTS

1. All of the affiliate's homes are Focus on Energy New Homes Program and Energy V3 certified. The average air leakage of homes built in 2011 was 53% better than certification requirements. This was achieved by focusing on the details of energy conservation at every step of the building process, from framing to installing appliances. These efforts provide a great end product that benefits not only the families but the environment as well.

2. The primary leakage concern is the building envelope, which is any surface between conditioned and unconditioned air. The building envelope should be a closed system, which means that all air/moisture flowing in or out of the building is "intentional" and controlled. Capping the "lid" (ceiling to the attic) is the most critical because it is the highest pressure point of the building envelope. For the walls, creating a completely sealed, 6-sided box for each wall cavity ensures that no air/moisture can be transported through the wall cavity. Maximum insulation efficiency (R-value) is ONLY achieved within "dead" air space. ANY airflow through the fiberglass batt insulation can reduce the R- value by 50% or more.

3. The average home experiences a 30% heat loss as a result of warm air leaking out of the house. Therefore, it is important to control both air and moisture movement by being VERY intentional about sealing every penetration and hole in the building envelope as well as from one level to the next. The most common leakage areas are doors and windows, foundation cracks, sump pits, sill/rim board areas, floor to wall seams, floor to ceiling seams, interior penetrations (i.e. one level to another) and exterior penetration (i.e. inside to outside).

4. It is critical to keep moisture where it can be seen (not hidden in walls or attics) by using appropriate air/moisture barriers/retarders. All building materials (e. g. OSB, sheetrock, plaster, fiberglass insulation, rigid or spray foam, poly/plastic, paint etc.) qualify as air and/or moisture barriers or retarders with varying permeability ratings (the rate at which moisture can pass through). Following is an example of how a moisture barrier/retarder can easily be compromised:

   EXAMPLE: A 4'x8' area of ½" sheetrock has a permeability rating of 90 (6 mil poly is rated at 0.06). At 70°F and 40% RH, ⅓ quart of water will diffuse through this sheet over a given amount of time. By simply adding a 1" square hole, moisture diffusion increases to 30 quarts of water over the same amount of time (i.e., several gaps around electrical boxes could easily add up to this 1" square).

12.2. PREPARATION

1. Mark all stud center locations on the floor with a red crayon prior to installing poly vapor barrier.

2. Mark the location of all HVAC ducts, basement ceiling duct dampers, and plumbing pipes that will protrude through the sheetrock using a red marking crayon. Draw a 6"-8" rectangle directly beneath ceiling heat vents, and in front of cold air return ducts and mark an "X" across corners. Draw a red circle for each pipe on the floor directly in front of the pipe or directly beneath the damper for HVAC damper controls.

3. Verify that all wall and ceiling electrical boxes are identified by a spray-painted pattern, about equal to the width of the box on the floor. If there are any electrical boxes that are not marked, use a red marking crayon and draw a rectangle the approximate size of the box on the floor, directly beneath or in front of the box.

4. Verify that the wall studs behind the countertop are all in the same plane to ensure the countertop will fit flush to the wall. Use the edge of a stainless steel straightedge to check the inside edge of the wall studs about 41" above the floor and shim any gaps until all studs are in line at that level. If the gap is ¼" or more, taper off each shim to a zero thickness upward about 20" and downward about 10" from the 41" height. Use tapered or cardboard shims. Attach shim(s) with white trim nails.

5. Verify that the Jack studs of sliding door openings are straight and plumb. Using a 6' level on the face of the Jack stud, verify Jack studs on all sliding door frames are straight and plumb to within 1/16". Check for plumb first. Add shims (side-by-side) to plumb the stud, then check again with the level and fill in any gaps due to bowing with layers of cardboard shims to straighten the face. If no shimming is required, mark "OK" with a red crayon or marking pen on the Jack stud face to indicate the studs have been checked.

6. Verify that exterior wall stud faces adjacent to flush sliding doors are straight, plumb and in the same plane. Use a 6' level to check the two closest studs to the eventual door location for plumb and straightness, as described in Step 5 above. Then turn the level to horizontal and check the three closest studs to the door location about 41" off the floor to determine if the exterior wall stud faces are in the same plane. If off by more than ⅛", use shims, centered on the 41" mark to bring the faces in line. Mark "OK" with a red crayon if no shimming is required.

