AIRTIGHTNESS TESTING AND THE IECC ■ SUPEREFFICIENT CLOTHES DRYERS

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Airtightness Testing and the 2009 and 2012 IECC

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The adoption of residential building codes that require more energy efficiency is one of the most exciting developments in state energy policy during the past four years. Over 30 states have now adopted codes that meet or exceed the energy efficiency requirements of the model 2009 International Energy Conservation Code (IECC). And by the end of 2015, it is estimated that as many as eight states will have adopted the even more challenging 2012 IECC.

An important driving force behind recent state adoption of new building codes has been the American Recovery and Reinvestment Act (ARRA). As part of a deal for receiving ARRA funds, governors from each state had to commit to adoption of a residential building code that was at least as good as the 2009 IECC, and to develop and implement a plan to achieve 90% compliance by 2017. Unfortunately, four years later 18 states still have no residential building code, or have a code that does not meet the ARRA requirements. But for the 32 states that have already taken concrete steps to meet their commitments, better codes offer a dramatic increase in the energy efficiency of new houses.

Adoption of the new IECC has many benefits. These include the obvious reduction of energy use and associated greenhouse gas emissions, increased comfort and durability of new houses, and a reduction in liability and callbacks for builders. The 2009 IECC represents a 15% improvement in energy efficiency over its 2006 predecessor, while the 2012 IECC raises the bar an additional 15%. An important component of this improvement has been the introduction of mandatory airtightness requirements for both building envelopes and duct systems. While the building science community has long known the benefits of reducing building infiltration and duct leakage, bringing that knowledge into the code adoption process is long overdue.

Airtightness Requirements

So the good news is that airtightness requirements are now embedded into the IECC. Unfortunately, a number of very important details are not included in the code language, and this lack of specificity could make meaningful enforcement of those requirements difficult. As with all important public policy initiatives, the devil is in the details.

Before we talk about what is missing, let's briefly summarize what is included in the IECC language.

Building Envelopes Both the 2009 and 2012 codes include a detailed mandatory air sealing checklist.

The 2009 code gives builders two compliance options: a blower door test that shows an airtightness measurement of less than 7 ACH_{50} *or* a visual inspection based on the air sealing checklist by either a code official or an approved third party.

The 2012 code lowers the allowable envelope leakage rate significantly (to less than 5 ACH_{50} in climate zones 1 and 2, and less than 3 ACH_{50} everywhere else) *and* requires that compliance be proved through a blower door test. Code officials may also require a visual inspection of checklist items in addition to the airtightness test.

Table 1. Allowable Duct Leakage Rates

	2009 IECC	2012 IECC
Postconstruction Test Airtightness measurement must be:	Total leakage of ≤ 12 CFM_{25}/100 ft^2 CFA* or leakage to outdoors of ≤ 8 CFM_{25}/100 ft^2 CFA	Total leakage of ≤ 4 CFM_{25}/100 ft^2 CFA
Rough-in Test Airtightness measurement must be:	Total leakage of ≤ 6 CFM_{25}/100 ft^2 CFA or if air handler is not installed then total leakage of ≤ 4 CFM_{25}/100 ft^2 CFA	Total leakage of ≤ 4 CFM_{25}/100 ft^2 CFA or if air handler is not installed then total leakage of ≤ 3 CFM_{25}/100 ft^2 CFA

** Conditioned floor area*

Duct Sealing Both the 2009 and 2012 codes require that all ducts, air handlers, and filter boxes be sealed. The 2012 code requires that air handlers meet a design air leakage standard.

Both the 2009 and 2012 codes require that a duct airtightness test be performed, unless all ducts and air handlers are located within conditioned space.

The allowable duct leakage rates have been significantly lowered in the 2012 code. Both codes allow several compliance testing options (see Table 1).

What Is Missing from the IECC?

As we said earlier, the devil is always in the details. Anyone who has performed duct and building envelope testing (DET) knows that numerous questions must be addressed in order for airtightness testing to be accurate, and equally important, for the tests to be repeatable. Here are just a few examples:

- How should the building and duct system be prepared prior to the test?
- What DET testing protocols should be used (such as single-point, multipoint, baseline and temperature adjustments, and pressurization versus depressurization)?
- Can we test building envelopes in windy weather? When is it too windy?
- What testing data must be recorded and reported?
- How should we test multifamily buildings covered by the code?
- What type of training or certification is required before someone can perform a duct leakage or blower door test?
- What are the accuracy requirements for the test equipment?

While the code language provides some basic instructions on building preparation, most of the questions listed above are not addressed. Airtightness test results must be accurate and repeatable (within reason) otherwise credibility in the testing process will be lost and frustration and uncertainty will limit the effectiveness of the requirements. And the testing procedures must be easily understood and not overcomplicated; otherwise, testing costs will be excessive and not many people will be able to pass them.

