2012 IECC Performance Testing: Lessons from the Duct and Envelope Tightness (DET) Verifier Program

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ABSTRACT

The 2012 International Energy Conservation Code (IECC) requires new homes and major renovations to have a pressure test of the building envelope and duct systems that are located outside of the thermal envelope. Testing is vital as leaky homes and ductwork often represent major sources of energy waste in homes. Many states will likely adopt the 2012 IECC over the next few years. However, many states currently lack the capacity to meet the testing requirements mandated by the 2012 IECC. To ensure code adoption and compliance, it is critical that states build a lasting infrastructure to offer testing services and that these services be available at a competitive price. If not, there could be a serious threat of a backlash against the testing provisions of the 2012 IECC, or perhaps the entire code.

In 2011, Georgia implemented a building energy code that requires duct and building envelope leakage testing (DET) and addresses performance testing issues left unresolved by the IECC such as who is qualified to perform the required testing, where the testing results should be recorded, how the testing requirements apply to upgrades and renovations to existing homes and duct systems, whether there should be special considerations for multifamily buildings (e.g., sampling), and what is an acceptable and effective duct sealant. This case study addresses key issues such as the appropriate experience and training required for DET professionals, acceptance of existing national testing certifications, and effective outreach strategies to recruit and train DET professionals.

INTRODUCTION

The U.S. Department of Energy has identified air leakage in building envelopes and duct systems as major sources of energy waste (PNNL and ORNL 2010). Air leakage can also be a source of comfort, durability, and indoor air quality problems (PNNL and ORNL 2010). Historically, updating building energy codes focused on increasing insulation levels and window and equipment efficiency requirements. However, the most recent versions of the International Energy Conservation Code (IECC) recognize the important contribution of air leakage to energy use and are more explicitly addressing both the best practice recommendations for reducing air leakage, as well as performance testing to set maximum thresholds for air leakage of the building envelope and duct systems.

Testing provisions were first referenced in the 2009 IECC, which required testing for ducts outside the thermal envelope and allowed for optional building envelope testing versus prescriptive air-sealing measures (ICC 2009). The 2009 IECC set criteria for both duct and envelope testing. The 2012 IECC requires both whole house air-leakage testing and the testing of duct systems when they are located outside of the thermal envelope (ICC 2012). The 2012 IECC also strengthened the passing criteria for both tests above the 2009 IECC performance thresholds. The majority of U.S. states have adopted or are at least on track for adopting the 2009 IECC and many will likely adopt the 2012 IECC over the next few years, with some states implementing the latest code as early as 2013 (see Figure 1).

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Although the 2009 IECC includes testing requirements or options, the manner in which testing is executed is unclear. Code enforcement bodies throughout the nation are struggling to address the testing criteria of both the 2009 and 2012 IECC. A primary concern is the greatly varying distribution of professionals trained in conducting whole house and duct system air-leakage testing, such as Residential Energy Services Network (RESNET) Home Energy Rating System (HERS) Raters (RESNET 2012) or Building Performance Institute (BPI) Professionals (BPI 2012). Furthermore, the level of expertise required to verify the testing criteria of the building energy code may not be as stringent as required for testing certification by existing organizations and beyond-code programs such as ENERGY STAR® or green building certification. To ensure successful code adoption and compliance, it is critical that states build lasting capacity to offer testing services that meet the code criteria, and that these services are available at a competitive price. Program administrators, government agencies and others need to plan to fill this gap in order to prepare the new construction marketplace for the full testing required by 2012 IECC implementation.

BACKGROUND

In 2010, Georgia adopted the Georgia State Minimum Standard Energy Code (IECC with Georgia State Supplements and Amendments) to be effective January 1, 2011. The Georgia energy code is based on the 2009 IECC; however, Georgia adopted amendments to the 2009 IECC that require duct and whole house building envelope air-leakage testing (GA DCA 2010). Georgia's mandated duct and envelope testing (DET) was later mirrored by the 2012 IECC. The Georgia energy code also addressed performance testing issues left unresolved by the 2009 and 2012 IECC codes. Table 1 presents a comparison of the 2009 and 2012 versions of the IECC and the 2011 Georgia energy code. For example, Georgia fully vetted the questions of who is qualified to perform the required testing (called a verifier), where the testing results should be recorded, how the testing requirements apply to upgrades and renovations to existing homes and duct systems, whether there should be special considerations for multifamily dwellings (e.g., sampling), and whether mastic should be required as a duct sealant. In answering these questions, Georgia developed a new certification program for individuals wishing to demonstrate compliance

