Multifamily Buildings: Air Sealing Measures, Materials Techniques and Tools

Wisconsin Weatherization Program

Division of Energy Services, State of Wisconsin Department of Administration

Attic Bypasses - Truss Attic or Otherwise Accessible

Techniques and materials for air sealing in accessible attics are similar to those for SF buildings. In the absence of a full blower door test, in-progress and post-sealing evaluation can be completed with artificial smoke or an IR camera.

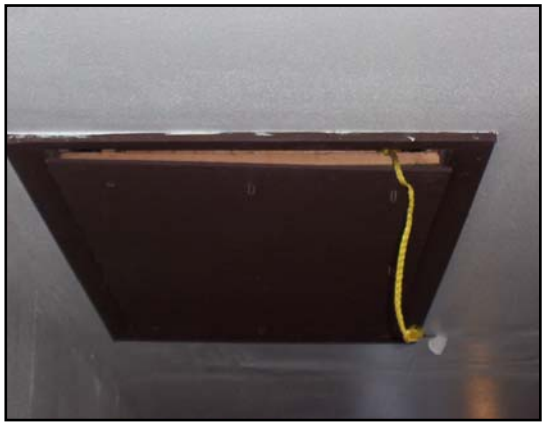
Sealing materials installed in attics at the top of MFBs need to resist high pressures generated by wind and stack effect. The material must be sufficiently strong to be stable across large openings at typical pressures (in excess of 20 Pa in low-rise buildings) and mechanically fastened or adhered to remain in place.

Attics in MFBs see much more traffic than in SF homes, from utility installers and trades workers. Consider building walkways above new insulation to facilitate access to the attic utilities and systems. Any new construction should be especially solid and durable, and operate freely and effectively.

If it can be made air-tight, the existing access/scuttle system can be assumed to meet the needs of the building managers. It is important that accesses be built with good construction techniques to reasonable tolerances. Most people accessing the attic will not take the time to manipulate a closure that needs coaxing or adjustment.

Note that Wisconsin Commercial Building codes require that significant installations of foam (attic hatches, elevator shaft insulation, etc.) have a 15 minute fire barrier (1/4" fireproof plywood or 26 ga. sheet metal) on the *attic* side of the material. Consider high-density fiberglass board in place of EPS board or Thermax when fire code restrictions are a consideration.

- Access doors and hatches
    - Seal door opening and around trim.



Options: Caulk edge of molding or ledger at the air barrier to the unconditioned space. Weather-strip access door. The closure system must be constructed to be securely fastened – do not depend upon springs or weight to engage the air sealing system. If the existing system is locked, the air-sealed system should also be able to be locked to prevent unauthorized access.

Another option is to create a secondary access door ("coffin" scuttle) above the existing ceiling and scuttle or access panel. Construct a wood chute (insulated on the attic side) in the attic above the existing access door, strong enough to hold body weight and air-sealed to the ceiling. An insulated panel installed on solid ledger material with commercial-grade weather stripping is then installed to fit into the chute. Install strong, durable handles on the underside of the panel to allow it to be pulled into place tightly.

- Chimney/Flue Chases
    - Seal penetration made by flue/chimney in accordance with fire code for active chimneys. It should always be assumed that the chimney may be placed back into service unless one end or the other is demolished to assure that the chimney is completely unusable.

Options: Sheet metal set in fire-rated sealant, or cement board adhered with non-combustible caulk, fire rated foam, or furnace cement.

- Dropped Soffits
    - Seal openings at top of the wall.

Options: Rigid foam adhered with foam or caulk. Drywall or light plywood stapled to studs - foam the edges securely. Dense-pack insulation blown into wall cavity may be useful.

- Duct Penetrations
    - Seal ceiling penetration created by duct.

Options: Foam or caulk. Large holes may require addition of duct board or rigid insulation.
Note: Make sure that these are not exhaust for kitchen, or flues from furnaces or boilers; while these types of penetrations should be sealed for moisture management, they will require non-combustible, fire-rated sealing systems. Best seal is from the attic.

- Ducts

  Note that, in MFBs, the air handlers/exhaust fans are frequently in operation 24/7. SF assumptions (that duct sealing may be of only moderate value) do not apply. Every effort should be made to seal ducts as tight as possible, but conventional tools do not provide good predictions for energy loss/energy savings. (Note that no good algorithm is readily available to assess appropriate duct insulation levels, either.)

  - Seal Joints

  Options: Mastic or butyl tape. If un-insulated, insulate duct.

  Note: Make sure that these are not exhaust for kitchens, or furnace/boiler flues; while these types of penetrations should be sealed for moisture management, they will require non-combustible, fire-rated sealing systems, and should not be insulated.

Elevator Shaft

- Seal penetration created by elevator shaft into attic.

  Options: Foam or caulk. Large holes may require addition of duct board or rigid insulation.

- Seal or cover top of cinder blocks if open. Some may be capped with concrete and require no action.

