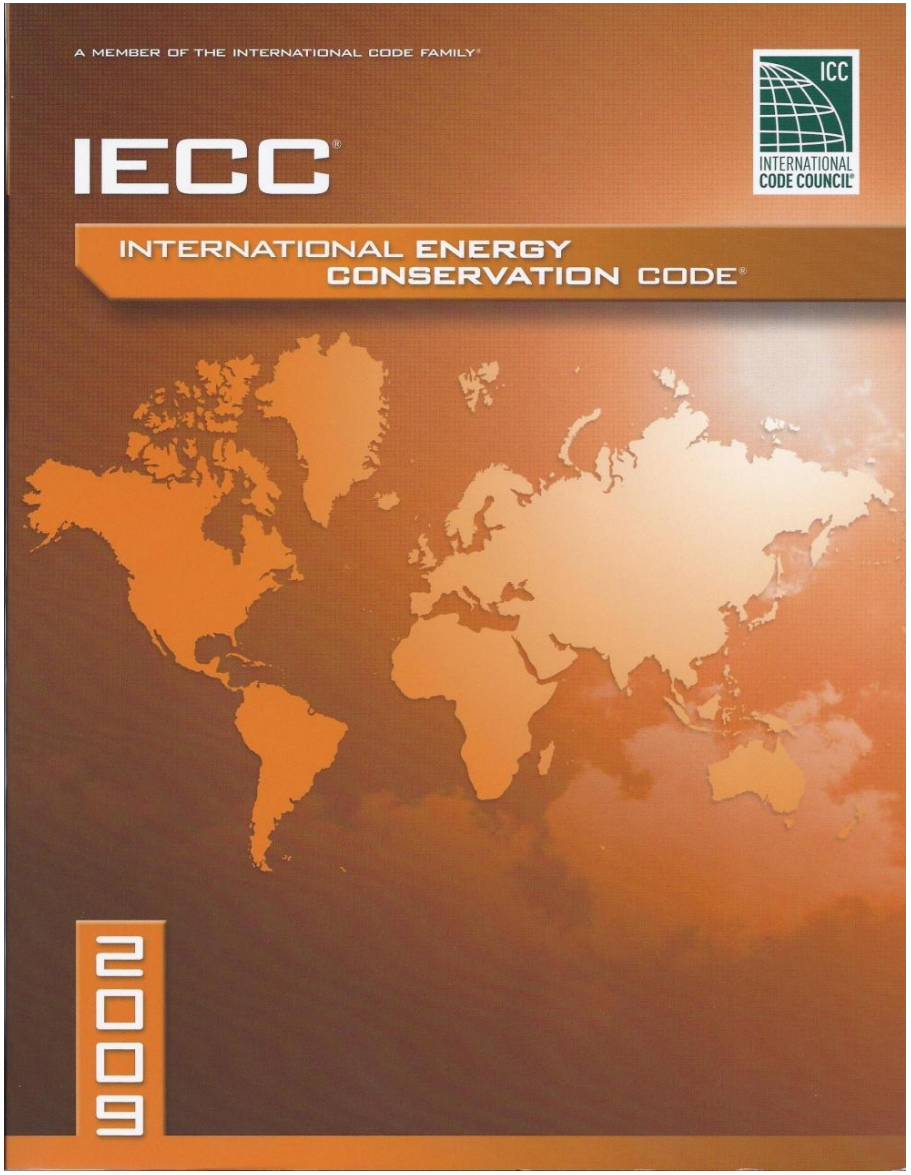
DUCT LEAKAGE TESTING AS REQUIRED BY IECC 2009 ENERGY CODE



402.4 Air leakage (Mandatory).

402.4.1 Building thermal envelope. The *building thermal envelope* shall be durably sealed to limit infiltration. The sealing methods between dissimilar materials shall allow for differential expansion and contraction. The following shall be caulked, gasketed, weatherstripped or otherwise sealed with an air barrier material, suitable film or solid material:

1. All joints, seams and penetrations.
2. Site-built windows, doors and skylights.
3. Openings between window and door assemblies and their respective jambs and framing.
4. Utility penetrations.
5. Dropped ceilings or chases adjacent to the thermal envelope.
6. Knee walls.
7. Walls and ceilings separating a garage from conditioned spaces.
8. Behind tubs and showers on exterior walls.
9. Common walls between dwelling units.
10. Attic access openings.
11. Rim joist junction.
12. Other sources of infiltration.

402.4.2 Air sealing and insulation. Building envelope air tightness and insulation installation shall be demonstrated to comply with one of the following options given by Section 402.4.2.1 or 402.4.2.2:

402.4.2.1 Testing option. Building envelope tightness and insulation installation shall be considered acceptable when tested air leakage is less than seven air changes per hour (ACH) when tested with a blower door at a pressure of 33.5 psf (50 Pa). Testing shall occur after rough in and after installation of penetrations of the building envelope, including penetrations for utilities, plumbing, electrical, ventilation and combustion appliances.

During testing:

1. Exterior windows and doors, fireplace and stove doors shall be closed, but not sealed;
2. Dampers shall be closed, but not sealed, including exhaust, intake, makeup air, backdraft and flue dampers;
3. Interior doors shall be open;
4. Exterior openings for continuous ventilation systems and heat recovery ventilators shall be closed and sealed;
5. Heating and cooling system(s) shall be turned off;
6. HVAC ducts shall not be sealed; and
7. Supply and return registers shall not be sealed.

402.4.2.2 Visual inspection option. Building envelope tightness and insulation installation shall be considered acceptable when the items listed in Table 402.4.2, applicable to the method of construction, are field verified. Where required by the *code official,* an *approved* party independent from the installer of the insulation shall inspect the air barrier and insulation.

402.4.3 Fireplaces. New wood-burning fireplaces shall have gasketed doors and outdoor combustion air.

402.4.4 Fenestration air leakage. Windows, skylights and sliding glass doors shall have an air infiltration rate of no more than 0.3 cfm per square foot (1.5 $L/s/m^2$), and swinging doors no more than 0.5 cfm per square foot (2.6 $L/s/m^2$), when tested according to NFRC 400 or *AAMA/WDMAI/* CSA 101/I.S.2/A440 by an accredited, independent laboratory and *listed* and *labeled* by the manufacturer.

Exceptions: Site-built windows, skylights and doors.

402.4.5 Recessed lighting. Recessed luminaires installed in the *building thermal envelope* shall be sealed to limit air leakage between conditioned and unconditioned spaces. All recessed luminaires shall be IC-rated and *labeLed* as meeting ASTM E 283 when tested at 1.57 psf (75 Pa) pressure differential with no more than 2.0 cfm (0.944 Lis) of air movement from the *conditioned space* to the ceiling cavity. All recessed luminaires shall be sealed with a gasket or caulk between the housing and the interior wall or ceiling covering.

402.5 Maximum fenestration U-factor and SBGC (Mandatory). The area-weighted average maximum fenestration *U-factor* permitted using trade-offs from Section 402.1.4 or 404 shall be 0.48 in Zones 4 and 5 and 0.40 in Zones 6 through 8 for vertical fenestration, and 0.75 in Zones 4 through 8 for skylights. The area-weighted average maximum fenestration SHGC permitted using trade-oft's from Section 405 in Zones 1 through 3 shall be 0.50.