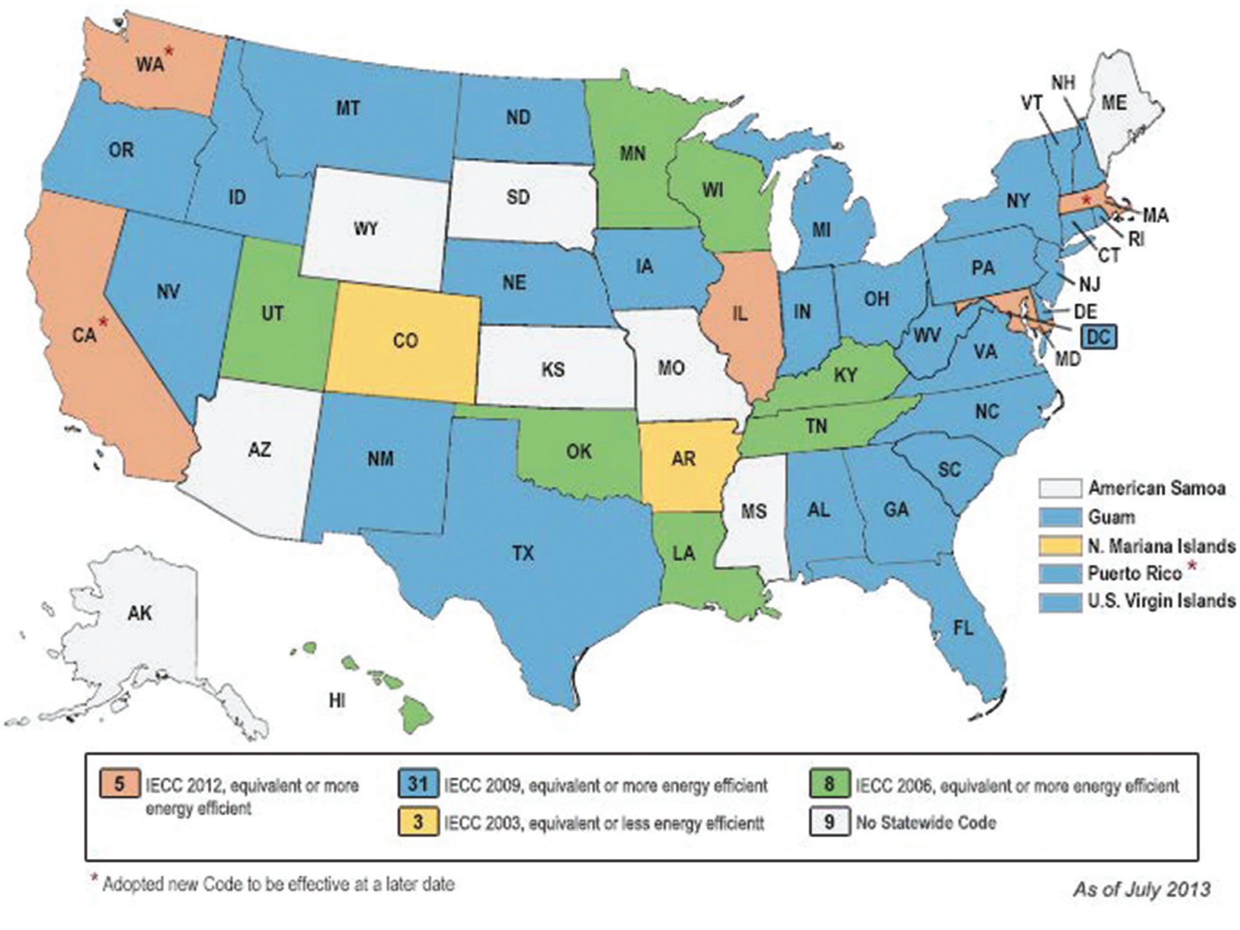

Figure 1 Current status of residential energy code adoption by state (DOE 2013).

with the duct and envelope testing requirements known as the DET Verifier Certification Program.

The relevance of having a successful DET Verifier Program was made evident during an attempt to roll back the Georgia energy code amendments by a small, but politically connected, faction in early 2012. The demonstration of substantial numbers of certified DET verifiers around the state prepared to offer the testing at affordable rates, plus a testing equipment loan program, helped quell this code-weakening effort.

Georgia determined that the verifiers who conduct the code-required testing must be trained and certified and that they must understand how to properly record the tightness results on an amended energy code compliance certificate. See Figure 2 for a completed example of the Georgia energy code compliance certificate template. The Atlanta-based non-profit organization Southface Energy Institute volunteered to develop a Duct and Envelope Tightness (DET) Verifier training curriculum for the Georgia Department of Community Affairs (DCA), the state agency tasked with oversight of building code adoption and interpretation. In the interest of consistent code implementation, Southface chose to provide the DET Verifier curriculum at no charge to other training entities that are deemed qualified by the Georgia DCA (Southface 2012). Additionally, Georgia recognized RESNET certified Home Energy Raters and BPI certified Building Analysts and Envelope Professionals as DET verifiers and did not require them to have additional training. Southface's DET experience, training curriculum, and supporting resources have been made available free-of-charge to assist other states in preparing for implementing the new code.