  Options: Cover with plywood/caulk, rigid foam, or similar material. Ideally, insulate sides as well as top of shaft.

- Garbage Chute
    - Seal ceiling and duct/chute juncture.

  Options: Foam or caulk. Large holes may require addition of duct board or rigid insulation.
  Note: Watch for party wall type openings. Sometimes, the chute will not be accessible from the attic space, and can only be sealed at the garbage room ceiling.

    - Control exfiltration into the chute. Code requires that whatever opening was designed into the top of the chute not be restricted or made smaller. Air seal to reduce air leakage into the shaft as much as possible. See "trash room" section below.

- Party Wall /Demising Wall /Partition Wall
    - Seal Top of Wall Opening

  Options: Rigid foam or duct board adhered with foam or caulk. Firewall may need to be temporarily opened to perform this action properly. The firewall must be replaced/reapplied if opened! Dense-pack cellulose in the entire cavity may be an option, but will degrade sound insulation properties.

- Wet walls
    - This is simply an over-sized party wall, except that numerous pipes, ducts, etc. may run from the attic into the conditioned space. Seal openings at top of the wall
      Options: Rigid foam, drywall or duct board adhered with foam or caulk. Some wet walls are large enough that use of EPS may trigger the requirement for a fire barrier enforced by some jurisdictions.

- "Tiger traps" – unusual framing features
    - Where framing anomalies leave large openings to conditioned space, it is common to see no ceiling at all, a cardboard cap, or even just a fiberglass batt dropped over opening. (Be careful during assessment!)


Options: EPS board or drywall, sealed with one-part foam. For large openings (1 foot by 2 feet or larger), framing may be required. If not accessible from above, install drywall at ceiling from below and tape joints/corners as typical.
In some cases, it may be more efficient to install sheet metal laid in fire-rated sealant, just as for an active flue.


- Recessed Light –Airtight and IC-rated (Insulation Contact)
    - Seal fixture and ceiling juncture.

Options: Clear, paintable caulk at finished side of ceiling. Foam fixture/ceiling juncture from above. Heat may be a factor – fire rated foam or non-combustible caulk recommended.

- Recessed Light – IC-rated, not air-tight
    - Install an air-tight box over fixture. Seal all seams of box and seal box to ceiling juncture. Seal all penetrations to the box.

  Options: Duct board, rigid fiberglass with foil face, or drywall for box. In some jurisdictions (Wisconsin Commercial/MF Code), drywall is explicitly NOT approved, and cement board is required. Use fire rated tape, mastic, or non-combustible caulk for seams and junctures. If not accessible from above, install foam gasket at ceiling from below and consider an air-tight insert.

- Recessed Light –non IC-rated
    - Install an air-tight box over fixture. Seal all seams of box and seal box to ceiling juncture. Seal all penetrations to the box.

  Options: Duct board, rigid fiberglass with foil face, or drywall for box. In some jurisdictions (Wisconsin Commercial/MF Code), drywall is explicitly NOT approved, and cement board is required. Use fire rated tape, mastic, or non-combustible caulk for seams and junctures. If not accessible from above, install foam gasket at ceiling from below and consider an air-tight insert.

- Soil stacks/Exhaust ducts
    - Seal ceiling penetration created by stack.

  Options: Foam or caulk. Large holes may require addition of duct board or rigid insulation. Note: Installing pipe insulation to metal stacks at this time may be desirable to prevent cold pipes from collecting condensation and causing attic floor rot or ceiling stains.

- Split level or change in roof level
    - Seal wall openings at top of lower wall

  Options: One-part foam, or rigid foam/duct board adhered with foam or caulk. Firewall may need to be temporarily opened to perform this work properly. The firewall must be replaced with joints re-taped, if opened. Dense-pack insulation blown into wall cavity may be an effective air sealing method, especially if exposed un-insulated sidewall leaves a thermal bypass.

- Roof/wall Connection
    - Seal gap to wall if open.

  Options: Foam, caulk, rigid foam. Note: Access may be difficult.

- Stairwell-Conditioned
    - Seal all penetrations connecting conditioned stairwell to unconditioned spaces.

  Options: Foam, caulk, rigid foam, commercial grade weather-stripping at doors. Assure that closer is adjusted properly and works as intended.

- Stairwell-Unconditioned
    - Seal all penetrations connecting unconditioned stairwell to conditioned spaces.

  Options: Foam, caulk, rigid foam, commercial grade weather-stripping at doors. Adjust door closers as necessary to assure complete closure with minimum noise.

- Vaulted ceiling/ flat ceiling junction
    - Seal openings at top of the lower ceiling/roof assembly.

  Options: Rigid foam or cardboard adhered with foam or caulk. Dense-pack insulation blown into the ceiling cavity (hot roof) may be an option if the ceiling can be air sealed completely and effectively. This carries a substantial risk of moisture failure unless the ceiling is air-tight and painted with latex paint, and the building is air conditioned in summer so that the ceiling has potential to dry to inside.

