Basic Duct Leakage Testing

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The Energy Conservatory
Housekeeping

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• We will be showing how to set up TEC equipment.
• Most of the information can be used regardless of the manufacturer of the equipment.
• Thank you for attending today.
The Energy Conservatory

Our mission is to make buildings more energy efficient through the development and manufacture of diagnostic tools.
We provide the most comprehensive and extensive technical support to our customers on the use of Minneapolis Blower Door™, Minneapolis Duct Blaster® and all of the equipment we manufacture.
Learning Objectives

#1: Learn about the current and future codes as they relate to duct leakage
#2: Learn how to perform a number of tests to measure duct leakage
#3: Learn what the results mean and the effects of duct leakage in a house
Agenda

• Overview of the IRC & IECC Code Status and Requirements
• DET and IDL
• Duct Testing
  • Types of testing
  • Procedures for testing
• What do the numbers mean?
IRC and IECC

• IRC addresses all topics related to residential construction
  – Structural, plumbing, electrical, mechanical etc.
  – Allows builder to carry only one code book
  – Chapter 11 covers energy efficiency

• IECC addresses only energy
• IECC addresses both residential and commercial
• The IRC has incorporated the residential energy provisions of the IECC
IECC
• Section R402.4.1.2

• Section N 1102.4.1.2 (R402.4.1.2)
http://bcap-energy.org/
What We Have Learned

• There 17 states that have not adopted IECC 2009 as the state energy code contrary to each of the states accepting federal funds that required the adoption of the energy code.

• States are free to adopt the I Codes by reference and then modify with State specific amendments
  – These amendments can make important clarifications.
  – The State of Georgia’s Amendments to the IECC will be discussed as an example
Modifications to Code

- Individual jurisdictions within a state are taking independent action to the state – both to be stricter and to be less strict.
  - El Paso County, CO - Stricter
  - Anonymous County, CA – Exempting all duct testing
- Many code officials are still learning what the code is, what tests are required and what to do with the test results.
- Always check with your local jurisdiction regarding requirements.
PA Amendments

• Tests shall be conducted in accordance with ANSI/ASHRAE 152-2004, Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems.
State Amendments to the 2009

- DET
  - Certified
  - Duct & Envelope Tightness Verifier
GA Amendments

- HERS Raters
- Home Performance with Energy Star Contractor
- BPI Building Analyst
- Or complete a Certified DET course

CERTIFIED DUCT AND ENVELOPE TIGHTNESS (DET) VERIFYER. A certified DET verifier shall be a certified Home Energy Rating Systems (HERS) rater, or be a certified Home Performance with ENERGY STAR contractor, or be a Building Performance Institute (BPI) Analyst, or successfully complete a certified DET verifier course that is approved by the Georgia Department of Community Affairs.
(Effective January 1, 2011)
DUCT AND ENVELOPE TIGHTNESS VERIFICATION TRAINING

This course is designed to introduce the skills necessary to become a Duct and Envelope Tightness (DET) Verifier, certified to perform the diagnostic testing required for new homes by the 2009 and 2012 IECC Georgia amendments.

This is a one-day course when taught on site at Southface and a two-day course when taught in Alabama and Chattanooga, Tennessee.

Learn:
After successful completion of this course, the participant will be able to test the leakage of a building envelope and duct system, and evaluate the results as measured against Georgia code requirements. Specific topics include:

- Protocols for blower door and duct leakage testing
- Calculations for $ACH_{150}$ and percent duct leakage
- Tips for successfully completing the written and in-field DET Verifier certification exams

Click here to view a detailed course agenda.

Earn:

- CEUs: AIA, 8.5 LU, BPI 4 units
- Certifications: Duct and Envelope Tightness Verifier. To achieve designation as a DET Verifier, a student must receive a passing score on both exams (included in tuition costs).