The DET Verifier Training is a one to two-day course designed to introduce the skills necessary to conduct pressure

Table 1. Duct and Envelope Tightness Requirements

Issue	2009 IECC	2011 GA Energy Code	2012 IECC
Envelope testing—single family	Optional: Blower door (BD) test or visual inspection checklist	Mandatory BD test with optional visual inspection checklist	Mandatory BD test and visual inspection checklist
Envelope testing—multifamily	Optional: BD test or visual inspection checklist	Optional – Visual Inspection or BD test. Sampling 1 in 4 units per floor or RESNET protocol	Mandatory BD test (no mention of sampling)
Envelope passing criteria	<7 ACH50 all climate zones (CZ)	<7 ACH50 all CZ (2–4)	≤3 ACH50 in CZ 3-8 ≤5 ACH50 in CZ 1-2
Clarify if envelope test required on alteration or renovation	No guidance	"When construction affects all aspects of building envelope (gut renovation)"	No guidance
Duct testing criteria at rough-in (RI) (Total)	4% – RI total no air handler 6% - RI total w/ air handler	6% - RI total w/ air handler	3% – RI total no air handler 4% – RI total with air handler
Duct Testing criteria at postconstruction—Postconstruction total (PCT) or postconstruction to outside (PCO)	12% – PCT 8% – PCO	12% – PCT 8% – PCO	4% PC (no incentive for testing at final or To Outside)
Record/display test results	Not required	On energy code certificate – template provided	On energy code certificate – no specifics on what to provide
Exempt from duct testing	Ducts and air-handler unit (AHU) entirely inside building thermal envelope	Ducts and AHU entirely inside building thermal envelope	Ducts and AHU entirely inside building thermal envelope
Duct pressure test required when modifying an existing system	No guidance	When >50% of existing duct system is modified. When AHU is changed out, test is not required but duct sealing with mastic through plenum connections is required	No guidance
Building cavities allowed as ducts	Only for returns	Not allowed for supply or returns	Not allowed for supply or returns
Duct sealing material	UL* tape, mastic, etc.	No UL* tape, only mastic and mastic tape	UL* tape, mastic, etc.
Qualified testers	No guidance	DET verifiers and RESNET and BPI certified professionals	No guidance

*UL = Underwriter's Laboratory.

Georgia Residential Energy Code Compliance Certificate*

Builder/Design Professional: Joe Builder   Phone: 404-555-1234

Envelope Summary:

- List the R-Value for the following components:

Flat ceiling/roof:	R-30	Sloped/vault ceiling:	
Exterior wall:	R-13	Above grade mass wall:	
Attic kneewall:	R-18	Attic kneewall sheathing:	
Basement stud wall:		Basement continuous:	
Crawlspace stud wall:		Crawlspace continuous:	
Foundation slab:		Floors over unconditioned space:	R19
Cantilevered Floor:		Other insulation:	

- Fenestration Components:

Window U-factor:	0.35	Window SHGC:	0.28
Skylight U-factor:		Skylight SHGC:	
Glazed Door U-factor:	0.50	Opaque Door U-factor: (<50% glazed)	0.60

- Building Envelope Tightness (BET):

BET test conducted by: Dee E.T. Verifier Phone: 404-555-1111

Fan Flow at 50 Pascals= 1700 CFM_{50} Total Conditioned Volume = 16200 ft^3

ACH_{50} = CFM_{50} x 60 / Volume= 6.30 ACH_{50} (must be less than 7 ACH_{50})

Low Rise Multifamily Visual Inspection Option

(The visual inspection option may be conducted by a third-party instead of the BET test for R-2 buildings only.)

Visual inspection conducted by: ______________ Phone: ______________

Mechanical Summary:

Water Heater Energy Factor: 0.58 Ef   Fuel type: ☑ Gas ☐ Electric ☐ Other

Number of Heating and Cooling Systems: 2

Heating System Type:

☑ Gas: 80% AFUE ☐ Air-Source Heat Pump: ______ HSPF

☐ Other: ______________ Efficiency: ______

Cooling System Type (Standard DX, Heat Pump, Geothermal, etc.): Standard DX

Cooling System Efficiency: 13 ☑ SEER ☐ EER ☐ Other

Heating/Cooling Load Calculations Performed by: Jay Manual Phone: 404-555-2222

Total Heating Load (Based on ACCA Man. J or other approved methodology): 36,777 Btu/h

Total Cooling Load (Based on ACCA Man. J or other approved methodology): 31,980 Btu/h

Cooling Sensible Load: 25,480 Btu/h Cooling Latent Load : 6,500 Btu/h

Total Air Handler CFM (based on design calculations): 1160 CFM

Duct Tightness Test Conducted by: Dee E.T. Verifier Phone: 404-555-1111

CFM_{25} per 100 ft^2 of conditioned floor area = CFM_{25} x 100 / Conditioned floor area served

If all ducts are not located within conditioned space, builder must verify that either the postconstruction duct leakage to outdoors (**PCO**) is ≤ 8%, the post construction total duct leakage (**PCT**) is ≤ 12%, or the rough-in total duct leakage (**RIT**) with air handler installed is ≤ 6%. State which method was used to conduct the duct tightness test: duct blower (**DB**), modified blower door subtraction method (**MBDS**), or automated multipoint blower door (**AMBD**).