SECTION 403
SYSTEMS

403.1 Controls (Mandatory). At least one thermostat shall be provided for each separate heating and cooling system .

403.1.1 Programmable thermostat. Where the primary heating system is a forced-air furnace, at least one thermostat per dwelling unit shall be capable of controlling the heating and cooling system on a daily schedule to maintain different temperature set points at different times of the day. This thermostat shall include the capability to set back or temporarily operate the system to maintain zone temperatures down to 55°P (l3^{0}C) or up to 8YP (29°C). The thermostat shall initially be programmed with a heating temperature set point no higher than 70^{0}P (21°C) and a cooling temperature set point no lower than 78°P (26°C).

403.1.2 Heat pump supplementary heat (Mandatory). Heat pumps having supplementary electric-resistance heat shall have controls that, except during defrost, prevent supplemental heat operation when the heat pump compressor can meet the heating load.

403.2 Ducts.

403.2.1 Insulation (prescriptive). Supply ducts in attics shall be insulated to a minimum of R -8, All other ducts shall be insulated to a minimum of R-6.

Exception: Ducts or portions thereof located completely inside the *building thermal envelope.*

403.2.2 Sealing (Mandatory). All ducts, air handlers, filter boxes and building cavities used as ducts shall be sealed.

Joints and seams shall comply with Section M1601.4.l of the *International Residential Code.*
Duct tightness shall be verified by either of the following:

1. Postconstruction test: Leakage to outdoors shall be less than or equal to 8 cfm per 100 ft^2 (9.29 m-) of *conditioned floor area* or a total leakage less than or equal to 12 cfm per 100 ft2 (9.29 m^2) of *conditioned floor area* when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test.

2. Rough-in test: Total leakage shall be less than or equal to 6 cfm per 100 ft2 (9.29 m^2) of *conditioned floor area* when tested at a pressure differential of 0.1 inches w.g. (25 Pa) across the roughed in system, including the manufacturer's air handler enclosure. All register boots shall be taped or otherwise sealed during the test. If the air handler is not installed at the time of the test, total leakage shall be less than or equal to 4 cfm per 100 ft^2 (9.29 m^2) of *conditioned floor area.*

Exceptions: Duct tightness test is not required if the air handler and all ducts are located within *conditioned space.*