This Training Includes:

- DET training workbook
- Written DET Verifier exam
- In-field DET Verifier exam
- RECA Guide
On January 1st, 2013, the State of Illinois implemented the 2012 Illinois Energy Conservation Code (based on the 2012 International Energy Conservation Code with Illinois amendments) through the Illinois Energy Efficient Building Act [20 ILCS 3125]. As part of the new energy code, blower door testing is required to demonstrate a building infiltration rate of no more than 5 ACH50. Duct tightness testing is required where the air-handler or any portion of the ducts are located outside of the building thermal envelope or pressure boundary. For more information on diagnostic energy testing in the new 2012 IECC please visit DCEO's Frequently Asked Questions page.
The Illinois Department of Commerce and Economic Opportunity (DCEO) and the Midwest Energy Efficiency Alliance (MEEA) are providing a list of individuals who have taken training or hold certifications related to using building diagnostic equipment including, but not limited to, blower door and duct pressurization equipment. These individuals have received training or certifications demonstrating that they are able to complete blower door testing and/or duct leakage testing in compliance with the 2012 Illinois Energy Conservation Code. The State of Illinois does not endorse individual building diagnostic testers. It is recommended that anyone interested in utilizing this list solicit multiple bids and check relevant insurance and licensing of the professionals being considered for building diagnostic tests. For more information on the types of training and certifications listed, please visit the More Information page.

- Use DET verifier program developed by Southface but adapted to Illinois requirements.
Louisiana Requirement

- Nationally recognized certification program
  - BPI
  - HERS
  - DET not nationally recognized
  - IDL (Infiltration and Duct Leakage) from BPI
    - Brand new
    - Considered nationally recognized
What We Have Learned

• Adoption to the code is slow but will continue.
• More education is needed throughout the system.
  – State energy office
  – Code developers – IECC and State
  – Code officials
  – Inspectors
  – Builders
  – Contractors
  – Home owners
2009 IECC 403.2.2
Duct Tightness Tests

• Duct tightness shall be verified
• Post construction
  – 2 Methods
    • Leakage to outdoors:
      • ≤ 8 cfm/per 100 ft² of conditioned floor area
    • or
    • Total leakage:
      • ≤ 12 cfm/per 100 ft² of conditioned floor area
        – tested at a pressure differential of 25 pa (0.1 in w.g.) across entire system, including manufacturer’s air handler enclosure
    • All register boots shall be taped or otherwise sealed during the test.
• 403.2 Ducts.
• 403.2.1 Insulation
  – Supply ducts in attic 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.
Ducts

• 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 IRC, Section M1601.4.1 Building framing cavities shall not be used as supply ducts
IECC SECTION 403

2009

• 403.2.2 Sealing (mandatory)
  – All ducts, air handlers, filter boxes and building cavities used as ducts shall be sealed

• 403.2.3 Building Cavities (mandatory)
  – Building framing cavities shall not be used as supply ducts

2012

• 403.2.2 Sealing (mandatory)
  – Ducts, air handlers and filter boxes shall be sealed

• 403.2.3 Building Cavities (mandatory)
  – Building framing cavities shall not be used as ducts or plenums
Performance Testing Tools
Conditioned Space Leakage
Leakage to the Outside
Duct Leakage Interactions

Leaks in your supply ducts cause expensive conditioned air to be dumped into the attic, crawlspace or garage instead of into your house.

Return leaks can pull pollutants and irritants such as mold, insulation fibers, pollen and dust directly into your house.

Return duct leaks pull outside air (hot in the summer, cold in the winter) into your duct system, forcing your cooling or heating system to run longer to keep you comfortable.
Interior Cavity Leakage

- Wall Cavity
- Return Air
- Return Air Diffuser
- Air from attic is drawn through wall cavity into return plenum
- Supply Duct
- Air Handler
Performance Testing Tools
Duct Insulation Exception: Ducts or portions thereof located completely inside the building thermal envelope
Exception: Ducts or portions thereof located completely inside the building thermal envelope
Testing

• 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
Types of Duct Leakage Tests

• Total Duct Leakage (required in 2009 and 2012)
  – 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.
Types of Duct Leakage Tests

• Duct Leakage to Outside (required in 2009 but not allowed in 2012)
  – 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).
Duct Leakage Test Results

• Rough-in test (air handler installed)
  – Total leakage ≤6 cfm/per 100 ft² of conditioned floor area
    • tested at a pressure differential 25Pa (0.1 in w.g.) across roughed-in system
    • all register boots taped or otherwise sealed
Duct Leakage Test Results

• Rough-in test (air handler not installed)
  – Total leakage ≤4 cfm/per 100 ft² of conditioned floor area
    • tested at a pressure differential 25Pa (0.1 in w.g.) across roughed-in system
    • all register boots taped or otherwise sealed
Types of Duct Leakage Tests

- **Total Duct Leakage**
  - Measures all duct leaks.
  - 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.
Types of Duct Leakage Tests

• Duct Leakage to Outside
  – Measures only duct leaks to outside the building envelope (e.g. attics, crawlspaces, garages).
  – 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.
Conditioned Space versus Enclosure

Exceptions: Duct tightness test is not required if the air handler and all ducts are located within conditioned space
Total Leakage Test (Pressurization)

Pressure in the duct system with reference to the attic is +25 Pascals (assuming attic is well vented).