System	Method (DB, MBDS, AMBD)	Test (PCO, PCT, RIT)	CFM_{25}	Area served (ft^2)	Result (%)
1 1st Floor	DB	PCO	44	900	4.9
2 2nd Floor	DB	PCO	65	900	7.2
3					

*Note: This permanent certificate shall be posted on or in the electrical distribution panel or air handler. Certificate shall be completed by the builder or registered design professional. Where there is more than one value for each component, certificate shall list the value covering the largest area.

Figure 2 *Sample of The Georgia Residential Energy Code Compliance Certificate source (Georgia Department of Community Affairs 2010).*

tests of the ducts and building envelope. Prior to taking the training, participants must demonstrate math proficiency through an on-line prerequisite course and must view ten-minute videos on duct testing using a duct blower and building envelope testing using a BD. In the classroom, participants then learn:

- Basics of the 2011 Georgia energy code including mandatory requirements such as air sealing and duct sealing details (2009 IECC based);
- Setup and testing protocols for BD and duct-leakage testing based on RESNET guidelines;
- Calculations for leakage testing, per the code requirements, plus how to fill in the results on the GA Energy Code Certificate; and
- Tips for successfully completing the written and in-field DET verifier certification exams, which are offered as part of the training.

The Georgia Code implementation schedule provided for approximately six months of time from adoption to statewide requirement of the DET verification implementation. To meet this ambitious schedule, Southface developed a train-the-trainer program on DET, which was targeted primarily at community college faculty and energy efficiency professionals. Southface, along with electric utility partners, private firms, and community colleges, trained over 500 verifiers in just four months. Many of the verifiers work in the housing industry in fields such as heating and air conditioning, construction management, and weatherization (see Figure 3). To help meet the statewide need for verifiers, the Georgia DCA partnered with local home builder associations to offer a loan program for BD and duct-testing equipment. The loan program charges a modest daily fee for equipment rental and is designed to allow verifiers to test the market for DET services and to serve rural areas of the state where new home construction is not strong enough to support equipment purchase by individual verifiers.

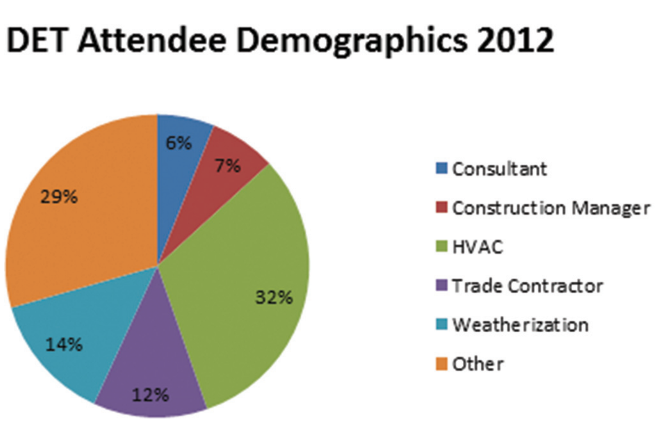

Figure 3 *Percentage of DET attendees who fell into each demographic category (Southface Energy Institute 2010).*

Lessons Learned

Several important lessons have been learned from the past two years, both in terms of training and outreach as well as in effectively implementing and maintaining the DET Verifier Program:

1. Need to educate industry professionals on ventilation. Ventilation strategies are now required by the 2012 codes (2012 IRC mandates the prescriptive ventilation tables, but not the formulas, of ASHRAE 62.2 [2010]). In section R303.4 of the *2012 International Residential Code*, intentional, whole-house ventilation is mandated for any home tighter than 5 air changes per hour at 50 Pa (ACH50) whereas in the 2012 IECC section R402.4.1.2, all homes must be <3 or 5 ACH50, depending on CZ. There is a need to teach how to determine the cubic feet per minute (CFM) of ventilation air required, the methods of ventilating a home, and how to commission and validate the actual quantity being delivered. This education is needed because intentional, whole-house ventilation has generally only been implemented by builders participating in beyond-code programs.

1. Need for the DET Verifier training to be multiday. An expanded format is necessary in order to allow additional hands-on field testing opportunities, as well as to provide more direction for a novice DET verifier if the home's envelope or duct system fails.
2. Need for one central database of certified DET verifiers. Unfortunately, Georgia does not have a central database of all DET verifiers. The Georgia DCA does keep a list of all approved DET trainers but the lack of a central database for DET verifiers makes it more challenging to identify a certified DET verifier. Alabama seems primed to have a superior approach wherein the State Licensing Board for Heating, Air Conditioning, and Refrigeration will keep a master list of all entities certified in the entire state (Alabama's testing requirement is currently scheduled to go active on January 1, 2014).
3. Need for continuing education and quality assurance (QA) on certified DET verifiers. While the opportunity still exists for Georgia to implement, unfortunately there are no formal provisions for actively maintaining the DET verifier certification. It is important to note that the DET verifier certification is for the individual and not for a company. Illinois is developing a DET verifier program that will utilize their established HERS industry group to administer QA to DET verifiers on an annual basis (IAER 2012).
4. Need for equipment loan program. the Georgia Environmental Financing Authority (state energy office). Allocated funds that placed testing equipment in a number of local home builder associations around the state. The intent is that this equipment can be rented for a modest fee and the revenue would be maintained by the local HBA. This access to equipment helps prevent spikes in testing

costs in smaller population centers and allows contractors to determine if there is a viable market for testing services prior to purchasing equipment.

