**Best Practice - Principles of CFM Reduction**

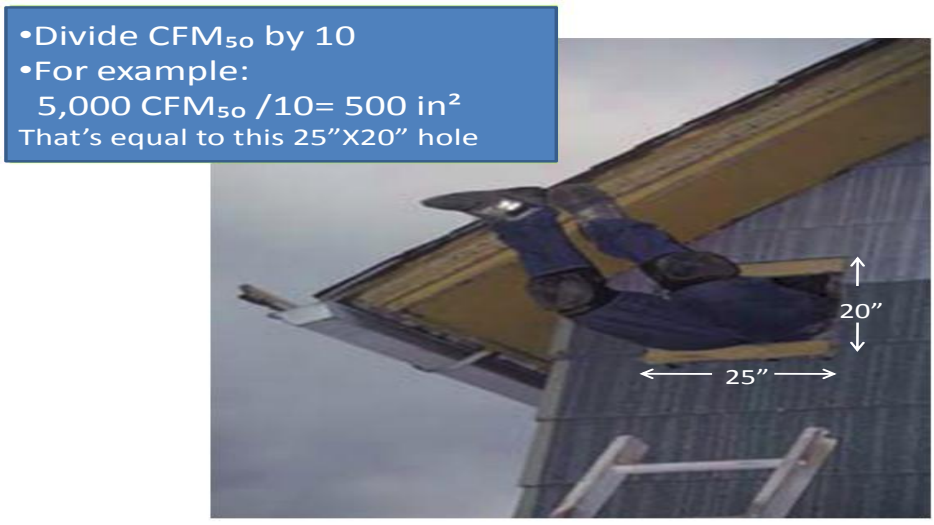
**Date**: Revised March 2018

**Subject**: Principles of CFM Reduction

**Problem or Question**: We, as a Subrecipient, want to do a better job at CFM reduction. We want to maximize air sealing efforts, by exceeding the minimum reduction target, on a more regular basis. What is the best approach to eliminating CFMs?

**Discussion**: Air Sealing is performed to reduce stack effect and to prevent moisture from entering a unit. Performing blower door driven air-sealing is recommended for achieving maximum CFM reduction. Properly air sealing houses is a major component to the reduction in energy bills for clients. The tighter a house, the longer the conditioned air remains in the house, causing the HVAC system/RACs to run less. Creating a well defined thermal boundary requires two steps: 1) air sealing, and 2) insulating attics, walls, and floors. If at the completion of weatherization work, you obtain a higher blower door reading than projected, it is essentially like running a refrigerator, with its well insulated shell, but leaving the door cracked open. Your goal is to achieve the lowest final blower door reading justifiably possible. **The ideal final target would be 0 CFMs with the proper mechanical ventilation.** WAP Subrecipients must utilize their diagnostic tests to ensure they maximize effective air sealing. The best WAP programs ventilate right so they can air seal TIGHT!