The ENERGY CONSERVATORY

DIAGNOSTIC TOOLS TO MEASURE BUILDING PERFORMANCE

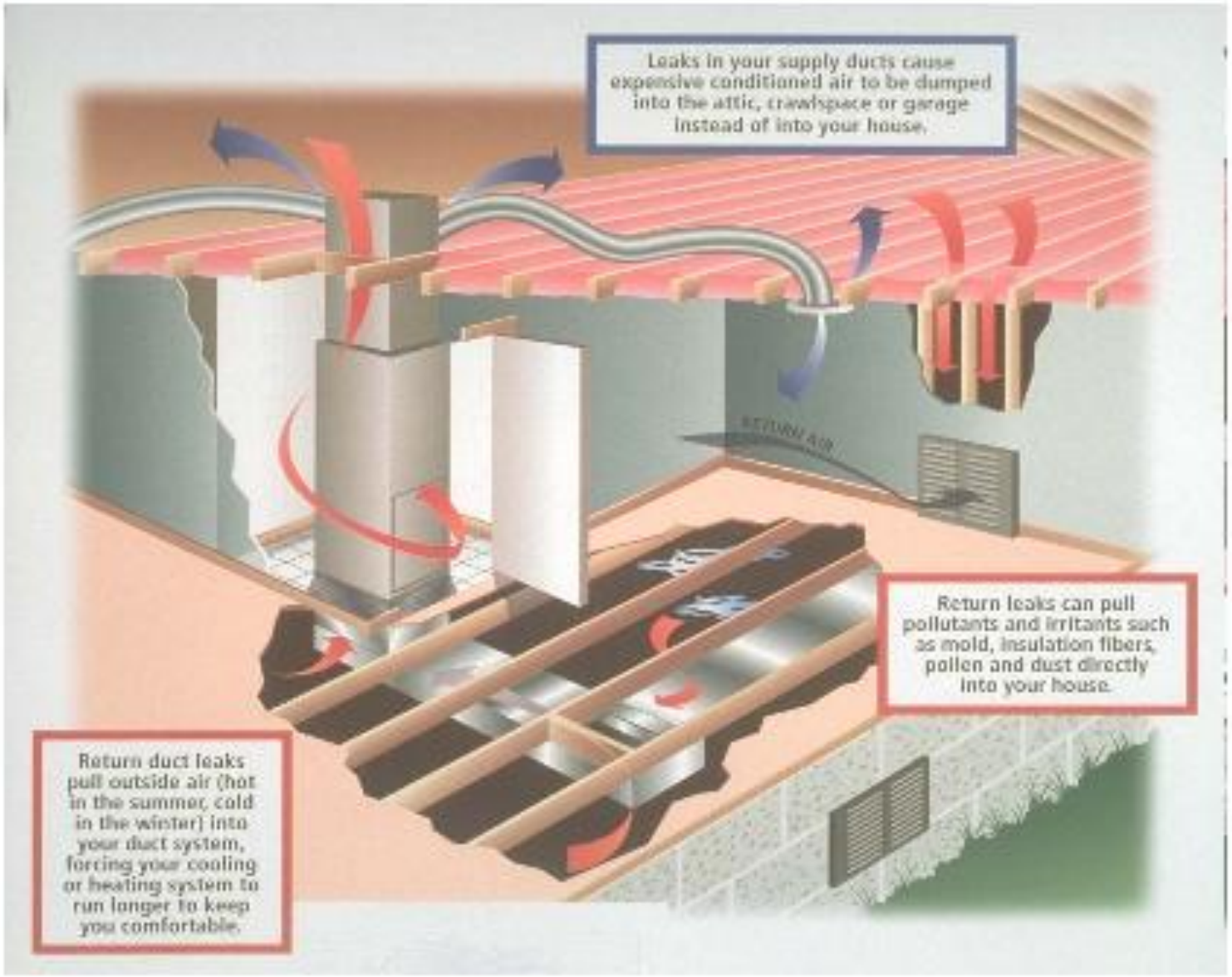
Duct Leakage Testing 101

Frank Spevak
The Energy Conservatory
Minneapolis, MN

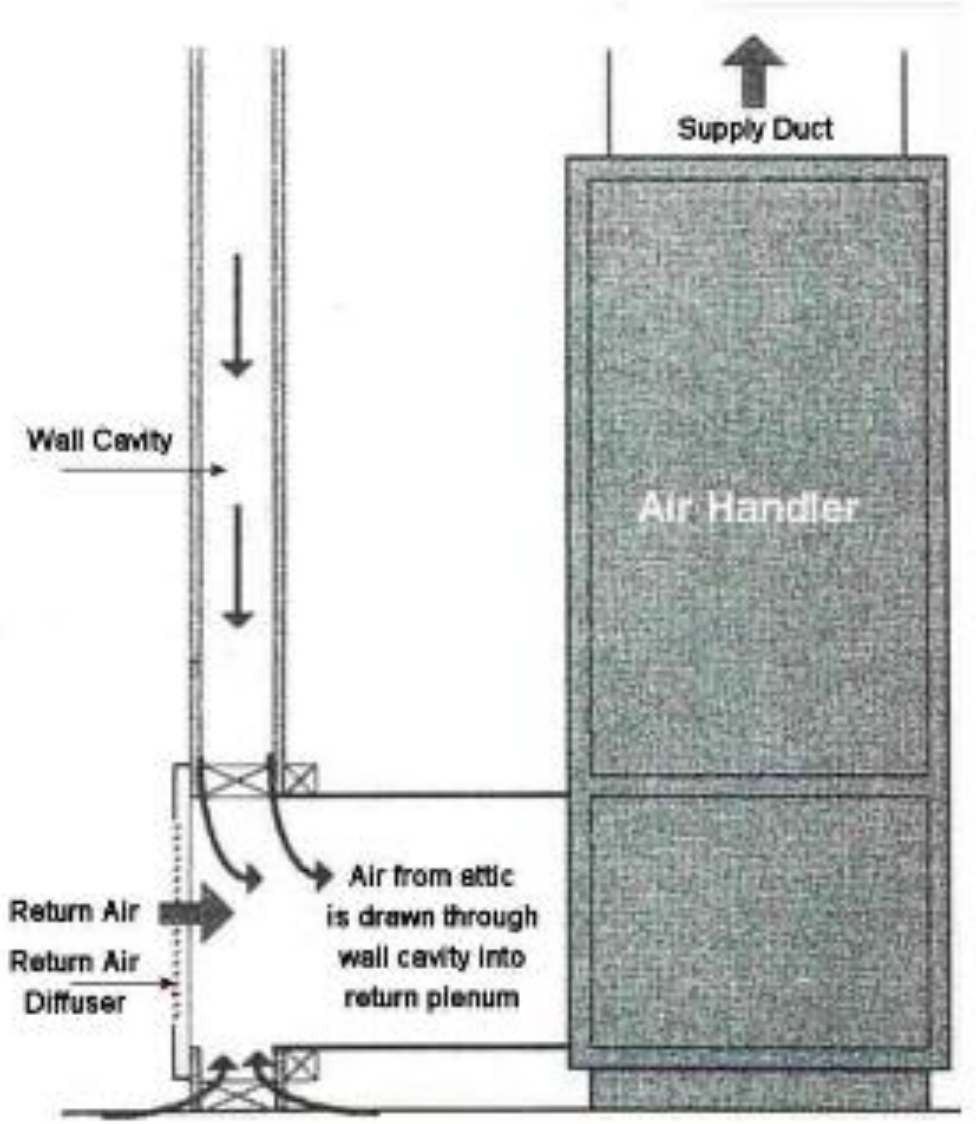
Agenda

- Duct Leakage and Interactions
- Types of Duct Leakage Tests
  - Total Duct Leakage
  - Duct Leakage to Outside
- Set-up for Total Duct Leakage
- Set-up for Duct Leakage to Outside
- Discussion of Leakage Results
- Duct Blaster® Calibration
- Other Tests Using a Duct Blaster®

Duct Leakage Interactions



Common Leakage Locations



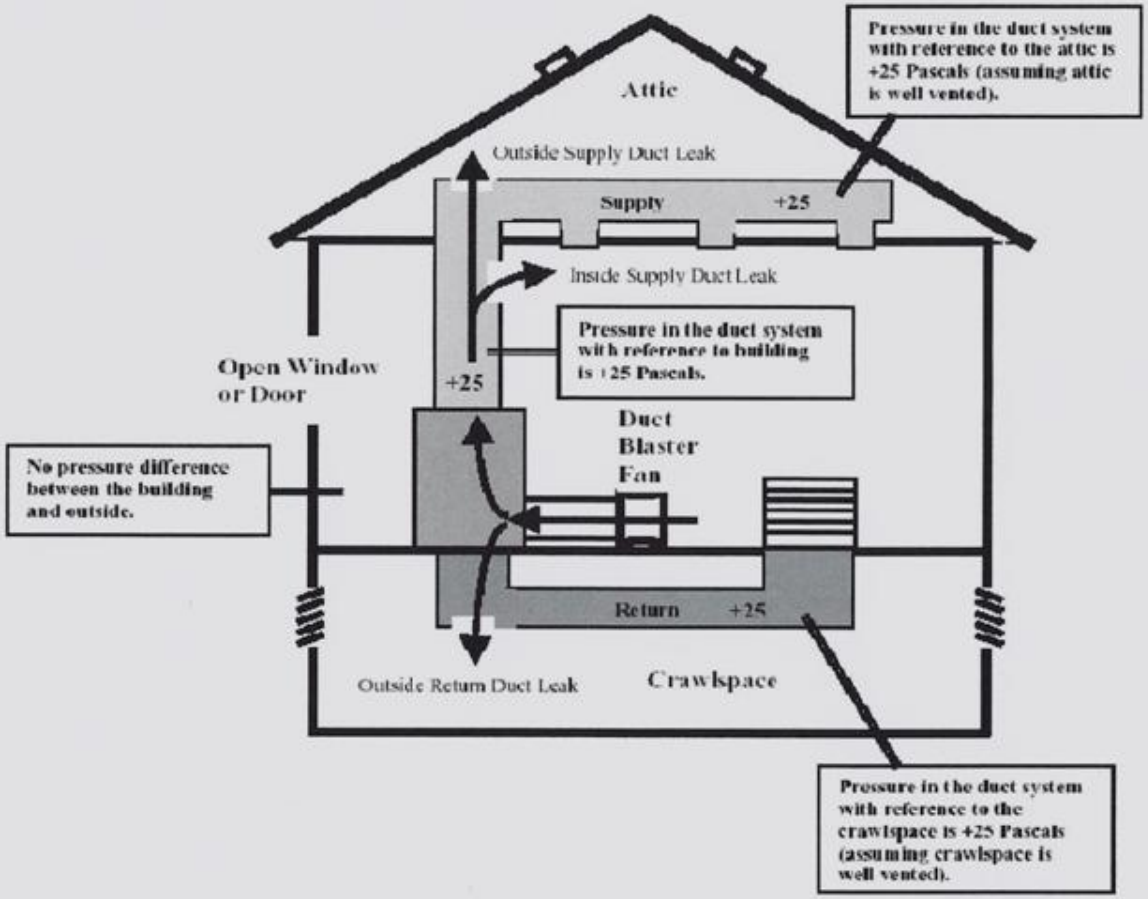
Types of Duct Leakage Tests

- Total Duct Leakage
  - Pressurize (or depressurize) duct work.
  - Duct Blaster® connected to central return or air handler.
  - Measure air flow (CFM) needed to pressurize ducts to 25 Pa.
  - Measures all duct leaks.

BLOWER DOOR WITH DG700 MANOMETER AND TECTITE TESTING SOFTWARE

Total Leakage Test

- Measures all leaks in the duct system, both inside and outside of the building.