5. Need for reciprocity. As other states come on board with DET verifier programs, it is important to establish reciprocity between states that at a minimum enables DET verifiers to work in housing markets that span state boundaries. Due to amendments, each individual state often has their own unique test results template (often the energy code compliance certificate) and the testing options allowed may be different. Examples for the state of Alabama and city of Chattanooga, Tennessee are presented in Figures 4 and 5. Although states may modify testing and reporting requirements, the fundamental skill set of how to conduct pressure tests remains the same.
6. Need for a discussion on certified versus third-party testing. The code is vague on this issue and always refers to the local code official. Third-party testing impacts costs, QA, and other issues. DET verifier is a certification that the contractor knows how to correctly conduct the test and the general intention is that certified DET verifiers could potentially test their own work. In other words, builders with the DET certification could conduct BD tests of the houses they have built and HVAC installers could perform duct-leakage tests of duct systems that they have installed.
7. Need for a consistent curriculum. Although the amendment was originally written in language that called upon the Georgia DCA to approve any curriculum, the agency quickly determined the value of just one training package. Southface developed the curriculum and has made an overview presentation available for general audiences to view for free. The instructional materials, including presentations, speaker notes, tests, and evaluation forms, have been shared with all DCA-approved training entities. These instructional materials have been modified for other states as typically the code and test results form has been unique to a given state.

DISCUSSION

Unfortunately, there have not been funds to fully evaluate the effectiveness of the DET program. However, the state and local chapters of the National Association of Home Builders have been supportive of the approach. In fact, these groups worked successfully to prevent repeal of the DET requirements in Georgia. This industry support indicates that the training and equipment loan programs are letting market forces meet the requirement for DET. As an active participant in a variety of housing forums in the state, Southface has anecdotal evidence that home builders have adequate access to DET verifiers and that testing services are not posing an undue financial burden.

For this paper, Southface polled four companies for data on their experience providing DET testing services. The four companies represented a variety in terms of company size, scopes of work (some performed sealing in addition to testing), and geographic and CZ areas where they offered services. Data was provided for single-family homes as well as multifamily dwellings and included projects simply being tested for minimum-code compliance as well as homes participating in beyond-code programs, such as EarthCraft House and ENERGY STAR.

Company Data Provided/Geographic Region/ Housing Type/Code vs. Beyond Code

Company A tested envelope and/or ductwork for over 1,200 single-family homes in the greater metro Atlanta area in 2012 (Climate Zones 3A and 4A). Data was made available for 944 homes of which 595 were for minimum-code compliance while 349 participated in a beyond-code program (EarthCraft or other).

Company B focused mainly on leakage-testing measurements for multifamily developments in the southern and eastern parts of the state (Climate zones 2A and 3A). Data was provided for 77 units in three different multifamily developments in three different cities. The buildings were all certified under a beyond-code program (EarthCraft) and dwelling unit floor areas ranged from 774 ft^2 to 1320 ft^2.

Company C provided testing data for 22 single-family homes in the southern portion of the state (Climate Zone 2A), with 19 of these homes tested for minimum-code compliance and three for ENERGY STAR v2.5.

Company D provided data for 55 single-family homes in some of the northernmost counties of the state (Climate Zone 4A). All homes were tested only for simple code compliance.

Envelope Testing Results

Company A released data for 936 homes that were BD tested (587 minimum code and 349 beyond code). The average building envelope leakage for code compliant homes was 4.42 ACH50 while the average for homes in beyond-code programs was 3.41 ACH50.

Company B showed that for 77 units in three different multifamily developments in three different cities under a beyond-code program (EarthCraft), the overall average ACH50 was 4.26. The data shows that, in spite of an ACH50 bias that favors large volume homes and works against small volume homes, multifamily units can still successfully pass leakage criteria, particularly when participating in a beyond-code program.

Company C provided BD results for twenty homes with an average ACH50 of 3.76. Seventeen of the homes featured spray foam rooflines and easily passed the BD test on the first attempt. The three remaining homes were conventional vented attic-style construction; two of these required retesting after not passing their initial envelope tightness test. These vented attic homes were also the only ones that required duct testing (since the spray foam houses created fully encapsulated ductwork).