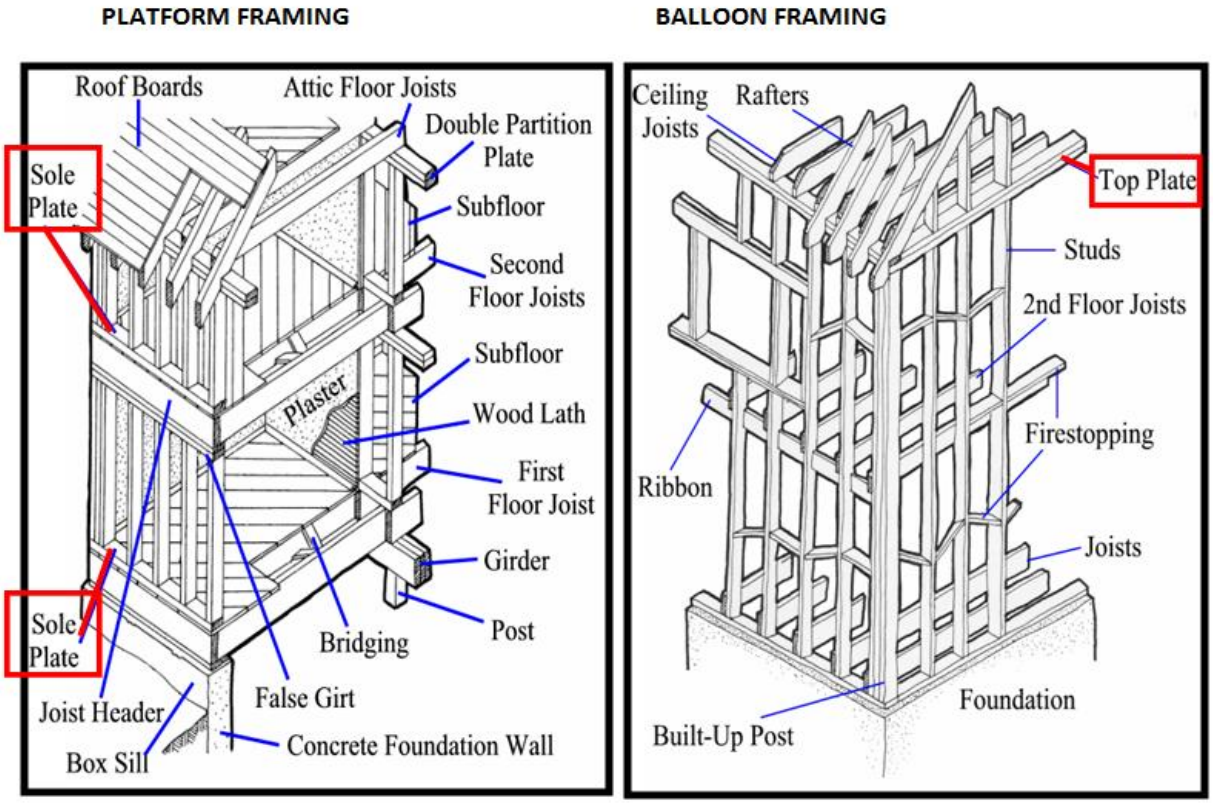
Below, illustrates the hole size to CFM relationship of air leakage:




The thermal boundary, or thermal envelope, restricts or slows the flow of heat from conditioned and unconditioned spaces. Conditioned spaces are the indoor areas that are heated and cooled, such as the living room, kitchen, bedrooms, and bathrooms. Unconditioned spaces are the outdoors or any areas in a residence that are not heated or cooled, such as the attic, crawl space, unfinished basement, and garage. The thermal boundary consists of two fully aligned components: an air barrier and insulation.

Maximally eliminating air that can cross the thermal boundary is a huge factor in reducing utility costs and maintaining comfort for the client.
Typically, most air leakage occurs between the inside of the house and the attic. The key to air sealing the attic is to block off the large openings between the attic floor and the ceiling of the living space, and to seal any smaller openings. This is systematically accomplished by working from one end of the attic to the other. Texas has a hot humid climate and climbing into an attic with temperatures in the mid-hundred range is not pleasant. Prior to sending a worker into the attic to air seal, gather as much valuable information during the initial assessment about where to air seal. This can reduce the time spent in an attic and proves most beneficial to quality air sealing. Run zonal pressure diagnostic (ZPD) tests, and pressure pan (PP) tests. Record the areas on which to concentrate air sealing measures. Provide the weatherization crew with a map, or clear verbal instructions of where to air seal. Further guidance on ZPD and PP tests are outlined near the end of this Best Practice.
The following list shows how to prioritize air sealing to achieve the most CFM reduction:

1. Air Seal openings between the attic and living space.
    - The attic must first be prepared by placing attic flags above any junctions or areas that electricians, HVAC technicians, or plumbers may possibly need to access in the future. These areas will be obscured by the insulation but need easy identification.
        - With the blower door running, use a smoke stick to identify areas that need to be sealed. Also, insulation that has turned black is an indicator of air movement through the insulation. Identify the source;
        - Seal chimney and attic chases, drop or soffit ceilings, and top plates;




        - An IR camera is a useful tool for identifying leaky top plate areas.