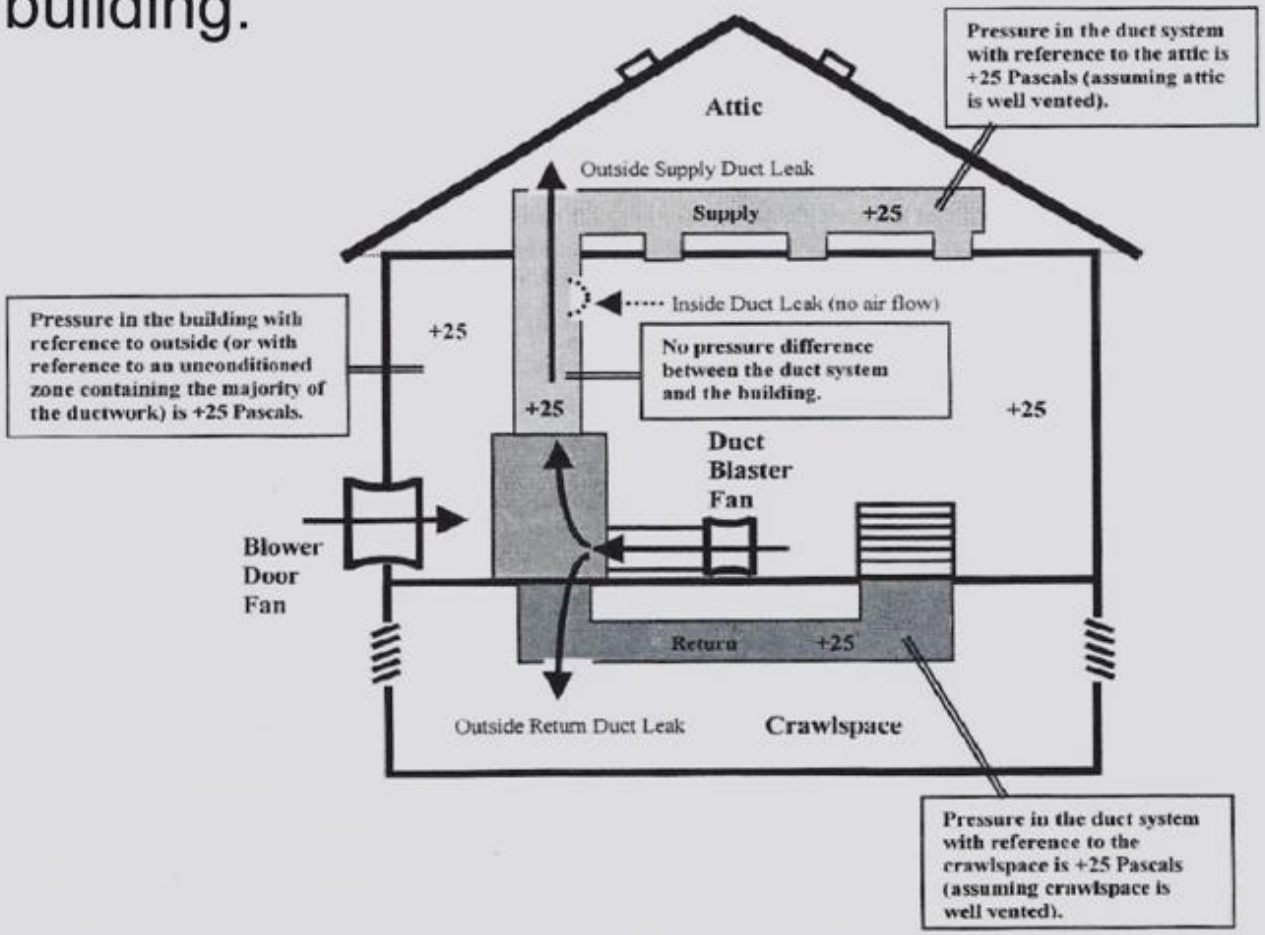


Types of Duct Leakage Tests

- Duct Leakage to Outside
  - Pressurize (or depressurize) duct work.
  - Duct Blaster connected to central return or air handler
  - Blower Door operating to pressurize house to 25 Pa.
  - Measure air flow (CFM) needed to equalize pressure in ducts to 0 Pa.
  - Measures only duct leaks to outside the building envelope (e.g. attics, crawlspaces, garages).

Outside Leakage Test

- Does not include duct leakage to inside the building.



Total vs. Outside Leakage Test

Total Leakage Test:

Pro:

- Can do test at rough-in.
- Shorter set-up time/easier test.
- Less equipment needed.

Con:

- Often results in larger leakage measurement than Outside test (unless all ducts are outside of the building).
- Harder to meet Energy Star requirements if leakage number is bigger.
- If testing at rough-in, often have to accept penalty for missing register grilles (2.5%), and missing air handler (2.5%).

Total vs. Outside Leakage Test

Outside Leakage Test:

Pro:

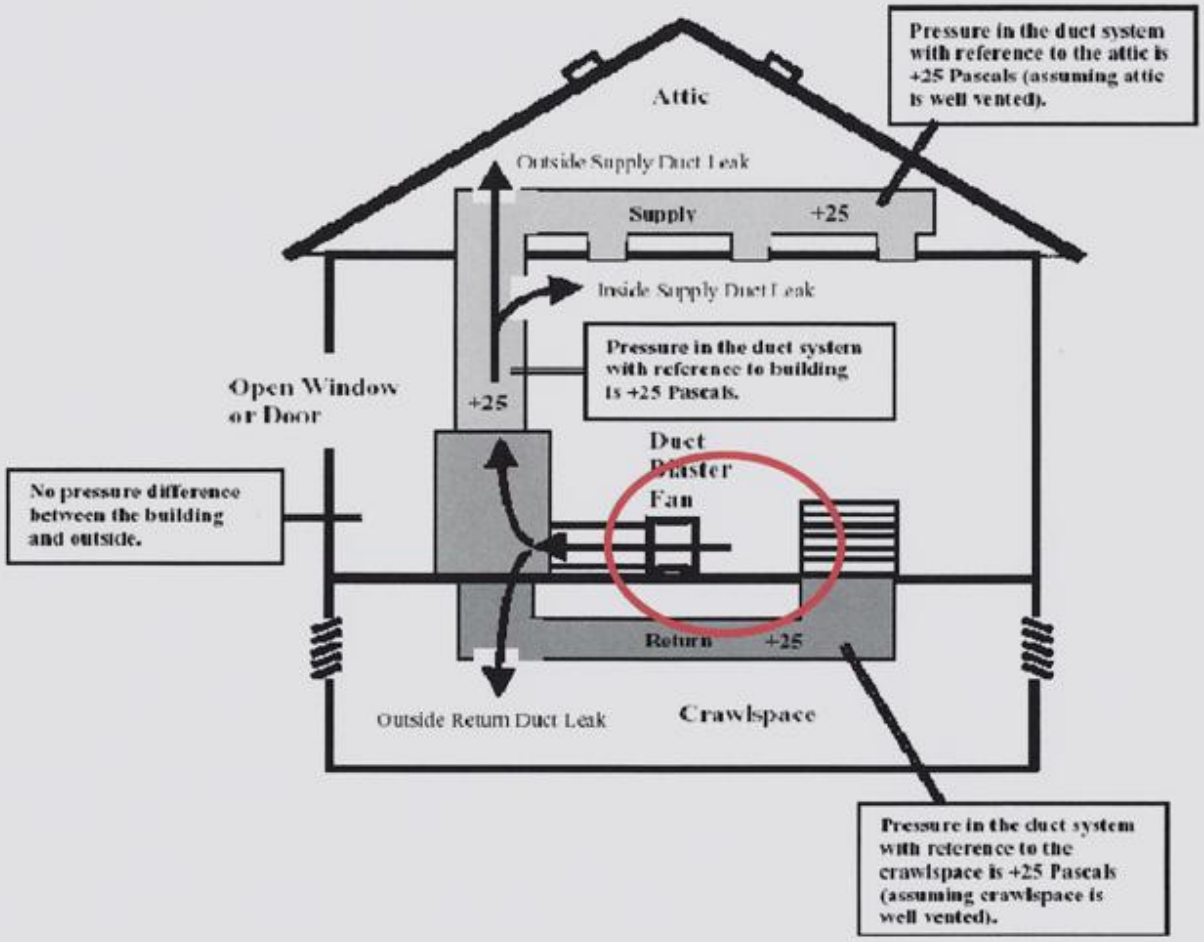
- Often results in smaller leakage measurement than Total test (unless all ducts outside).
- Easier to meet Energy Star requirement if leakage measurement is smaller.