7. Verify that all blocking has been installed per Section 10.5.3. Complete blocking as required.

8. Remove the temporary 2x4 plenum support block positioned across the range plenum.

9. Vacuum debris from all wall cavities and from sub-floor areas along exterior wall bottom plates prior to caulking and installing insulation.

10. Vacuum debris from the sub-flooring around all in-floor heating ducts as well as the inside area around the top of the duct. Also, vacuum inside the cold air return boots, particularly the joint between the duct and the boot. This will create clean surfaces for flashing and HVAC tape application.

11. Verify that foamboard has been installed along the basement foundation walls and the foam has been pushed tight to the exterior walls using scrap wood. If foamboard has not

been secured, slide scrap OSB or 2x pieces along wall studs to push foamboard tight to the wall and secure with 3¼" collated nails for 2x or 2⅜" collated nails for OSB.

12.3. AIR SEALING

12.3.1. Main Level

1. Fill all holes in each of the wall and ceiling electrical boxes with air sealing caulk.

   NOTE: It is not necessary to caulk the attic light electrical box.

2. Use air sealing caulk or spray foam to seal all holes in both **interior and exterior** wall studs. This is recommended to help insulate and to create a fire block.

3. Fill all holes, including unused holes, in the top and bottom plates on interior and exterior walls with air sealing caulk.

4. Use air sealing caulk or spray foam to seal all holes (being used or not) or gaps in the foamboard or OSB that are visible from inside the house. If holes are open to the outside (e.g., through the sill box), seal with finish caulk.

5. Seal around the range plenum duct exit to the exterior with spray foam.

6. Fill the gap between the exterior door jambs and the door framing (rough opening) with spray foam (or air sealing caulk if gap is less than ¼"). Fill cavity until FULLY EXPANDED foam reaches the inside edge of the framing. Fill in multiple passes (waiting 15-20 minutes between each pass) to allow foam to fully expand before applying the next layer. Trim any excess foam ONLY AFTER it has dried thoroughly.

7. Seal the bottom of the windows with air sealing caulk.

8. Partially fill the gap between the windows and the window framing (rough opening) with spray foam (or air sealing caulk if the gap is less than ¼"). Fill the cavity until neither the window flange nor the exterior sheathing (blue foam board or OSB) is visible. DO NOT FILL THE ENTIRE DEPTH to the inside of the window frame (too much expanding foam can bow the frame). Trim any excess foam ONLY AFTER it has dried thoroughly. If more than one pass is required, wait 15-20 minutes between passes to allow foam to fully expand before applying the next layer.

   NOTE: It is best to have only one experienced volunteer do both the door and window spray foaming.

9. Apply a bead of air sealing caulk to the following areas and use a tongue depressor to push caulk into the seams:

a. The inside seam between the sub-floor and inside edge of each exterior door threshold plus the outside perimeter of both adjoining door jambs.

b. The inside seam between all exterior wall corners.

c. The inside seam between the sub-floor and the exterior wall bottom plates.

10. Seal the inside seam between the upper plate and the top plate of exterior walls with air sealing tape.

11. Seal the inside seam between the exterior door and window components with air sealing tape.

12. Install foamboard instead of fiberglass behind all PVC pipes, insulating from the bottom plate to just beyond the height of the pipe, and to at least the width of the pipes. Cut all foam pieces to the same width. Install up to three layers of scrap foamboard behind each pipe, then fill in around the rest of the stud bay with fiberglass insulation. Stagger seams between foam layers. Do not force foamboard behind the pipe. Forcing can push out the exterior foamboard and put stress on the pipe joints.

13. Install scrap foamboard behind exterior wall blocking and in front of overhead electrical box blocking. Use scrap foamboard to fill the space behind or in front of 2x blocking. Attach the foamboard to blocking with air sealing tape.

14. Install foamboard above window and door headers. Use air sealing caulk to seal the perimeter of the foamboard to framing. If foamboard is flush with the framing, seal the perimeter with air sealing tape.

15. Use scrap foamboard to insulate behind electrical boxes along exterior walls. Cut foamboard to the overall dimension of the box and gently wedge it behind the box. Push foam all the way to the stud. Do not force the foam; if the fit is too tight it will bulge out the exterior foamboard. If too loose, use spray foam or bits of fiberglass to wedge the foamboard in place.