- Small eyebrow roof and overhangs may be possible to access from the exterior by removing the soffit or filling it with dense-packed cellulose.

- Seal around plumbing penetrations with spray foam;

-Place shields around fixtures & flues

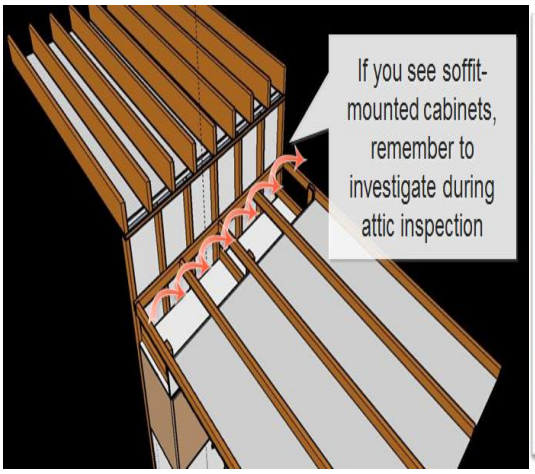
-Anticipated ventilation installed

-Wiring safe

-Juncture boxes and recessed lights marked

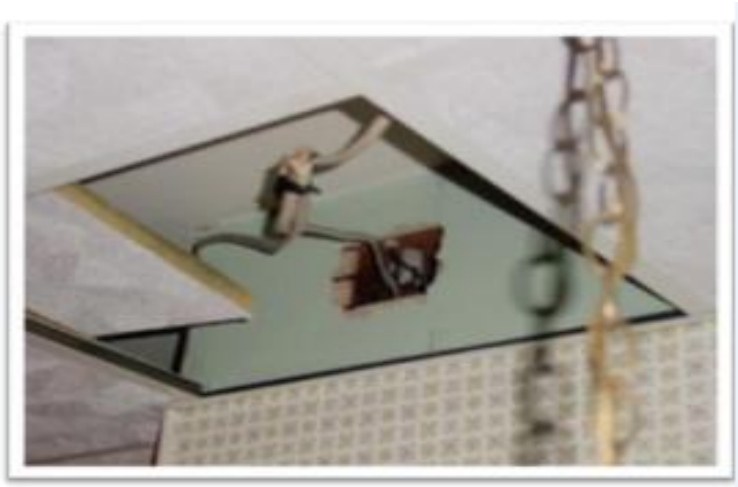
- Seal around electrical penetrations with spray foam;
  - Care should be taken to not cover un-insulated wires or wire connections not inside covered junction boxes.
  - See Knob and Tube best practice
- Seal above open-to-attic kitchen soffit;
- Seal the attic access hatch in accordance with program regulations (SWS);

**Seal All Bypasses**

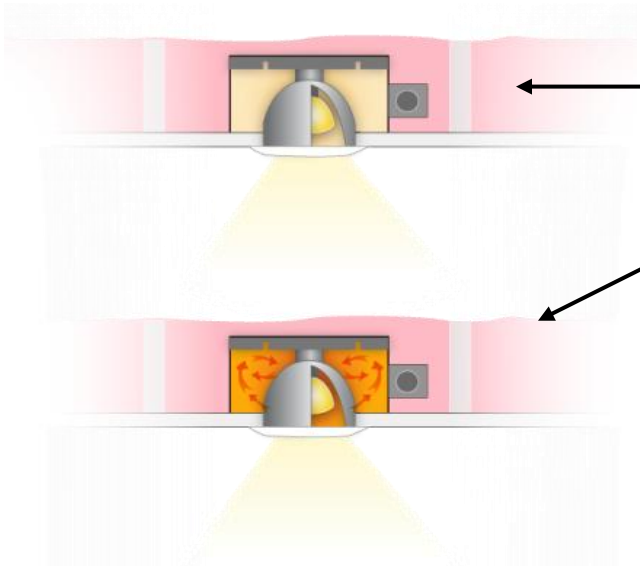



Use any air-barrier (sheetrock, foam board, plywood, etc) cut to fill in the area and foam seal in place.