Company D provided simple code compliance data for 55 single-family homes in north Georgia (Climate Zone 4A). Of the

Alabama Residential Energy Code Duct and Envelope Testing Results*

Address: 1234 Sample House Lane

Builder/Designer: Bill D. Home Phone: 222-333-4444

Envelope Summary: Building Envelope Tightness (BET)

BET test conducted by: Joe Tester Phone: 222-555-6666

Fan Flow at 50 Pascals= 1,844 CFM_{50} Total Conditioned Volume = 22,600 ft^3

$ACH_{50} = CFM_{50} \times 60$ / Volume= 4.9 ACH_{50} (must be less than 7 ACH_{50})

Visual Inspection Option (may be conducted by an approved third-party instead of the BET test)

Visual Inspection Conducted by: ______________________ Phone: ______________

AIR BARRIER AND INSULATION INSPECTION

	COMPONENT	CRITERIA
	Air barrier and thermal barrier	Exterior thermal envelope insulation for framed walls is installed in substantial contact and continuous alignment with building envelope air barrier. Breaks or joints in the air barrier are filled or repaired. Air-permeable insulation is not used as a sealing material.
	Ceiling/attic	Air barrier in any dropped ceiling/soffit is substantially aligned with insulation and any gaps are sealed Attic access (except unvented attic), knee wall door, or drop down stair is sealed.
	Walls	Corners and headers are insulated. Junction of foundation and sill plate is sealed.
	Windows and doors	Space between window/door jambs and framing is sealed.
	Rim joists	Rim joists are insulated and include an air barrier.
	Floors (including above garage and cantilevered floors)	Insulation is installed to maintain permanent contact with underside of subfloor decking. Air barrier is installed at any exposed edge of floor.
	Crawlspace walls	Insulation is permanently attached to walls. Exposed earth in unvented crawlspaces is covered with Class I vapor retarder with overlapping joints taped.
	Shafts, penetrations	Duct shafts, utility penetrations, knee walls and flue shafts opening to exterior or unconditioned space are sealed.
	Narrow cavities	Batts in narrow cavities are cut to fit, or narrow cavities are filled by sprayed/blown insulation.
	Garage separation	Air sealing is provided between the garage and conditioned spaces.
	Recessed lighting	Recessed light fixtures are airtight, IC rated and sealed to drywall. Exception—fixtures in conditioned space.
	Plumbing and wiring	Insulation is placed between outside and pipes. Batt insulation is cut to fit around wiring and plumbing, or sprayed/blown insulation extends behind piping and wiring.
	Shower/tub on exterior wall	Showers and tubs on exterior walls have insulation and an air barrier separating them from the exterior wall.
	Electrical/phone box on exterior wall	Air barrier extends behind boxes or air sealed type boxes are installed.
	Common wall	Air barrier is installed in common wall between dwelling units.
	HVAC register boots	HVAC register boots that penetrate building envelope are sealed to subfloor or drywall.
	Fireplace	Fireplace walls include an air barrier.

Mechanical Summary: Duct Tightness Verification (DTV)

DTV Test Conducted by: Jane Tester Phone: 777-888-9999

Tool used to conduct the duct tightness test: duct blower (**DB**), blower door subtraction method (**BDS**), or flow hood (**FH**).

Unless all ducts are located within conditioned space, builder must verify one of the following:

- Post-construction duct leakage to outdoors (**PCO**) is ≤ 8%,
- Post-construction total duct leakage (**PCT**) is ≤ 12%
- Rough-in total duct leakage (**RIT**) with air handler installed is ≤ 6%
- Rough-in total duct leakage without air handler installed (**RITnah**) is ≤ 4%

% Duct Leakage Result = CFM_{25} x 100 / Conditioned floor area served

System	Tool (DB, BDS, FH)	Test (PCO, PCT, RIT, RITnah)	CFM_{25}	Area served (ft^2)	Result (%)
1 Main	DB	PCO	165	2,300	7.2%
2					
3					

*Note: This document to be posted on or in the electrical distribution panel or on main air handling unit.

Figure 4 *Sample of The Alabama Residential Energy Code Duct and Envelope Testing Results data sheet (Alabama Power 2013).*

City of Chattanooga Residential Energy Code Compliance Certificate

HOUSE ADDRESS: ____________________

BUILDER/DESIGN PROFESSIONAL NAME: ____________________

COMPANY: ____________________ PHONE: ____________________

EMAIL: ____________________

ENVELOPE SUMMARY (*To be completed by Builder or Design Professional.*)

FLAT CEILING/ATTIC	______R-VALUE	WINDOWS:		
SLOPED/VAULTED CEILING	______R-VALUE		______SHGC	______U-FACTOR
ATTIC KNEEWALL	______R-VALUE			
EXTERIOR WALL	______R-VALUE	SKYLIGHT:		
ABOVE GRADE MASS WALL	______R-VALUE		______SHGC	______U-FACTOR
BASEMENT STUD WALL	______R-VALUE			
BASEMENT (CONTINUOUS)	______R-VALUE	OPAQUE DOOR (<50% Glazed):		
CRAWLSPACE STUD WALL	______R-VALUE		______SHGC	______U-FACTOR
CRAWLSPACE (CONTINUOUS)	______R-VALUE			
FLOOR	______R-VALUE	OTHER INSULATION COMMENTS:		
CANTILEVERED FLOOR	______R-VALUE			
FOUNDATION SLAB	______R-VALUE	____________________		