Con:

- Longer set-up time.
- More equipment needed (Blower Door).
- Must wait until building envelope completed before conducting test.

Total Leakage Test (Pressurization)

Conducting a Total Leakage Test



Total Leakage Test

- Connect the Duct Testing Fan to either:
  - The largest return grille, or
  - The blower access door.

Total Leakage Test

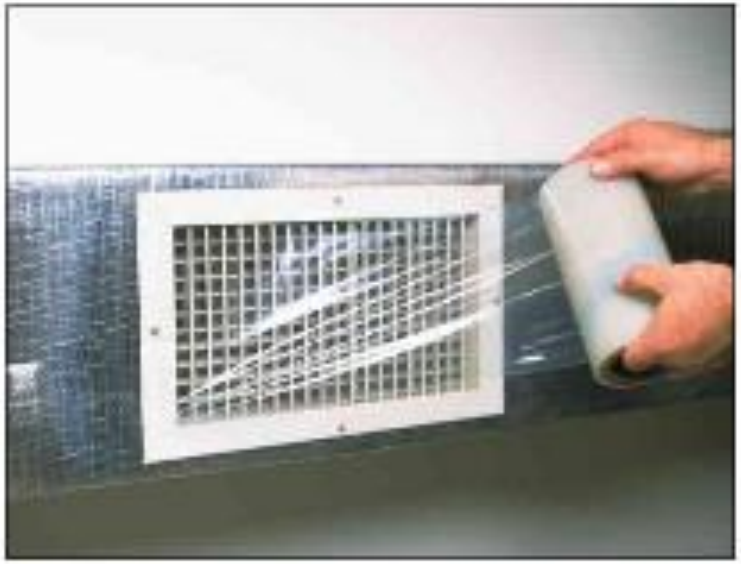
- Install the Flow Ring on the fan that you think best matches the needed fan flow (can always change Ring during test).

Fan Configuration	Flow Range (cfm) For Series B Duct Blaster
Open (no Flow Ring)	1,500 - 600
Ring 1	800 – 225
Ring 2	300 – 90
Ring 3	125 – 10

Total Leakage Test

- Turn off the air handler so that it does not come on during test.

- Temporarily seal off all remaining supply and return registers using painters tape, Duct Mask or other temporary seal.

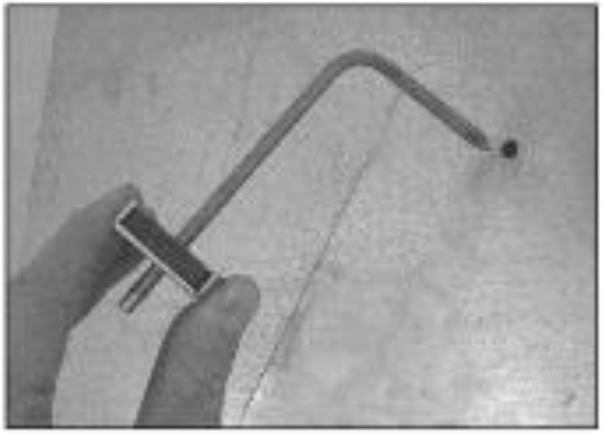


Total Leakage Test

- Turn off exhaust fans, dryers etc.
- Remove all filters from the duct system.
- Open a door or window between the house and outside (prevents changes in house pressure during the test), and interior doors.
- Open access doors from unconditioned spaces (e.g. attics) containing ducts to outside.

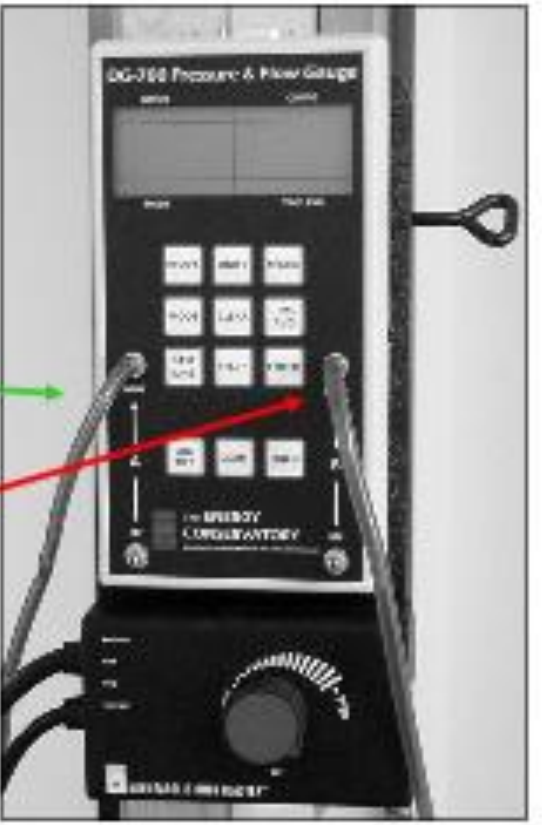
Total Leakage Test

- Select a location to measure duct pressure.
  - Either in the supply plenum, supply trunkline, or at a supply register.
  - In a tight duct system (i.e. < 200 CFM25), location choice will have very little effect on results.
  - In zoned systems, must have dampers open, or will need to test each supply run separately *(this is a big problem)*.