- Suspended ceilings can hide tremendous leakage areas, especially if they have attic spaces above them;



- Recessed light fixtures can significantly contribute to the air leakage in a home. It is estimated that one conventional (IC or non-IC) fixture can be responsible for the loss of $5 to $30 per year worth of energy. Air leakage from recessed cans, in a cooling climate, can cause hot humid air to infiltrate the building shell, increasing the demand on the AC and energy costs;



**RECESSED LIGHTS**

- IC Rated fixtures can be covered in insulation
- Non-IC rated fixtures cannot.
- Covering non-IC rated fixtures leads to heat build up which:
  - Reduces bulb life
  - Increases fire hazard

- non-IC rated fixtures, may be retrofitted with new air-tight IC rated cans or LED recessed down light retrofits, **IF** they are justifiable (i.e. – rank in energy audit or are justified on PL)
- IC rated fixtures can be sealed by:
  - By building an air tight box and foaming the perimeter to the ceiling. The box must be made of noncombustible material and large enough

(approximately 3" clearance from unit, in all directions) to dissipate heat generated by the fixture.

Sheetrock + foil tape

polystyrene + foam

Recessed light cover foamed in place

2. Identify and seal openings between the house and an attached garage.
   - This is not only an air infiltration issue, but also a health and safety issue.
     - Weatherize any doors connecting the house to the garage.
       - If the door does not latch properly, you may have to adjust the weatherstripping or the door's strike plate.

3. When possible, air seal between the house and the foundation. For example, a pier and beam foundation, that is accessible for insulating, should be insulated.
   - Seal the chase-ways and bottom plates;
   - Seal around plumbing and electrical penetrations
   - Pier and beam foundations with hardwood flooring can have a polyurethane sealer applied to eliminate air infiltration through flooring joints


4. Reduce leakage through building cavities, using dense pack cellulose
   - Repair broken windows;
   - Patch holes in walls;
   - Seal ceilings in closets or cabinets open to attic area.

5. Seal around interior plumbing and electrical penetrations, caulk windows and door casings, caulk moldings and baseboards, or other significant areas found while running the blower door.

**CFM Reduction Techniques:**

**The following techniques have been effectively used by Subrecipients to significantly reduce air infiltration in weatherized.**

1. Run all your diagnostic tests and use that information to complete a quality initial assessment. Diagnostic tests run during an initial can identify quantifiably valuable information as to where to prioritize air sealing measures. The more detailed the information gathered during the initial assessment, the more detail can be provided to the contractor on the work order. All of these diagnostic tests should be performed during the initial assessment while the blower door is running at -50Pa:
    a. **Zonal Pressure Diagnostic Test (ZPD):**
        *i.* *If your ceiling and floor are not established air barriers, those areas of air infiltration need to be maximized before moving on to any other measure.*

        ii. **Ceiling Barrier:** This test shows how effective your pressure barrier is. Drill a small hole in the ceiling sheetrock (in a bedroom closet or somewhere inconspicuous); avoid ceiling joists, so you can get the pressure probe through the ceiling and insulation. With the blower door running, check the ZPD reading on your manometer. The closer the ZPD reading is to -50Pa, the closer it is to the outside. The closer the ZPD reading is to zero, the more it is like the house. If the ceiling is a good air barrier, the pressure difference between the pressure probe in the attic and the open manometer port in the bedroom closet should be -50Pa. The attic would be "outside" the thermal boundary. If the ZPD reading for the attic is -35Pa, or less negative, this indicates that there is a significant bypass. Begin locating where unconditioned attic air is interacting with conditioned house air.

        *iii.* **Floor Barrier:** On a non-slab, elevated house (EX: pier and beam), the same strategy can be applied: drill a hole in the floor, send the probe through, and the goal is to get as close to -50Pa as possible.