12.3.2. Basement Level

1. Fill all holes in all of the wall and ceiling electrical boxes with air sealing caulk.

2. Fill all holes in the top plates on interior and exterior walls with air sealing caulk to create a fire block.

3. Use air sealing caulk or spray foam to fill all holes in both interior and exterior wall studs.

4. Use finish caulk or spray foam to seal all sillbox penetrations such as dryer vent, plumbing pipe, gas line, etc.

5. Use air sealing caulk or spray foam to fill any holes in the subfloor such as water lines, drains, vent stack etc.

6. If gaps exist between the top of the foundation wall foamboard and the wall upper plate, fill with sealing caulk if the gap is < ¼" or spray foam if > ¼".

7. If the plumber has run drain pipes for the tub, cover the hole in the floor for the bathtub plumbing with scrap OSB, fasten with several 1¼" sheetrock screws, and seal tight with spray foam or air sealing caulk if gaps are < ¼".

   REQUIREMENT: This is a Building Code and a Focus on Energy New Homes program requirement.

8. If there is a 6" bath fan vent duct (for a future bathroom) exiting through the sill box, use spray foam to seal the vent perimeter around the sillbox foamboard. Push a garbage bag into the duct from the inside (see Figure 12-1). Completely fill the duct and the sill box around the vent with fiberglass insulation (see Figure 12-2).

Figure 12-1. Plastic Bag Inserted Into Future Fan Vent Duct.

Figure 12-2. Insulation Filled Around Future Fan Vent Duct.

9. Install fiberglass insulation in front of foam insulation in all sillboxes. For long walls, cut insulation into 19" lengths, rotate 90°, then cut these in half to yield two 11.5" x 19" pieces. For short walls, cut to 32" lengths, rotate 90°, then cut these in half to yield two 11.5" x 32" pieces. Install tight to the foam. Do not compress. Manipulate insulation to cover sillbox corners.

12.3.3. HVAC

1. Secure every in-floor heating duct to the OSB sub-floor by nailing it with two soffit nails (see Figure 12-3). Prior to nailing, adjust the duct up or down as needed so the top edge is flush with the top of the sub-flooring.

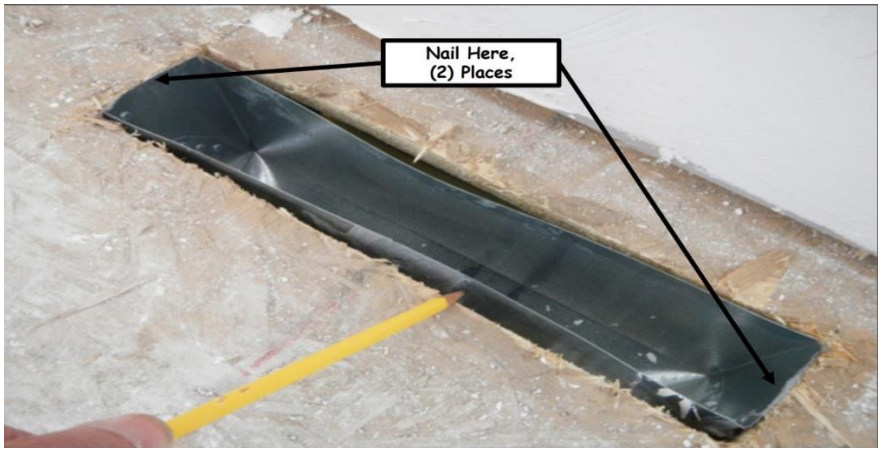

Figure 12-3. Securing In-Floor Heating Duct.

2. Seal gaps between in-floor heating ducts and OSB sub-flooring with a 6" wide piece of HVAC tape. Cut the tape 3" longer than the duct width. Remove the peel strip, center over the duct and apply to the OSB. Make a cut down the center of the tape (long direction), stopping 1" short of each duct side. Make four short diagonal cuts from each corner to each end of the center cut, (e.g. cut looks like this [>----<]. Fold the cut ends down and seal to the duct (see Figure 12-4).

Figure 12-4. Sealing In-Floor Heating Duct.

3. Seal the joints between the cold air return ducts and the cold air return boots with HVAC tape. Try sealing the outside surface of the joint first, which is accessed

from the basement. If this is too difficult to reach, seal from the inside. Cut tape into 3" wide pieces, 4"-6" long and apply to the joint in shingle fashion (see Figure 12-5).

NOTE: The tape shown in Figures 12-4 and 12-5 is flashing tape, not HVAC tape (revised pictures forthcoming). Instead, be sure to use the silver HVAC tape for sealing ducts.