- Hallway exhaust ventilation (whole building fans, installed to exhaust from halls to promote summer cooling)

  Note: These systems are contrary (in many jurisdictions) to original (post-1960s) codes, as they encourage the migration of odors and fire/smoke from individual units into the hall. They may also be less effective, and promote dust/heat migration back to conditioned space, unless the roof venting is far larger than the 1:300 minimum required by most cold-climate codes. The best option is to remove the system, and encourage alternate passive cooling methods (hall windows).
    - The next best alternative (if the owner cannot be persuaded to remove fans entirely) is to replace with an insulated, air-tight whole-house fan.

  Options: see Tamarack HV-1000, HV-1600, or HV-3400 for examples.
    - The least effective method is a seasonal seal system for the existing fan.

  Options: Magnetic sheet cover on the ceiling grille or rigid foam cover installed from the attic. Aesthetics may be a concern with a grille cover visible from the hall. The best air seal is from the interior, but insulation can be added if the building manager will apply a cover from the attic side. (In that case, build a storage platform for the cover in the attic right next to the fan.)

Attic Bypasses-Flat Roof or Otherwise Inaccessible

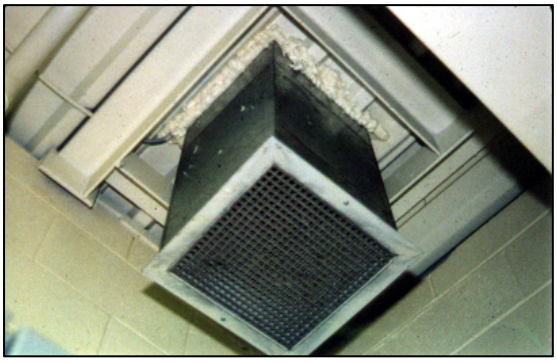
Note: Opening most cavity flat roofs for in-cavity insulation will be cost prohibitive, unless roof is due for replacement. Upon tear-off of existing roof, follow guidelines for Attic Bypasses- Pitched or Otherwise Accessible. Be prepared to complete air sealing as rapidly as possible!

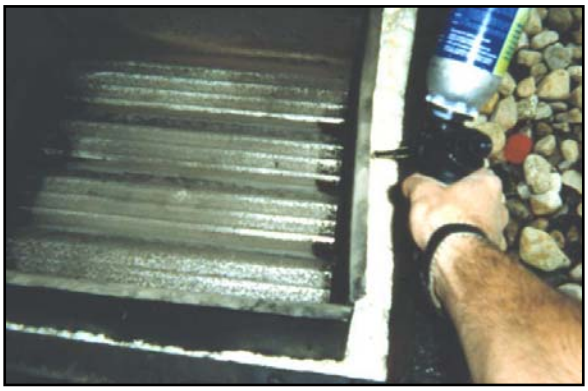
If the membrane or built-up roof is not being replaced, dense-packing the attic cavity from below is possible (especially if the roof is uninsulated). This strategy does carry a significant risk (especially in humid or cold climates) of moisture intrusion leading to severe/catastrophic roof framing failure unless the building is air conditioned in summer and the ceiling has good potential to dry to inside. This work should be combined with detail sealing of penetrations into the roof cavity – that is, the dense-pack should not be the sole air sealing strategy.

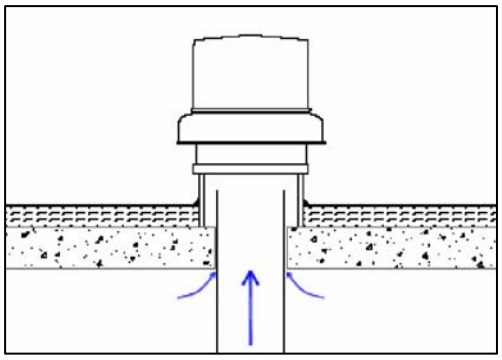
Sealing materials installed in areas at the top of MFBs need to resist high pressures generated by wind and stack effect. The material must be sufficiently strong to be stable at typical pressures (up to or in excess of 50 Pa) and mechanically fastened or adhered to remain in place.

- Exhaust Fan
    - Seal ceiling and unit juncture.

  Options: Caulk or foam. Heat and vibration may be factors to consider in choosing a sealant system. Fire-rated foam or non-combustible caulk is recommended.







- Beams and structural Supports
    - Seal all penetrations separating conditioned space from unconditioned space.

  Options: Foam or caulk junction of beam and wall. Where beam runs parallel to a wall, it may be necessary to drill the web and fill much of the void (two-part foam only) to achieve a complete seal. Note: Best seal is from interior.

- Fluted Steel Decking – Corrugated
    - Seal decking seams and decking wall juncture.

  Options: Drill or punch a hole, close to wall juncture, in flutes and inject flutes with enough two-part foam to fill several feet of flute. If flute opens to wall, an effective seal is achieved only when the entire open flute is sealed.

- Wall/Roof Junction
    - Seal any penetrations.