Total Leakage Test

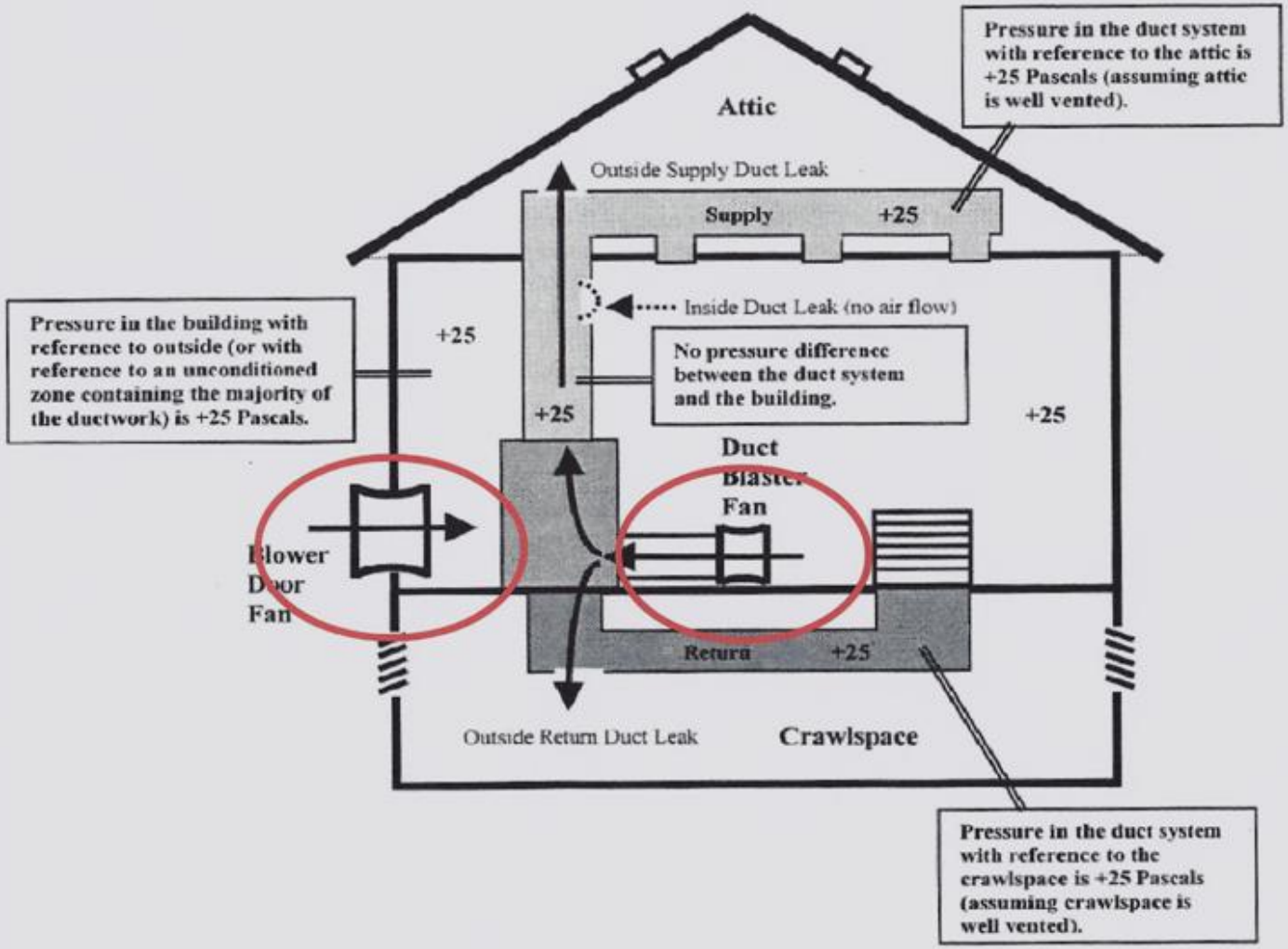
- Connect tubing to the DG-700 Gauge.
  - Green tubing from duct pressure probe to Input of Channel A.
  - Red tubing from Duct Blaster fan to input of Channel B.



Total Leakage Test

- Put DG-700 in **PR/ FL @25** Mode, enter Device and Configuration, adjust fan to about 25 Pa duct pressure on Channel A.
  - Gauge displays CFM25 on Channel B. (Can't Reach 25 Factor is built-in to the flow reading)
  - Saves time - no need to adjust test pressure to exactly 25 Pa - just get close (20 - 30).
  - In very leaky duct systems, displays leakage estimate if Duct Pressure is at least 5 Pa.

Outside Leakage Test (Pressurization)



Outside Leakage Test

- When possible, unconditioned zones containing ducts shall be opened to outside and conditioned zones containing ducts shall be opened to inside. If this is not possible, leave as is.
- Windows and doors to outside must be closed.
- Prepare house for a Blower Door test.
  - Water heater on pilot.
  - Turn off heating and cooling system.

Outside Leakage Test

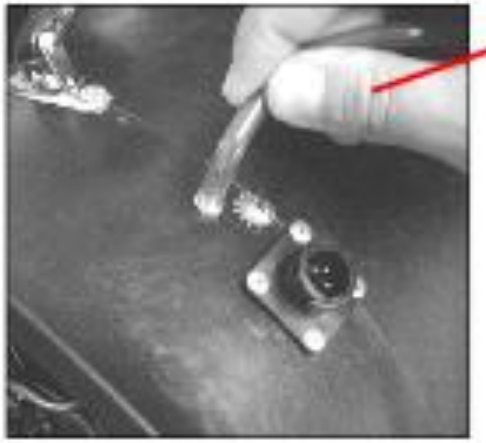
- Seal off all registers and returns as in a Total Duct Leakage Test.
- Duct Testing Fan set up is the same as Total Leakage Test.
- Install Blower Door fan to pressurize house (not measuring flow from Blower Door fan).

Outside Leakage Test (Blower Door)

- Start DG-700 gauge on the Blower Door and go to the Cruise Mode.
- Set for 25 Pa.
- Start fan to maintain house at 25 Pa.

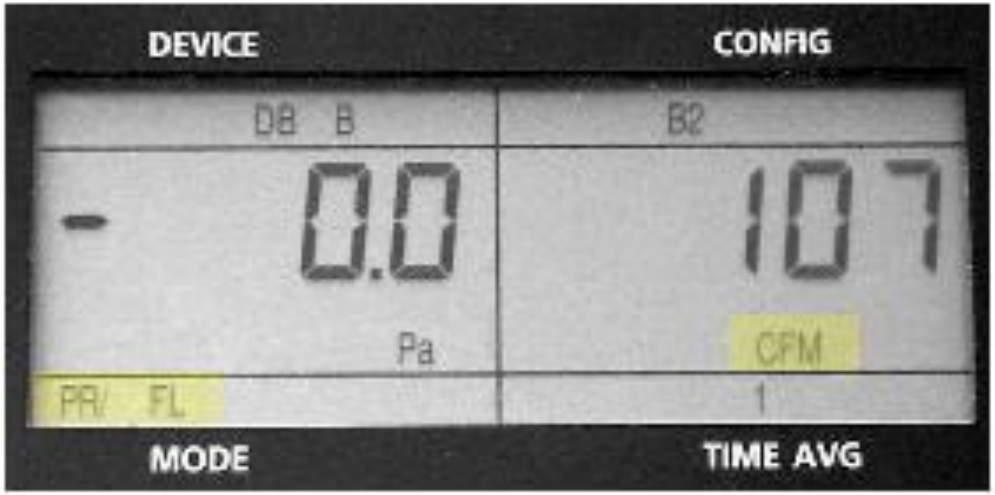
Outside Leakage Test

- With Duct Blaster DG-700, connect tubing to the gauge (same as Total Leakage Test).
  - Green tubing from duct pressure probe to Input of Channel A.
  - Red tubing from Duct Blaster fan to input of Channel B.