Figure 12-5. Sealing Cold Air Return Joints

12.4. INSTALLING INSULATION IN WALL CAVITIES

1. Batt type insulation performs best when installed properly. Failure to seal all air leaks can cause the insulation to lose up to half of its insulation R-value.

2. Failure to fluff the insulation in the wall cavity, or compressing it as little as an inch can cause the insulation value to go from an R-19 to an R-10.

3. Insulate all outside walls with (R-19) batt insulation. Install loosely, never pack it in.

4. Split the batt in half to fit it around electrical wires (see Figure 12-6).

Figure 12-6. Insulating Around Electrical Wires.

5. For those areas where the batt needs to be "cut to size", cut the batt ¾" larger than the size of the area.

   EXAMPLE: If an area measures 18" x 30", cut the batt to 18¾" x 30¾".

6. Use foamboard to fill any wall cavity less than 3" wide. It is very hard to fill such a small space effectively with the batt insulation. Seal any joints or gaps between the interior layers of foamboard with air sealing tape. Use air sealing tape, air sealing caulk or spray foam to seal the perimeter gap between foamboard and studs.

7. Cut out around electrical boxes, as tightly to the box as possible (see Figure 12-7).

   EXAMPLE: If the box measures 4" for the height, 3" for the width and 3" for the depth, cut out the insulation only to that size. Be sure to install insulation behind the box.

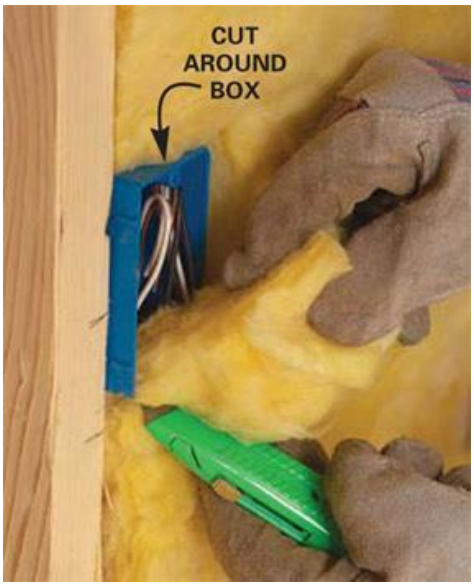

Figure 12-7. Insulating Around Electrical Box.

8. Do not insulate any ceiling areas.

9. **Do not cover thermostat and doorbell chime wires with insulation.** Feed them through the insulation, at the height they are attached to the studs, so they are visible for the crews installing vapor barrier and sheetrock.

   NOTE: The chime wire is typically located above the thermostat wire.

10. If the bathroom vanity light is not running through an electrical box, feed the wire through the insulation (so it visible at the height it is attached to the stud) and leave it hanging in the stud bay. The electricians will drill a hole later and fish out vanity wire through the wall rock.

11. Take time to ensure insulation is fluffed/pulled out so it is flush to the interior face of the wall studs. Make sure insulation fills the entire space from top plate to bottom plate and from stud to stud. The sharp end of a pencil inserted into the edges of the insulation works well to fluff the batts.

12.5. INSTALLING POLY VAPOR BARRIER

12.5.1. General Poly Installation Rules

1. Minimize the number of staples (more is not better) to reduce the number of holes in the poly. An adequate stapling interval is 2'.

2. Use air sealing tape to seal any holes or punctures in the poly.

3. All poly overlaps must cover two studs (including corner stud) or trusses.

4. BEFORE STAPLING CORNERS at wall intersections, be sure to "tuck" poly COMPLETELY into the corners and tight to the ceiling blocking. Use a hand stapler to push the poly into the corners before stapling. A folded poly corner not cleanly conforming to the shape of the corner framing and may result in a tear that will compromise the barrier or could break off a corner of the sheetrock upon installation.

   NOTE: Folded and stapled corners should be checked early in the day by crew mentors to verify installers understand how to make tight corners. Poly corners not tight to the framing should be pulled out and re-stapled or slit and taped with air sealing tape.

5. For poly installation, consider these orientation definitions:

   a. WIDTH of a room runs parallel to the trusses.

   b. LENGTH of a room runs perpendicular to the trusses.