  Options: Caulk or tar any openings such as mechanicals, soil stacks, and drain scupper. Pay close attention to parapet juncture.

- Garbage Chute
    - Seal roof deck and duct/chute penetration.

  Options: Foam or caulk. Large holes may require addition of sheet metal infill panels.

  Note: If the chase is very large, it is sometimes possible to reach into the garbage chute at the wash-down access door, and seal well above the wash-down head. Most often the chute/deck junction will not be accessible from below, and sealing is achieved by lifting the roof panel. In that case, a roofing contractor may be brought on site to install the air seal and replace the flashing panel without creating roof leaks and to maintain any roof warranty.

    - Control exfiltration out of the chute. Wisconsin fire code (and national model codes) requires that whatever opening was designed into the top of the chute not be restricted or made smaller, so the air sealing strategy should be to control air leakage from conditioned space into the chute. No commercially-available door system acceptable for installation at the bottom of the chute is designed to be air-tight. Seal the doors, walls and ceiling of the garbage room (since the garbage room is a fire-rated space, see

"Mechanical Room" and "Trash Room" section for details). This may require the installation of exhaust ventilation to control odors. Educate building staff on the value of keeping garbage room doors closed at all times. (Note that the cap system on the chute in the lower photo is not in fact code-compliant. However, it is more energy-efficient than code normally allows, and should not be changed.

Basement

Note: Survey for high humidity and/or standing water. If moisture level in space is high, it may need to be reduced to acceptable humidity levels before work is to proceed. Specify exterior grading or downspout repair, plumbing repair, exhaust ventilation (after basement air sealing) or active dehumidification to control humidity levels.

- Access Door –crawlspace
    - If it is not feasible to air seal between the crawl space and outdoors, seal basement/crawl access door opening and around trim.

  Options: Caulk edge of molding connecting the conditioned space to the unconditioned space. Weather-strip access door.

- Exhaust Duct
    - Seal Penetration.

  Options: Caulk or foam. Heat is a factor; fire rated foam or non-combustible caulk recommended.

- Plumbing chases
    - Seal floor deck penetration created by plumbing.

  Options: Foam or caulk chaseway. Installing pipe insulation at this time may be desirable to avoid pipes from condensing and causing floor rot.

  Note: This is a boundary that is within the typically defined thermal boundary, (i.e. exterior walls) – the goal is not to separate conditioned space from the unconditioned space. Rather, it is useful to separate directly/intentionally conditioned space from indirectly conditioned space. Consider insulating the floor, water pipes, and boiler pipes at the same time.

  Warning: Decreasing the heat in this space does create the possibility for mold and mildew problems if concealed plumbing develops a slow leak.

- Service Penetrations (Electrical, cable, plumbing)
    - Seal all penetrations connecting conditioned space to unconditioned space.

  Options: Foam or caulk. Ideally, seal from inside.

- Sill plate
    - Seal rim/band and foundation juncture.

Options: Foam or caulk. Best seal is from interior.

- CMU/Block foundation wall
    - Seal top of wall at sill.

  Options: Foam or caulk. Best seal is from interior.
  Seal block cores if possible.
  Options: Stuff core with fiberglass, then blow in a plug of foam. One-part foam can be used if applied evenly.

- Sill Box
    - Seal band joist.

  Options: Rigid foam or duct board adhered with foam or caulk. Best seal is from interior.

- Wall
    - Air seal porous walls as discovered by blower door test.

  Options: Apply spray foam or rigid foam to cracks and penetrations in walls. Butyl tape, caulk or foam seams and fittings (backer rod, gasket systems, etc.)
  Light-weight CMU walls can be quite porous through the field of the block. Application of foundation paint (epoxy) or multiple coats of concrete-tolerant (base-resistant) latex can reduce air infiltration, and will especially inhibit humidity transfer in below-grade walls.

Mechanical Spaces

Note: Make explicit decisions about whether various mechanical spaces are "inside" the conditioned space and intended air barrier or "outside." This intentional "compartmentalization" of the building can have profound efficiency effects. Atmospherically-vented appliances should almost always be placed outside the building air barrier. In some jurisdictions, air sealing of fire-rated partitions and assemblies can be performed only by licensed smoke-stopping contractors.

Note that mid-rise flat-roof and high-rise buildings may have an elevator mechanical space on top of the building. These spaces are frequently passively ventilated or may have active exhaust fans. (Power transformers, elevator motors, transformers, etc. produce a lot of heat.) There is very substantial exfiltration of conditioned air into these spaces. Air sealing to compartmentalize these spaces may be the most important energy improvement completed.

- Mechanical Room
  - The mechanical room should always be sealed to separate from residential space. In most codes, it is intended to be a fire-resistant and smoke-sealed space. If a combustion air opening is necessary for atmospheric appliances of for pressure relief, this air sealing should be very thorough and carefully detailed. The walls and ceiling are intended to be fire-rated assemblies, and flammable materials are to be avoided.
  - Seal penetrations from mechanical room to conditioned space. (Water pipes, electrical, ducts, doors.)
  - Check that door closers are adjusted properly to assure effective action of weather stripping.