Pressure in the duct system with reference to the building is +25 Pascals.

Pressure in the duct system with reference to the crawlspace is +25 Pascals (assuming crawlspace is well vented).

No pressure difference between the building and outside.
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).

• Now have Ring 4

<table>
<thead>
<tr>
<th>Fan Configuration</th>
<th>Flow Range (cfm) For Series B Duct Blaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open (no Flow Ring)</td>
<td>1,500 - 600</td>
</tr>
<tr>
<td>Ring 1</td>
<td>800 – 225</td>
</tr>
<tr>
<td>Ring 2</td>
<td>300 – 90</td>
</tr>
<tr>
<td>Ring 3</td>
<td>125 – 10</td>
</tr>
</tbody>
</table>
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 trunk, 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)

Pressure in the building with reference to outside (or with reference to an unconditioned zone containing the majority of the ductwork) is +25 Pascals.

Supply +25

Pressure in the duct system with reference to the attic is +25 Pascals (assuming attic is well vented).

Pressure in the duct system with reference to the crawlspace is +25 Pascals (assuming crawlspace is well vented).
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 \(\text{not } PR/ FL \@ 25\), 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.
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%).
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.
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.

• Provides you with a 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

• 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 CFM 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.
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.
Duct Blaster Field Calibration Plate

- Used to perform a field calibration check on your Series B Minneapolis Duct Blaster System (with DG-700 gauge).

- Designed to simulate a duct leakage test with a leakage rate of 106 CFM @25 Pa.
Finding Leaks

Performance Testing Tools
• Foggers
Duct Diagnostics Using A Blower Door

• Duct Leakage Diagnostics:
  • Pressure Pan test to determine if duct work is connected to the outside.
  • With Blower Door maintaining 50 Pa, test registers with Pressure Pan.
  • Qualitative test.
  • Helps find dominant leak to the outside.
Duct Diagnostics Using A Blower Door

- **Blower Door Subtraction**
  - Test total envelope leakage of house.
  - Seal all registers.
  - Test house again.
  - Compare test results with registers sealed and unsealed.
  - Result should be duct leakage to outside.
Tools For Finding Leaks

- Blower doors
- Infrared Scanners
- Smoke pencils and theatrical fog
More Useful Information

- Fan Calibration
  - Fans maintain their calibration unless physical damage occurs.
  - These conditions are easily detected and should be tested for on a regular basis.
Main Issues Affecting Fan Calibration

• The 2 most important aspects to maintaining proper fan calibration:
  • No leaks in flow sensor.
  • Sensor in proper position.

• Damaged fan housing (e.g. broken flange) and broken/ missing blades.
Flow Sensor Position

• Because the Blower Door and Duct Blaster flow sensors are connected to the motor, the motor determines the sensor position.

• Motors can move if fan is dropped, or motor mounts can bend.
Checking Flow Sensor Position

- Measure the distance between the inlet plane of the fan housing and the face of flow sensor.

- Distance for a Duct Blaster fan should be between 7/16” to 9/16”. Adjust sensor position.

- Return to TEC to replace bent motor mounts or damaged props.
Digital Gauge Calibration

- Calibration is recommended once every two years.
- Calibration is performed at TEC factory.
- Cost is $100 and is usually completed in about 3 or 4 days.
- Blower Door and Duct Blaster® manuals describe how to perform a calibration check in the field.
- Upgrade of older DG-700 to Cruise is an extra $50 on top of recalibration.
More Useful Information

- Visit our new website (www.energyconservatory.com)
- Articles on airsealing and duct leakage diagnostics.
- Previous newsletters.
- All product manuals and guides are online.
- Video Quick Guides for Blower Door and Duct Blaster®
- Links to other sites.
- Download latest version of Software.
• Thank You