6. Use nominal 12' wide poly for ceiling areas; 8' wide poly for walls.

7. Install all ceiling poly before installing wall poly.

8. After installing poly, cut an X across corners of each electrical box. Cut slightly smaller than the inside of the box (staying ¼"–½" away from the corner) and push the poly up ½" around the outside of the box for a snug fit. Pushing the poly up keeps it out of the way of the spiral saw bit. TAPE WITH AIR SEALING TAPE ONLY IF THE FIT IS NOT TIGHT.

12.5.2. Installing Ceiling Poly Vapor Barrier in Bedrooms and Bathrooms

1. Install poly in bedrooms and kitchen/dining/living room first. Bathrooms, closets and hallway areas are generally completed last, often utilizing scrap pieces of poly.

2. Create a reference chalk line on the bottom of the trusses. A reference line is used to keep the poly straight during installation, and to ensure a nominal 6" poly covering along the top of all walls. Determine the width (parallel to the trusses) of the ceiling area to be covered with poly. Divide this measurement in half and make a midpoint mark on the bottom of both end trusses in the room. Snap a chalk line between the marks.

3. Measure the width of each room to determine the best utilization of the poly. In general

   a. If the room width is > 10', cut the poly 1' longer than the room width (parallel to the trusses). Fold the cut length of poly in half. Use a felt marking pen to draw a straight, continuous line along the fold. Unfold the layers underneath this line and draw the line on all folded layers. This poly line will be used to align the poly to the reference chalk line created in Step 2 above.

   b. If the room width is < 10', cut the poly 1' longer than the room length (perpendicular to the trusses). Use the factory crease line down the middle of the 12' wide sheet to align the poly to the reference chalk line created in Step 2 above.

4. Begin installation at room center, at an exterior wall that is parallel to the trusses. Unfold the poly sheet, and at the poly reference line, or the center crease line, grab the poly in a cape-like (or tent-like) fashion, behind the shoulders, and walk it up a step ladder to the ceiling. Extend the poly forward so it hangs down the top of the wall about 6"-8" and align the poly reference/crease line to the reference chalk line. Starting at one end, staple at room center. Add one additional staple on each side of center. Continue toward the opposite wall, making sure to align the poly reference/crease line with the chalk line, stapling the center area only with three staples per truss.

5. Once the center is stapled, use push brooms to support the poly and keep it tight while stapling toward the walls. Ensure that at a minimum, the top and upper plates of all walls are completely covered with ceiling poly.

6. The wall portion above closets with flush sliding door headers should be completely covered with ceiling poly. Because these areas are exposed to the exterior wall, they require a vapor barrier.

   a. Extend poly down from the ceiling to cover the header, then staple the poly to the top plate, header and jack stud. Trim any extra poly along the bottom of the header with a utility knife.

   b. Slit the poly that extends beyond the closet along the front corner of the 25" closet wall, extend it back toward the interior wall and staple it to the trusses. Fold the poly at the corner where the header meets the exterior wall and tape with air sealing tape.

      NOTE: There is no blocking around the exterior wall end of headers supporting flush sliding doors, so these corners cannot be stapled unless there is an exterior stud very close to the header. Make sure the unstapled poly corners are loose enough to allow installation of sheetrock without stretching the poly.

   c. Use a separate piece of ceiling poly on the inside of bedroom closets. Make sure the piece is large enough to extend 12" down the back and sides of the closet, and to completely cover the inside front down to the bottom of the header. Fold and tape the poly along the header corner at the exterior wall. Fold and staple all other inside corners tight to the framing.

7. If the poly length is insufficient to cover the entire ceiling area of a room, cut an additional piece and overlap the seam a minimum of two trusses. Make sure to include this overlap and the 6"-8" extension down the wall in the measurement prior to cutting. Center the overlap end of the new poly piece on the bottom chord of the truss, complete the stapling, then tape the seam along the truss chord to ensure a good seal.

   NOTE: All ceiling poly seams must be parallel to the trusses, with the exception of outside corners, support posts, entry areas into bedrooms, etc.

8. Tape all ceiling seams with air sealing tape.

   NOTE: When taping the poly at the point where two intersecting walls and the ceiling meet, make sure the poly and tape are tucked tightly into the corner so as to not interfere with the installation of sheet rock.

9. After covering the bathroom ceiling, cut the poly over the bath fan by slicing through the poly along the outer edge of the fan flange with a utility knife. Attach the poly to the fan flange using air sealing tape.