Options: Use cement board or drywall to fill/cover gross openings. Drywall tape and compound is necessary on all drywall seams. (including existing untaped joints.) Use only drywall compound, fire rated mastic, non-combustible caulk, or fire mortar (concrete assemblies) as sealant.

- Combustion Air-Return Opening (when replacing all atmospheric appliances with sealed combustion systems)
  - Cover outside with metal panel painted to match building exterior. If this panel is sealed into place, assure that weep holes are left along bottom edge. Inside of cover (at inner surface of wall) install a rigid, fire-proof panel with foam insulation on cold side. Caulk the panel into place.

- Combustion Air-Return Air Duct (if running through conditioned space)
    - Seal joints and seams.

  Options: Use mastic or butyl tape. Some tapes may require surface prep or cleaning.
  Note: These ducts need only be sealed if they pass through conditioned space on their way to the mechanical room. In that case, the duct should also be insulated.

    - Seal penetrations between duct and walls/ceilings.

  Options: Seal penetrations connecting conditioned space to unconditioned space with fire rated foam or non-combustible caulk. Both the duct penetration through the outside wall and the penetration through the mechanical room wall should be sealed.

- Exhaust Ducts
    - Seal Penetration

  Options: Caulk or foam.
  Heat- and fire-resistance is a factor if a fire originates in or moves into the duct (especially applicable to ducts serving kitchens). Fire-rated foam or non-combustible caulk recommended.

- Service Penetrations (Electrical, cable, plumbing)
    - Seal all penetrations connecting conditioned space to unconditioned space.

  Options: Foam or caulk. The best seal is usually achieved from inside the mechanical room.

- Trash Room

  Note: Garbage chute exfiltration can cost $10K/year in a cold-climate ten-story building. Wisconsin fire code (and national model codes) requires that whatever opening was designed into the top of the chute not be restricted or made smaller, so the air sealing strategy should be to control air leakage from conditioned space into the chute. The commercially-available door systems allowed for installation at the bottom of the chute (with fusible link) are designed to close (automatically) only in the case of a fire in the compactor room. They are designed to always be open unless/until a fire melts the link. No

commercially-available door system acceptable for installation at the bottom of the chute is designed to be air-tight. The only way to reduce enormous stack-effect exfiltration is to limit the movement of conditioned air into the garbage room from the rest of the building.

- Seal the doors, walls and ceiling of the garbage room (since the garbage room is a fire-rated space, see "Mechanical Room" section for more details). This may require the installation of exhaust ventilation to help control odors.
  Options: Foam or fire-rated caulk around all penetrations. Use door sweep and weather-stripping. Use fire mortar systems on concrete assemblies. Fixtures should be waterproof to accommodate wash-down procedures. Consider high-gloss, oil-based enamel paint to air-seal permeable CMU walls.
- Educate building staff on the value of keeping garbage room doors closed at all times.
- Seal all penetrations connecting conditioned space to the trash room. Test that the exhaust fan (if present) is functional, and served by sealed ducts.

Crawl Space – Heated/unintentionally Conditioned – Plumbing Present)
Under-building Parking Areas

Note: If there is standing water in the crawl space it should be controlled to reduce humidity to acceptable levels before work proceeds. Exterior grading and gutter repair should be evaluated. A sump pump may need to be installed.

Define a clear strategy from the start. Often, the decision is made to bring the entire crawl within the typical thermal boundary, (i.e. place boundary at exterior/foundation walls.) In that case, insulating and air sealing at the foundation wall is preferred. Even in this case, insulating heating supply ducts, DHW pipes and boiler distribution lines will reduce system losses, and may still be a useful efficiency strategy. Note that decreasing heat supply to this space does increase RH in the space, and increase the possibility for mold and mildew problems in the presence of moisture.

If moisture levels in space are commonly high (high water table), this area may need constant exhaust to the exterior with provision made for pressure relief from a basement or other semi-conditioned space (in preference to pulling air from conditioned space.) In that case, the crawl space may be placed "outside" the thermal envelope, and the floor deck is air sealed. (Alternatively, a continuous sheet-form vapor-permeable air barrier may be applied under insulation installed in the floor joist space . All pipes and ducts should be insulated as well as air sealed, making the crawl space an unheated volume. Consider the need for freeze protection on traps and sewers.

- Duct Penetrations
  - Seal floor deck penetration created by duct.

  Options: Foam or caulk. Large holes may require addition of duct board or rigid insulation.

- Ducts
  - Seal Joints. This is especially critical for return ducts, which will suck in contaminant from the garage or crawl area.

  Options: Mastic or butyl tape. If duct is un-insulated, insulate.

- Floor
  - Apply vapor retarder on ground and seal to foundation wall.

  Options: Six or 10 mil polyethylene or cross-linked poly laid on floor and overlapped by 12-24 inches. Glue joints with caulk or foam. Adhere to wall with foam or caulk. If the crawl is accessed regularly, place existing walk planks on top of vapor barrier, and install perimeter termination bar to secure vapor barrier to foundation wall.