MECHANICAL SUMMARY (*To be completed by HVAC Contractor.*)

NUMBER OF HEATING AND COOLING SYSTEMS: ______

HEATING SYSTEM 1 TYPE (choose one) ☐ GAS: ______AFUE ☐ AIR-SOURCE HEAT PUMP:______HSPF ☐ OTHER

COOLING SYSTEM 1 TYPE (Standard DX, Heat Pump, Geothermal, Etc.) ____________________

COOLING SYSTEM 1 EFFICIENCY: ____________ ☐ SEER ☐ EER ☐ OTHER

HEATING SYSTEM 2 TYPE (choose one) ☐ GAS: ______AFUE ☐ AIR-SOURCE HEAT PUMP:______HSPF ☐ OTHER

COOLING SYSTEM 2 TYPE (Standard DX, Heat Pump, Geothermal, Etc.) ____________________

COOLING SYSTEM 2 EFFICIENCY: ____________ ☐ SEER ☐ EER ☐ OTHER

WATER HEATER ENERGY FACTOR: ____________Ef FUEL TYPE: ☐ GAS ☐ ELEC ☐ OTHER

FIELD TESTING (*To be completed by a qualified Third-Party Verifier*)

BUILDING ENVELOPE TIGHTNESS:

FAN FLOW AT 50 PASCALS: ______ CFM_{50} TOTAL CONDITIONED VOLUME: ______ ft^3

$ACH_{50} = CFM_{50} \times 60$ / Volume = ______ ACH_{50} (*must be less than 7* ACH_{50})

DUCT TIGHTNESS TESTING:

SYSTEM	METHOD* (PCO, PCT, RIT)	CFM_{25}	AREA SERVED (ft^2)	TEST RESULTS**	COMMENTS
1					
2					

* **PCO** (Post Construction Leakage to Outdoors) 8% max; **PCT** (Post Construction Total Leakage) 12% max; **RIT** (Rough-in w/Air Handler installed) 6% max

** CFM_{25} per 100 ft^2 of Conditioned Floor Area = $CFM_{25} \times 100$ / Conditioned Floor Area Served

BUILDING ENVELOPE TIGHTNESS / DUCT TIGHTNESS TEST CONDUCTED BY:

NAME: ____________________ SIGNATURE: ____________________

COMPANY: ____________________ QUALIFICATION: ☐ HERS ☐ BPI ☐ DET

Figure 5 *Sample of The City of Chattanooga Energy Code Compliance Certificate (City of Chattanooga Department of Public Works [Southface 2013]).*

45 homes that passed, the average BD test score was 4.7 ACH50. For the 10 homes that did not pass the BD test, the results ranged from 7.5 to 12 ACH50. Only two homes chose to retest since the county code officials chose to grant the Certificate of Occupancy without enforcing energy code performance requirements.

Duct-Leakage Testing Results

Company A performed a total of 1,617 duct-leakage tests (1,022 systems to meet minimum code requirements and 595 systems for homes in beyond-code programs). The ducts were tested either at rough-in stage (RIT) or at final stage measuring leakage to outside (PCO). The average duct leakage for minimum-code compliance was 3.9% while the average beyond-code program duct leakage was 2.9%.

Company B measured duct leakage in 77 multifamily beyond code units that averaged 2.7%.

Company C provided duct testing data for the five homes out of 22 that were conventionally vented attic-style construction. These vented attic homes were also the only ones that required duct testing (since the sprayed-foam roofline houses created fully encapsulated ductwork). Five duct systems were tested but only three passed initially; the other two required minor sealing around the boot penetrations and some touch-up around the air handler but, after this were able to pass while still on the initial visit.

Company D only leak tested 18 duct systems out of the 55 single-family homes in the northern part of the state (Climate Zone 4A). About half of the remaining duct systems did not require testing since the ductwork was inside the thermal envelope. The other half ignored the required testing, but the home still received a Certificate of Occupancy due to the jurisdiction's lack of energy code enforcement. The average passing duct-leakage test score was around 11% total leakage at final (PCT). This value is close to the noncompliant threshold of 12%. Five of 18 duct systems failed but only two chose to retest since code compliance was not being enforced.

Additional

Company A also performed air sealing and inspection services in many of their over 1, 200 single-family homes. In all cases, the need to perform BD or duct-leakage retests was fairly small (less than 2%).

Company B also evaluated 32 single-family homes that passed all envelope and duct-leakage tests. Failure rate here was estimated at less than one percent.

Company C did not perform air sealing as part of their scope of work. They did bring air-sealing materials along to help educate on how to seal top plates, penetrations, and chases. Company C did not charge for this service but saw the value of fostering good business relationships in case the homes did not pass on the first BD attempt.