Outside Leakage Test

- Put DG-700 in **PR/ FL** Mode *(not PR/ FL @25)*, enter Device and Configuration.
- With Blower Door pressurizing building to 25 Pa, adjust Duct Blaster to create zero pressure between ducts and building (Channel A). Flow value from Channel B is the measured leakage.



Tips and Troubleshooting

- When performing a Leakage to Outside Test, perform a Total Leakage Test first to determine if house passes without the Outside Test.
- Also provides you with an maximum leakage number. The Outside Test can not have a number larger than the Total Test.
- Remember, for Outside Test, have the gauge in **PL/FL** mode not **PL/FL@25** mode – common error.

Leakage Results

- Any duct leakage that is outside of the building envelope creates an energy penalty as well as air quality problem.
- Duct leakage to the inside is not a large energy penalty, but can contribute to problems related to delivery of air, comfort issues and other problems related to pressurization or depressurization of the house.
- Be aware that sealing all ductwork can cause other problems related to the air handler or combustion safety.

Leakage Results

- How much duct leakage is acceptable?
- Use California as example (all ductwork is usually outside building envelope)
  - For Retrofit
    - Total duct leakage can not exceed 15% of rated flow of air handler, or
    - Reduction of total duct leakage by 60%. (Requires a pre test of duct leakage)
- Energy Star
  - For New construction
    - 6 cfm leakage to the outside per 100 sq. ft. of floor area.

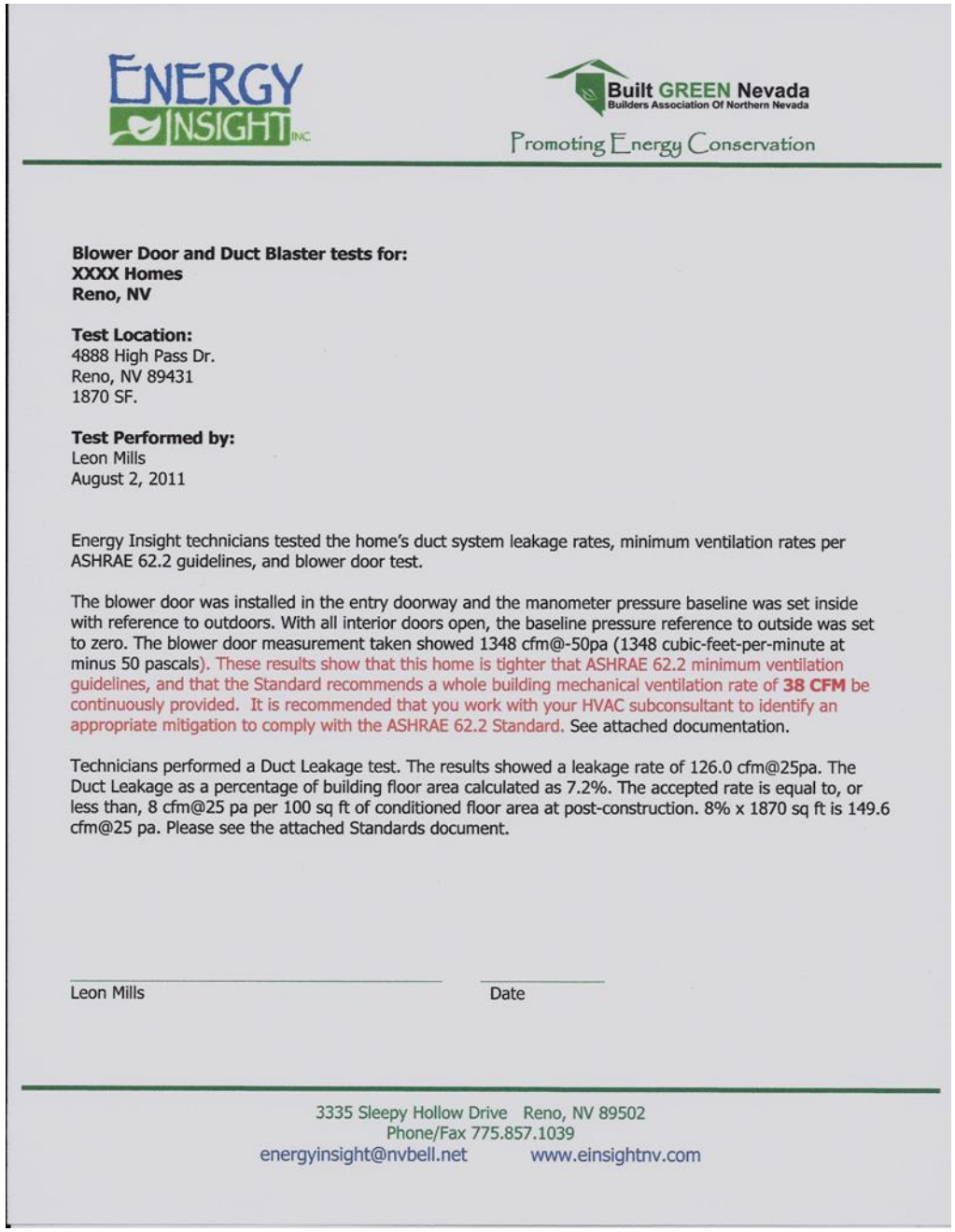
Leakage Results

- How much leakage are we talking about?
- Retrofit:
  - House system has 2 ½ tons of cooling.
  - At 400 CFM per ton equals 1,000 CFM.
  - Retrofit @ 15% = 150 CFM25 of total leakage.
- New construction:
  - 1000 square feet
  - Energy Star @ 6% equals 60 CFM25 of leakage to the outside

Duct Leakage Impacts

- Example –
  - Outside duct leakage test results are 300 CFM25 on a 2 ½ ton system.
  - Assuming the leaks are split equally between supply and return, the result is a 22.5% annual energy penalty.
  - A 12 SEER system is now only 9.3.
  - An 80% furnace is now only 62%.
- Duct Leakage to Outside is a direct energy penalty for heating and cooling.

TYPICAL BLOWER DOOR AND DUCT BLASTER REPORT AS PROVIDED TO THE BUILDER.



ENERGY INSIGHT INC

Built GREEN Nevada
Builders Association Of Northern Nevada

Promoting Energy Conservation

Blower Door and Duct Blaster tests for:
XXXX Homes
Reno, NV

Test Location:
4888 High Pass Dr.
Reno, NV 89431
1870 SF.

Test Performed by:
Leon Mills
August 2, 2011

Energy Insight technicians tested the home's duct system leakage rates, minimum ventilation rates per ASHRAE 62.2 guidelines, and blower door test.