- Plumbing chases
  - Seal floor deck penetration created by plumbing.

Options: Foam or caulk chaseway. Installing pipe insulation at this time may be desirable to avoid pipes from condensing and causing floor rot.

- Service Penetrations (Electrical, cable, plumbing)
    - Seal all penetrations connecting conditioned space to unconditioned space. Sealing in concrete/spancrete assemblies may require fire mortar systems and licensed fire-stopping contractors.

  Options: Foam or caulk. The best seal is typically made from the crawl space.

- Sill plate
    - Seal rim joist/foundation junction.

  Options: Foam or caulk. The best seal is from the interior.

- Sill Box
    - Seal rim/band joist.

  Options: Rigid foam or duct board adhered with foam or caulk. Best seal is from interior.

- Crawl space vents to exterior
    - Block crawl space vent.

  Options: Rigid foam adhered with caulk or foam. A metal or wood facing may be used at the exterior side to conceal the foam and protect it from sun exposure and damage.
  Note: Check with local building codes to verify requirements on crawlspace venting.

Crawl Space – Unheated/no plumbing/no ducts

Note: If there is standing water in the crawl space it should be controlled to reduce humidity to acceptable levels before work proceeds. Exterior grading and gutter repair should be evaluated. A sump pump may need to be installed.

Define a clear strategy from the start. Usually, the goal is to reduce the heated volume of the buildings, and place the entire crawl outside the thermal boundary, (i.e. place boundary at exterior/foundation walls.) In that case, air sealing at the floor deck is preferred, prior to insulating under the floor deck. (Alternatively, a continuous sheet-form vapor-permeable air barrier may be applied under insulation installed in the floor joist space. Consider the need for freeze protection on traps and sewers.

Warning: Decreasing the heat in this space does create the possibility for mold and mildew problems in the presence of moisture. If moisture levels in space are commonly high (high water table), this area may need constant exhaust to the exterior with provision made for pressure relief from a basement or other semi-conditioned space (in preference to pulling air from conditioned space.)

If structural complexity or access considerations make working under the floor deck more complicated, it may be decided to make the crawl a "conditioned" space. In that case all the measures necessary for a heated crawl (above) are used.

- Access door
    - Seal door opening and around trim.

  Options: Caulk edge of molding connecting the conditioned space to the unconditioned space. Weather-strip access door.

- Duct Penetrations
    - Seal deck penetration created by duct.

  Options: Foam or caulk. Large holes may require addition of duct board or rigid insulation.

- Ducts
    - Seal Joints.

  Options: Mastic or butyl tape. If duct un-insulated, insulate.

- Party Wall/Demising Wall/Partition Wall
    - Seal bottom of wall opening.

  Options: Rigid foam or duct board adhered with foam or caulk. If there are large openings, it may feasible to dense-pack the entire cavity. This will probably increase noise transmission through the wall, so it is generally best to avoid this measure.

- Plumbing chases
    - Seal floor deck penetration created by plumbing.

  Options: Foam or caulk chaseway. Installing pipe insulation at this time may be desirable to avoid pipes from condensing and causing floor rot.

- Service Penetrations (Electrical, cable, plumbing)
    - Seal all penetrations connecting conditioned space to unconditioned space.

  Options: Foam or caulk. The best seal is typically made from inside.

Exterior

- Cantilevered floor or window
    - Seal overhang.

  Note: Work here will require temporary removal of the soffit panels. Be prepared to install plywood sheathing above the soffit panel, as the soffit may be the only barrier in the original construction.

  Options: To create air barrier immediately above siding/soffit panels, insulate soffit, then secure plywood soffit sheathing and seal all edges and seams with caulk or foam. (This system is the best choice if there are second-floor heating ducts in the soffit). To create air barrier in line with first floor wall, bag-and-blow floor joist cavities, seal wiring penetrations in second-floor walls, insulate soffit cavity and install sheathing. In this case, the sheathing does not need to be sealed in place. If the cantilever is under a first-floor bump-out, rigid insulation board (not EPS board) may be a suitable bottom panel. Dense pack floor of cantilever, or caulk/seal insulation board in place to air seal.

- Porches
    - Seal porch/wall juncture.

  Options: Rigid foam or duct board adhered with foam or caulk. If there are large openings, plan to bag-and-blow or dense-pack wall cavities.

  Note: This may require temporarily removing the soffit to access.

- Skylight
    - Seal framing and ceiling junctures.

  Options: Foam or caulk.

  Note: Do not seal weep holes.

- T1-11 Siding
    - Seal seams.

  Options: Exterior-grade paintable caulk.

  Note: This type of siding is

known to harbor moisture unless the tar paper underneath is intact and effective and all z-flashings are intact and functioning. The exterior walls and wall cavities should be thoroughly inspected (from inside) for moisture damage. If mold or mildew is found, proper mitigation techniques should be performed prior to air sealing any portion of the building.