10. Cut an X opening for the scuttle hole, wrap poly around rough opening and staple. Trim any excess.

12.5.3. Installing Ceiling Poly Vapor Barrier in Kitchen/Living Rooms

1. Create a reference chalk line 6' in from the exterior long wall and make a mark on the bottom of the trusses located at opposite ends of the room. Snap a continuous line from these marks.

2. Measure the room width (parallel to the trusses) at one end of the room. Unwind the poly from the bottom of the roll and cut off a length 1' longer than the measured room width. Use a felt marking pen, create a poly reference line by drawing a straight line across the top of the poly, 6½' from one end.

3. Unfold the poly, orienting the 6½' referenced end toward the exterior long wall. This will align the line on the poly to the chalk line and ensure a nominal 6" of poly extension down the top of the long wall as the poly is installed. The main objective is to ensure that at a minimum, there is poly covering the upper and top plates.

4. Begin installation on the 5th or 6th truss, depending on the spacing of the first truss to the outside wall. Measure the distance from the bottom of the 6th truss. Poly length is 12'-4". If the poly is too short, start installation on the 5th truss. Lift the poly up to the starting truss and align the poly line with the chalk line. Align one poly factory edge along the center of the truss and staple directly under the chalk line. Add one additional staple on each side of the line. Continue stapling toward the opposite end. Staple the entire sheet along the poly line first before stapling outward toward the bearing walls.

5. Use push brooms to support the poly and keep it tight while pulling the poly toward the walls. Continue stapling every 2'.

6. Continue with more pieces until the room is completely covered. Measure the room widths required and mark a reference line 7' from the cut end of each piece. All additional poly sections must overlap the previous poly a minimum of two trusses. Center the overlap end of the new poly piece on the bottom chord of a truss, complete the stapling, then tape the seam along the truss chord with air sealing tape.

12.5.4. Installing Wall Poly Vapor Barrier

1. Before installing wall poly, verify that the centers of all stud locations have been marked on the floor with a RED CRAYON. Mark any missing stud center references.

2. Install the wall poly on all exterior walls. Staple at every stud, plate and window/door rough opening, spacing staples about 2' apart. When wrapping around corners, extend the poly to cover the first stud on the intersecting wall. Use care in wrapping in and around corners so the poly does not bunch up or "stretch" across the corner. Tuck poly tightly into the corner before stapling and keep staples

1" away from the corner to avoid tearing or puncturing poly. Overlap seams a minimum of two studs (including corner stud).

3. To facilitate hanging poly and provide quality corners, begin in a corner of an exterior wall, **verify a sufficient free length exists to wrap the corner to the first stud on the adjacent intersecting wall,** and align the factory cut edge of poly along the top edge of the wall top plate. Staple along the top plate for at least four studs, then continue stapling down these studs to the bottom plate. When this initial section is stapled, secure the corner, and then secure the short free end to the adjacent wall stud and continue toward the opposite end.

4. To install poly around closets without a flush sliding door, wrap the poly around the front closet wall and staple to the Jack or King stud supporting the header. Use a separate piece to wrap the exterior wall corners inside the closet.

5. To install poly around closets with a flush sliding door, cut a "U" shaped slot in the poly to fit around the header, enter the closet and continue wrapping to the first interior wall stud past the exterior/interior wall corner. Staple the corner tight to the framing before completing the attachment to the interior wall stud in the closet. Use air sealing tape to seal the slot to the folded ceiling poly on each side of the header.

6. After the poly has been installed, remove the poly covering the windows. At each corner, make a 2" long 45° cut toward the interior of the window, then finish by cutting straight down and straight across to cut out a rectangular piece of poly. Place these rectangles in the bath tub for use under paint trays on painting days. Wrap the poly remaining around the windows into the rough openings and staple to the frame.

7. At each exterior door, cut poly along the outside edge of the door jamb. Roll poly up from the bottom and tape it above the door with a small piece of air sealing tape. This will be unrolled during plastering/painting to help protect the door surfaces and hardware from plaster and paint.

8. When installing poly over loose wires (e.g., bathroom vanity light, thermostat, etc.), push the wire through the poly at its stud attachment height and leave it hanging outside the poly. Seal the hole with air sealing tape if poly is not tight to the wire.

9. Install any unusable scrap pieces of poly on any interior wall (except bathroom walls) to minimize waste and reduce contributions to the landfill.

10. Tape all seams that have less than a two stud overlap with air sealing tape.