The blower door was installed in the entry doorway and the manometer pressure baseline was set inside with reference to outdoors. With all interior doors open, the baseline pressure reference to outside was set to zero. The blower door measurement taken showed 1348 cfm@-50pa (1348 cubic-feet-per-minute at minus 50 pascals). These results show that this home is tighter that ASHRAE 62.2 minimum ventilation guidelines, and that the Standard recommends a whole building mechanical ventilation rate of **38 CFM** be continuously provided. It is recommended that you work with your HVAC subconsultant to identify an appropriate mitigation to comply with the ASHRAE 62.2 Standard. See attached documentation.

Technicians performed a Duct Leakage test. The results showed a leakage rate of 126.0 cfm@25pa. The Duct Leakage as a percentage of building floor area calculated as 7.2%. The accepted rate is equal to, or less than, 8 cfm@25 pa per 100 sq ft of conditioned floor area at post-construction. 8% x 1870 sq ft is 149.6 cfm@25 pa. Please see the attached Standards document.

Leon Mills _____ Date _____

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Phone/Fax 775.857.1039
energyinsight@nvbell.net www.einsightnv.com

OTHER RESOURCES

WWW.ENERGYCONSERVATORY.COM

Select PRODUCTS, and then either Blower Door or Duct Blaster and desired subject, test procedure or brochure.

WWW.RETROTEC.COM

WWW.FLIR.COM

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WWW.WXTVONLINE.ORG

Short videos produced by Montana State University pertaining to weatherization of residential structures.

Duct Testing & Sealing

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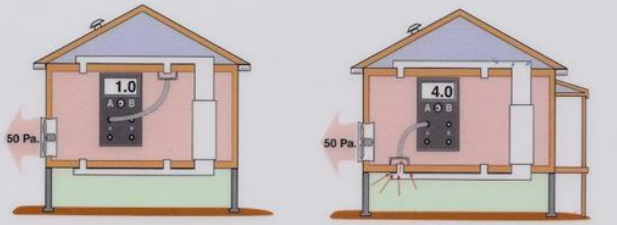
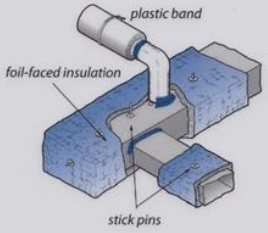


Pressure Pan Testing

Pressure pan testing helps to locate duct air leaks without inspecting or needlessly sealing the whole duct system.

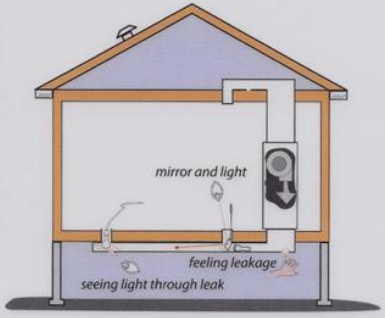
1. Open interior doors to connect all conditioned living spaces together. Close doors to outdoors and to unconditioned areas like crawl spaces.
2. Install a blower door and depressurize the house to –50 pascals.
3. Cover each register with the pressure pan, which is connected to the input port of a digital manometer and reads positive pressure cause by air leaking into the ductwork from outdoors.
4. Registers registering numbers greater than 2 pascals reflect nearby duct leakage or general duct leakage.
5. Using the pressure pan and blower door as your guide, find and seal the largest duct air leaks.
6. Readings less than 1 pascal are considered good.



Duct insulation: Supply ducts located in unheated areas should be insulated to a minimum of R-6.

Finding Duct Leaks by Touch and Sight

1. Use a light and inspection mirror to look into the ducts and inspect joints.
2. Use the air handler blower to pressurize supply ducts. Closing the dampers on supply registers temporarily or partially blocking the register with pieces of carpet, magazines, or any object that won't be blown off by the register's airflow will increase the duct pressure and make duct leaks easier to find.
3. Place a trouble light, with a 100-watt bulb, inside the duct through a register. Look for light emanating from the exterior of duct joints and seams.
4. Recognize which duct joints were difficult to fasten and seal during original installation. These joints are likely duct-leakage locations.



Recycled Stock. Sustainable Forest Initiative (SFI) & Forest Stewardship Council (FSC) Chain of Custody dual certification.

Plenums: Joints in the plenum can be major leakage locations. The best plenums are metal, sealed with mastic and fabric webbing. Use silicone caulking between the air handler and plenum if you think the air handler could be replaced.

Tabbed sleeve and sectioned elbow

Duct Leak Locations

The following is a list of duct-leak locations in order of their relative importance. Leaks nearer to the air handler see higher pressure and so rank higher than leaks further away.

Air handler: Leaks in the air handler are the top air-sealing priority.

Plenum joints at air handler: These joints may have been difficult to fasten and seal because of tight access. Go the extra mile to seal them airtight with mastic and fabric mesh tape.

Joints at branch takeoffs: These important joints should be sealed with a thick layer of mastic. Fabric mesh tape is a plus for new installations or when access is easy.

Joints in sectioned elbows: Known as gores, these are usually leaky.

Large holes: Seal with metal patch and mastic.

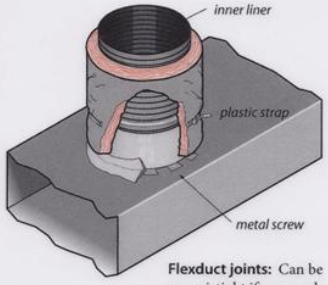
Tabbed sleeves: Attach the sleeve to the main duct with 4-to-6 screws and lay on the mastic.

Joints in main-duct sections: Make sure these sections have a couple screws on each side fastening them together. Run mastic and mesh tape around the joint.

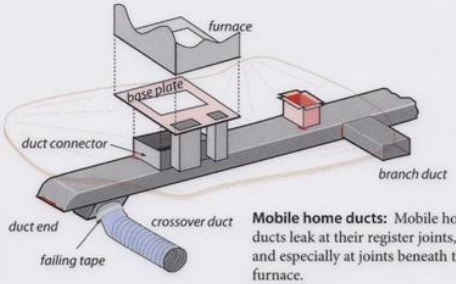
Ductboard with loose tape: Clamp the flexduct's inner liner with the strap tightener. Run a screw or two next to the strap when the flexduct is pulling slightly on the metal collar to keep it from separating. Clamp the insulation and outer liner with another strap.

Ductboard with loose tape: Dust the surfaces off as best you can first. Stick the tape back on with mastic and mastic over the tape. When the customer can afford it, trash the ductboard and give them a new extended-plenum metal system.

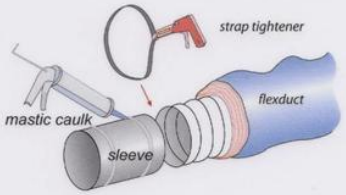
Sealing a tabbed sleeve inside a rooftop unit's plenum at replacement



Flexduct joints: Can be very airtight if prepared or repaired correctly.



Mobile home ducts: Mobile home ducts leak at their register joints, ends, and especially at joints beneath the furnace.



DIGITAL PHOTO

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