- Windows
    - Seal frame/wall junction.

  Options: Foam at rough opening. This may require removing trim. Caulk both edges of trim (to window jamb and to drywall/plaster) with clear, paintable caulk.
  Note: Do not seal weep holes.
  Note: Best seal is from the interior.

- Windows
    - In structural brick buildings, shifting brick or corroded lintels may open a gap at the window header. This opening is usually difficult to seal from the interior, and can only be sealed from the outside.

  Options: If the gap is consistent in size, clean metal and brick as thoroughly as possible, then seal with high-quality exterior caulk installed over correctly-sized backer rod. In irregularly-shaped gaps, foam can be installed carefully and evenly, recessed well to the interior of the façade, and used as backer for caulking.

Interior and In-unit Measures

- Sleeve (thru-wall) Air Conditioner

  Note: The best seal occurs if the air sealing is on the inside of the unit.

  - Seal sleeve/wall junction (or seal trim into place)

    Options: Sleeve/wall/trim – use only clear, paintable caulk.
  - Seal A/C unit into sleeve OR apply a cover over entire sleeve and A/C unit.

  Options: A/C unit-to-sleeve; 2" EPS foam board, cut to seal in gaps between A/C unit and sleeve. This is difficult to do well, and not likely to be permanent. This inner barrier must be applied so that the appliance can be removed if necessary.

  - Apply cover over A/C unit and sleeve.

  Options: A tight-fitting rigid molded air conditioner cover is installed directly against the drywall and securely fastened, with rotating clip fasteners installed into framing. Edges should be weather-stripped if the cover does not have integral gaskets. If the cover is installed onto the trim, that makes the trim part of the air barrier, and the exposed edge should be sealed neatly with clear, paintable caulk.

  Note: The best long-term performance is attained if the owner/manager (paying the heating bill) takes responsibility for installing covers in the fall and removing/storing them in spring.

- Duct Penetrations
  - Seal ceiling penetration created by duct. Seal boot and ceiling plane connection.

  Options: Foam or caulk. Large holes may require addition of duct board or rigid insulation.

  Note: Make sure that these are not exhaust for kitchen, furnaces, or boilers; while these types of penetrations should be sealed for moisture management, they will require a non-combustible or fire-rated sealing system. Best seal is from interior.

- Doors
  - Seal jambs connected to exterior as determined by a blower door test.

  Options: Caulk or foam. Trim may need to be removed.
  - Weather strip the door.

  Options: Apply commercial-grade weather-stripping and door sweeps. Adjust hinges and closers as necessary to achieve a tight seal that allows door to close completely.
- Dropped Ceilings

- Lift the ceiling in multiple places to assess penetrations hidden above the ceiling. Pay special attention in top floor halls or first floor common areas near exterior soffits. Seal penetrations connecting the conditioned space to the unconditioned space.

Options: Foam or caulk penetrations. Larger holes may need the addition of rigid foam, drywall or plywood.

Note: Penetrations to look for include, but are not limited to: service penetrations, steel columns, construction flaws, open soffits and fluted decking. Heat may be a factor; fire rated foam or non-combustible caulk may need to be considered.

- Residential-style bath exhaust fans
  - Seal drywall ceiling at penetration. Assess (from inside) whether duct is attached.

Options: Caulk or foam. If the fan has an incorporated heat lamp, heat is a factor, and fire-rated foam or non-combustible caulk recommended.

- Electric Baseboard Cabinets
  - Seal penetration.

Options: Caulk or foam. If the unit was wired according to current code, it may be safe to simply pull the unit and seal behind it. Don't assume this to be the case; it is far safer to lock out the breaker panel or take other appropriate electrical safety measures. Heat and fire-resistance may a factor, according to code. In that case, fire-rated foam or non-combustible caulk is recommended.

- Kitchen exhaust fans
  - Seal penetration.

Options: Caulk or foam. Heat and fire-resistance may a factor, according to code. In that case, fire-rated foam or non-combustible caulk is recommended.

- Fire Hose Closet
  - Seal wall penetration created by plumbing.

Options: Caulk or foam penetrations.

  - Seal wall insert as needed.

Options: Caulk or foam penetrations. May need to unscrew cabinet from wall.

- Fire Extinguisher Closet
  - Seal wall insert as needed.

Options: Caulk or foam penetrations. Plan to unscrew cabinet from wall, as that is often the only way to get at significant penetrations.

- Garbage Chute doors
    - Weather strip tenant garbage chute doors.

  Options: Use only commercial-grade systems, mechanically attached. (Adhered systems are not durable enough for this demanding application.)
    - Seal garbage chute door assembly to wall.

  Options: Clear, paintable caulk frame to drywall. Or caulk or foam rough opening -- unscrew assembly from wall and apply sealant in gap. Discuss appearance of finished work with owner before proceeding.

- Service Penetrations (Electrical, cable, plumbing)
    - Seal all penetrations connecting conditioned space to unconditioned space.