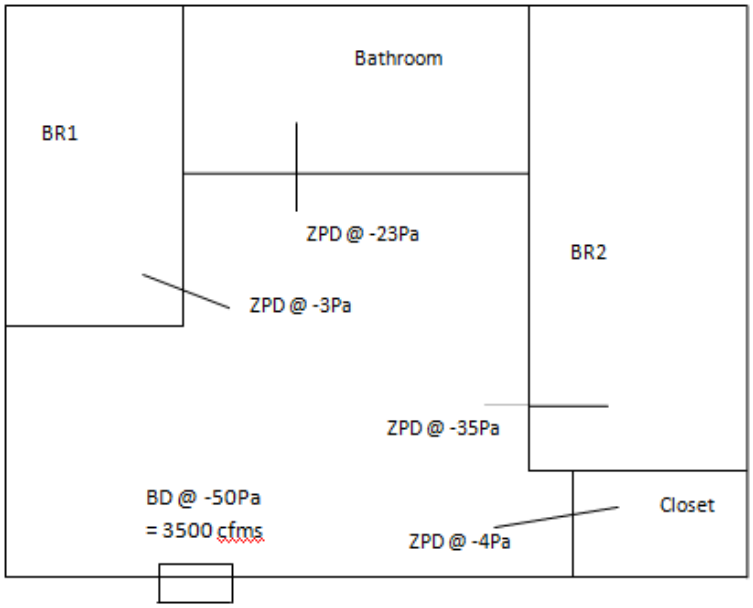
Note: If you are ever working on a house where you are going to install floor insulation, with an exposed belly, always perform these repairs as much as can be properly justified: repair plumbing leaks; tightly seal all holes in the floor (air infiltration); inspect and seal duct system; repair the rodent barrier; install a ground-moisture barrier in the crawl space if the site is wet; make sure to install a vapor barrier at the completion of floor insulation to protect the new insulation.

        iv. **Effective Weather-stripping:** With BD at -50Pa, you stand inside the house, and send your probe across/through a weather-stripped door (probe through back door to outside, probe from hallway through door to zoned off room like utility closet or combustion appliance) and shut that door; that ZPD should also be at/near -50Pa. If probe is across the weather-stripping, the door is shut, the probe is "outside" but the ZPD is -20Pa, that door is not properly sealed and that needs to be addressed/corrected immediately (adjust the weather-stripping;

add more sash locks to ensure consistent seal, etc). If your ZPD is not -45Pa or more negative, the door is not properly sealed, the weather-stripping is not effective, and those leaky bypasses (EX: hi/low combustion pipes) are allowing major leaks into the house!

v. **Interior ZPDs:** While walking around inside the house, you can stand in the hallway, throw the manometer hose under the bedroom/bathroom/closet door, shut that door and see what the pressure difference is between 2 interior rooms. The ideal pressure difference is 0Pa because you want no pressure difference between interior inside rooms. If there is a bedroom with a ZPD of -35Pa, that room is more outside than inside and air sealing in that room should be a high priority. If you have a bedroom or closet with a ZPD of 5Pa or less, there is little to no pressure difference, so air sealing that area will not be effective and your BD will not decrease = waste of time and money.

*Below is a very simple example of interior ZPDs obtained at initial assessment.*




*In the example above, regarding the rooms: proper prioritization would be to air seal in BR2 first (this room is more outside than inside), then the bathroom, and NO air sealing done in BR1 or the closet. Any air sealing done in BR1 or the closet, even if there are visual things identified, will not significantly decrease our BD because the ZPD tells us those items are NOT leaking any air. BR2 and bathroom would be addressed as well as the main body of the house, and that would reduce the BD reading most effectively. Once those initial measures are completed, if funds are still available, conducting secondary ZPDs to ensure reduction has been achieved and identifying more air sealing opportunities is a fantastic option! Make sure you maximize the work that can be justified in those appropriate areas; do not leave available funds on the table if you haven't hit your target yet!*

Utilizing ZPDs allows you to locate, quantify, and prioritize the specific holes and bypasses in each area and hit the worst areas first.