Company D expressed frustration at the lack of or inconsistent code enforcement. Retests were rarely performed even if the envelope or duct system failed; only fear of liability was enough to spur some builders to pay for a retest. Other blatant lack of enforcement issues included walkout basements with no insulation on the concrete walls as required by code and frustration that certain counties were not even performing insulation inspections.

CONCLUSIONS

The 2009 IECC (2011 Georgia Energy Code) Requirements Can be Met

Overall, the data indicate that with a fairly modest effort, the performance levels for DET required by the code are easily obtainable. The thresholds arguably are too easy, especially for larger homes and floor areas served by larger duct systems. The performance thresholds in the 2012 IECC are significantly more challenging to achieve and may be especially difficult for the majority of states that have not mandated testing in the 2009 code cycle.

Beyond-Code Programs Work

The data show that beyond-code certification programs consistently produce homes that exceed code-built homes. Many beyond-code programs, such as EarthCraft House and ENERGY STAR, mandate complete compliance with the energy code as a baseline. Beyond code homes will typically exceed energy code regardless of local enforcement activity and capability.

Companies that Performed Additional Services Achieved Higher Performance

While some may question the inherent bias of testing homes where the subcontractor performed the work and later did the testing, the data indicate that the these homes achieved high performance levels. Generally the subcontractor has a vested interest in the home passing and quickly learns where the trouble spots are in the envelope and ductwork. Use of BD guided-air sealing was occasionally performed by all of the contractors.

Energy Code Enforcement Matters

Regions where energy code enforcement was spotty indicate poor performance testing results for ducts and homes. Although admittedly a small sample size, nearly 20% (10 out of 55) of the BD tested homes in counties with minimal enforcement failed the leakage test the first time out. And, duct systems that did pass were very close to the failure threshold.

SOUTHFACE ENERGY INSTITUTE RECOMMENDATIONS

In addition to the results of this limited poll, Southface offers the following recommendations based on our experience teaching over 1,500 Energy Code and DET verifier courses over the past decade, as well as our experience working directly with over 25,000 single-family and multifamily homes certified under the EarthCraft green building program and other beyond-code programs.

- Improve the IECC Table R402.4.1.1 – Air Barrier and Insulation Installation checklist. The concept of Table R402.4.1.1 is solid, but the wording is cryptic and confusing; a graphic demonstration of many of the items is recommended. An example is the provision that "corners and headers shall be insulated" without providing details or minimum R-values to the builder and code official (IECC 2012).
- There are numerous ways to report and adjust BD scores based on house size. The ACH50 approach (ACH50 = CFM50 × 60/Volume*)* is biased against small homes and not a sufficiently robust standard for larger homes as their much greater volumes tend to dominate the calculation. The code should move away from ACH50 and to a different metric such as envelope leakage ratio (ELR). This approach (ELR_{50} = CFM_5/square feet of building thermal envelope) does not artificially favor larger homes since the CFM50 of measured leakage is divided by the size of the home's building thermal envelope instead of the volume. This approach is more consistent across all building sizes and has been used in certain beyond-code programs for some time. Also, a similar version (tested at 75 Pa instead of 50 Pa) has been incorporated as a commercial building testing standard and adopted by the U.S. Army Core of Engineers and the commercial section of the 2012 IECC.
- Single-family homes should be individually tested for code compliance but the code should include a sampling protocol for multifamily buildings. Georgia adopted a standard of testing one in four dwelling units per floor of a multifamily building. One piece of language missing from the Georgia amendments is what to do if the tested unit fails—the implication is that the unit must be retested and the other three must also be tested. If the sampling identifies problems, then all units must be tested.
- Duct testing techniques have changed in the 2012 IECC. Postconstruction testing at final has effectively been discouraged since the threshold for passing is no different (4%) than when testing total leakage at rough-in (RIT). Rough-in testing of ducts should include a stricter passing criteria than when testing at final since additional construction activity could impact the final leakage rate. Duct testing without an air handler (AH) should be eliminated as an option since the cabinet of the AH is allowed to leak up to 20 cfm on a relatively small, 2.5-ton system (section R403.2.2.1, up to 2% of system airflow is allowed by the AH cabinet alone) (IECC 2012). Finally, certain methods of indirect duct testing should be deemed unacceptable, namely the BD subtraction method and simply adding flow-hood measurements at each grill while the house is pressurized with a BD, as these techniques do not provide the accuracy and repeatability attained by direct pressure testing.
- The code should adopt regionally appropriate ventilation strategies. For example, the code should prohibit exhaust only strategies for whole house ventilation in humid regions of the country, such as CZs 1A, 2A, and 3A, since a building experiencing continuous negative pressure increases the risk of mold or other moisture failure
- Finally, the code should provide a detailed template of the energy code certificate that clearly indicates what testing information must be provided. The IECC should mimic aspects of the Georgia, Alabama, and Chattanooga, Tennessee compliance templates. The Georgia template also requires a summary of the manual J-load calculations plus the name and contact info of the individual who performed the calculations as well as the DET verifier.

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