  Options: Foam or caulk.

- Sprinkler System
    - Seal wall penetration created by plumbing.

  Options: CAREFULLY move or remove escutcheon. Caulk or foam penetrations. Replace escutcheon.

- Windows
    - Seal frame/wall juncture.

  Options: Apply clear/paintable caulk at rough opening if possible; this may require removing trim. If trim is broken, replace. (Have compatible trim stock on hand.)
    - Repair/replace broken closers, locks or hardware.
    - Install new weather-stripping.

  Options: Apply new fin-seal weather-stripping in existing metal frame. If trim is broken, replace.

Re-weather stripping metal slider windows should be completed by experienced window installers. Successful air sealing of existing windows is strongly dependent on selection of the correct retrofit weather stripping material, with profile, shape and material that are compatible with the frame, installed with careful work by experienced window technicians, and careful adjustment of the finished work.

Under-building Parking Areas

Techniques and strategies for underground parking areas are similar to those for unheated crawl spaces, since the garage may be passively or actively ventilated. (There may be some heat supply to the garage.) Sealing garage ceiling penetrations may increase the CO level in the parking structure, as CO will be less likely to be vented (to the living space) through penetrations connecting the garage to the conditioned space. Parking garage exhaust fans should be in proper working condition. Treatment of garage ventilation and heating are outside the scope of this document.

In all cases, thoroughly air seal the garage from conditioned space. Recognize that conditioned space, laundry areas and the like, may be on the same level. Their walls were rarely treated as a thermal or air barriers at original construction. They should be air sealed, and it is usually cost-effective to insulate these assemblies. Manage bulk moisture and rainwater penetration as much as possible. If there is standing water, it should be controlled to reduce humidity to acceptable levels before work proceeds. Exterior grading and gutter repair should be evaluated. A sump pump may need to be installed. Existing floor drains may need repair.

Note: All air sealing should be done with fire-rated foam and/or non-combustible caulk. Use fire mortar systems on concrete assemblies. In some jurisdictions, this work can be completed only by a licensed fire-stopping contractor.

- Doors (Stairwell)
    - Re-weather strip as needed, using commercial-grade materials.

  Options: Apply weather-stripping.
    - Door sweep as needed.

  Options: Apply door sweep.

- Mechanical Room
    - Seal penetrations from mechanical room to conditioned space. (Water pipes, electrical, ducts.)

  Options: Fire-rated mastic, non-combustible caulk, fire-rated foam, or tape for penetrations, seams and junctures. Use fire mortar on concrete assemblies. Some jurisdictions will require work be performed only by a licensed fire/smoke stopping contractor.

- Beams and Structural Supports
    - Seal penetrations connecting conditioned space to unconditioned space.

  Options: Foam or caulk junctures of beam and wall. Where beam runs parallel to the wall, fill void.
  Note: Look under dropped ceilings.

- Service Penetrations (Electrical, cable, plumbing)
    - Seal all penetrations connecting conditioned space to unconditioned space.

Options: Fire-rated foam or non-combustible caulk. The best seal is usually from the parking garage side. However, if the other side of the penetration is in accessible conditioned space, sealants may work better where there is less temperature variation.

- Structural Supports
    - Seal penetrations connecting conditioned space to unconditioned space. This detail is often difficult to spot, but is very common, in pre-cast concrete framing systems. It is often possible to de-pressurize enclosed garages (use the exhaust system) and use smoke pencils to find the leaks.

Options: Fire-rated foam or non-combustible caulk. Foam at stairwell-structural support joints and precast spancrete-to-wall joints. It is usually not necessary to treat the spancrete "seams" where there is a finished floor above, as topping is typically floated on top of the spancrete.

If the cells running the length of the planks are readily accessible at the thermal boundary (rare), it *may* be worthwhile to pull the "sponge" cell plug and fill the cell ends with one-part or two-part foam. Conduct an IR assessment during cold weather to see if there is significant thermal loss at the building perimeter. In that case, it *might* be worthwhile to pull the trim/water table or band trim to seal the cells. It is more likely, though, that the problem is a thermal bridge issue, which will be resolved only if insulation can be applied across the plank ends and still fit under the siding or trim.

Picture References:

Flat Roofs

- Beams and Structural Supports
  - http://www.hilti.co.uk/holuk/modules/editorial/edit_singlepage.jsp?contentOID=174066
- Exhaust Fans
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- Vent to exterior
  - http://www.allpointinspections.com/new.htm

Exteriors

- T1-11
  - http://www.house-painting-info.com/peelingpaint.html
- Window Lintel
  - http://www.inspectapedia.com/structure/Brick_Structural_Walls.htm

Interiors

- Electric Baseboard Cabinets
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A preliminary version of this document was developed by staff of Franklin Energy Services, as part of work performed under contract with the State of Wisconsin. All pictures not referenced were taken by staff of Franklin Energy while on contract with the State of Wisconsin, or by Don Hynek and Wisconsin Division of Energy Services staff.

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