b. **Pressure Pan Readings (PP):** check all duct registers, and switch plate and outlet covers on both interior and exterior walls. These readings will quantify ducts or walls that are contributing the most air leakage. High PP readings between two duct registers indicate which duct runs are the leakiest. PP readings on the return air will quantify how much unconditioned air is being allowed to enter the HVAC system, causing it to work harder/longer. PP readings on switch/outlet covers will diagnose which walls, whether exterior or interior, have the biggest bypasses, showing you which walls need to be sealed (either from the exterior, or the top plate in the attic). Prioritize air sealing accordingly; including completely replacing duct runs if necessary. If the PP readings show acceptable readings (less than 0.8Pa), there is no need to waste time in those areas.

c. **Duct Sealing:** This separate measure eliminates the amount of unconditioned air that is able to infiltrate into the duct system or enter the house. Concentrate efforts on effectively sealing the return air, the supply plenum to the HVAC cabinet, and supply plenum itself. Sealing/replacing duct runs should be driven by your PP readings and then verify the effectiveness of the work at the final inspection. These efforts contribute to achieving the CFM reduction goal.

An example work order, from such a comprehensive assessment, might read: "Air seal exterior doors; air seal plumbing penetrations under the kitchen and bathroom sink(s); air seal the master bedroom closet ceiling; seal HVAC return/plenum/and cabinet plenum; air seal top plate of wall above the living room TV from attic; weather-strip attic hatch, address duct run to master bedroom and bath; seal around windows in BR2; do NOT do any air sealing in BR1 or entry closet." A detailed work order focuses efforts and makes verification of measures easier during the final inspection. Don't allow the contractor to spend time/material/money installing measures that are not effective.

2. Air sealing while a blower door is running is the most effective way to achieve reduction goals. CFMs cannot be identified and eliminated without running a blower door. Once one significant leak is covered up, another leak (previously undetectable) may emerge, but only if you are running a blower door. Note that different blower door systems provide slightly different readings depending on their calibration and origin of manufacturer, so make sure to calibrate all applicable equipment regularly.

   General Rule: With blower-door is running if the air sealing person cannot reduce more than 100 CFMs per hour, you are likely past the point of diminishing returns.

3. Provide the weatherization contractor the CFM target. After the work-order is completed, the contractor should run a blower-door test to verify the CFM target was reached or exceeded. If the specific goal for reduction is not met, the Subrecipient, with contractor input, should consider utilizing the same diagnostic methods used at the assessment to identify leaky areas to authorizing additional weatherization measures to reach that goal, as funds remain available and justifiable.
   a. Ask weatherization contractors to place a phone call (or email photos) to request a change to any counter-infiltration work on the work-order. Consider designating a QC person or specific supervisor to work with contractors. Consider using a "change order form" to track any additional changes or costs. One technique is to provide a verbal "confirmation number" of approval, so weatherization crews do not have to stop work. Have agency staff or assessors conduct a site visit to verify and approve the request for increased CFM costs/work. Document the approval confirmation number on the work-order or on a "change-control" document.
4. Subrecipient staff and contractors need to evaluate their own work to try and identify air sealing practices that are most effective. TDHCA is fully aware that CFM reduction targets will not be

met in 100% of weatherized homes; however, if the target is not met or exceeded in 60+% or more of the houses weatherized, then the Subrecipient and their contractor need to: (1) ensure that all the diagnostic tests are being utilized to gather as much information as possible to create a properly prioritized work order, (2) run the proper diagnostic tests at the final to see if the work done accomplished the goal, and if neither of those work, (3) request training from Department program staff to find more effective ways to air seal and achieve targets more consistently.

MAXIMIZE THIS MEASURE! Do NOT be satisfied with minimal CFM reduction, if it can be justified to achieve better air sealing results, and funds are available, DO IT! **Remember: the ideal final target would be 0 CFMs with the proper mechanical ventilation.** Subrecipients must utilize their diagnostic tests to ensure they maximize effective air sealing. The best WAP programs ventilate right (ASHRAE) so they can air seal TIGHT!