How to Add the Necessary Details

When a state adopts a model code, it often adopts supplements and amendments that flesh out important implementation and enforcement details of the code, or make specific changes to code requirements that are deemed to be in the best interest of the state. For example, when the state of Georgia adopted the 2009 IECC in 2010, it required that all new houses be blower door tested to the 7 ACH_{50} standard, rather than allowing for a visual inspection as an acceptable compliance option. Georgia also adopted provisions that dealt with many of the issues raised above. These provisions include

- more detailed instructions for house preparation;
- referencing blower door manufacturers' testing protocols for duct and building testing, and providing clarifying language on certain test procedures;
- specifying that DET tests can be performed by individuals certified as HERS raters, BPI Building Analysts, Home Performance with Energy Star contractors, or anyone being certified by a DET verifier course approved by the Georgia Department of Community Affairs; and
- instructions on sampling methods for testing building envelopes in low-rise multifamily buildings (and allowing for visual envelope inspections as an alternative compliance option).

While these supplements and amendments go a long way toward providing clarity, they may still leave room for ambiguity when it comes to specifying testing protocols that provide reliable, consistent, and repeatable DET test results. So what would we recommend for states that are just starting to grapple with the problem of implementing DET testing into their code requirements? First, we would encourage states to consider referencing the newly adopted "RESNET Standard for Performance Testing" (Chapter 8 of the RESNET National Home Energy

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Rating Systems Standards) as a model DET standard in their code documents.

RESNET Standard Testing

The "RESNET National Home Energy Rating Systems Standards" was developed to ensure that home energy ratings conducted across the country are performed on an accurate and consistent basis. Chapter 8 of the RESNET standard, titled Standard for Performance Testing, contains detailed duct- and envelope-testing protocols that were developed by a technical committee of experienced building scientists, using a consensus approach. The goal of the technical committee was to create a set of standards that provide enough specificity to the testing process to ensure accurate and repeatable results, without making it prohibitively complicated.

The committee decided against simply referencing existing duct and envelope technical testing standards (such as ASTM E779-10), because it felt that those standards were too complex and did not address certain important issues, such as how to deal with envelope testing results in windy weather. The committee also decided that simply referencing a manufacturer's recommended testing protocols was problematic, because different companies have different protocols, and because these protocols are periodically changed.

Envelope Testing Chapter 8 of the RESNET standard provides three envelope-testing options: a simple single-point test, a multipoint test, and a repeated single-point test. It provides detailed building setup instructions, baseline measurement procedures, and data collection and reporting requirements. It also provides a simple way to determine when the test results are adversely affected by wind. For example, with the single-point test, the technician records five ten-second average building baseline readings and uses those readings to determine the accuracy level of the test. Here is how it is done:

- Calculate the baseline range by determining the difference between the highest and lowest baseline reading. Let's say your five baseline readings are – 3.2 Pa, – 2.5 Pa, – 2.9 Pa, – 1.0 Pa, and + 0.8 Pa. The baseline range in this case is 4.0 Pa (–3.2 to 0.8 Pa).
- Then determine the level of accuracy.
- Baseline range less than 5 Pa range = standard level of accuracy.
- Between 5 Pa and 10 Pa = reduced level of accuracy.
- Greater than 10 Pa = single-point test cannot be performed. The technician must perform multipoint or repeated single-point test.

For the case above, the test is classified as a standard level of accuracy. But what if the baseline range were larger (due to wind) and the test were classified as reduced level of accuracy? In that case, Chapter 8 requires you to adjust your airtightness test result by adding a 10% uncertainty penalty. This adjustment for reduced accuracy tests accounts for the increased uncertainty in test results due to wind, and provides greater confidence that the airtightness threshold has actually been met. Finally, if it is really windy outside (greater than 10 Pa range), you are prohibited from using a single-point test and must use a test procedure that works better under high-wind conditions. Both the multipoint and the repeated single-point test have their own methods of determining test accuracy and uncertainty penalties.

What about corrections for temperature and altitude? Chapter 8 of the RESNET standard provides simple instructions on how to make these corrections, but also allows the corrections to be omitted under certain conditions (indoor-outdoor temperature difference less than 30^0F, and altitudes under 5,000 feet). When testing in more extreme weather and at higher altitudes, failure to account for differences in air density can have a significant effect on test results.

For example, if you performed a blower door test on a house when the inside temperature was 70^0F and the outside temperature was 0^0F, and then performed another test on the same house (in the same physical condition) when the inside temperature was 70^0F and the outside temperature was 90^0F, you would expect to see test result differences of about 8% if you didn't make corrections for temperature. Barometric pressure also affects air density, and Chapter 8 of the RESNET standard makes a simple correction based on site altitude. If you feel intimidated by the calculation requirements, don't worry. Free software is available that will do the calculations for you. The software allows you either to enter the test data manually, or to fully automate the entire envelope test procedure.

Duct Leakage Testing Chapter 8 of the RESNET standard includes specific test procedures for both the total leakage and the leakage to outdoors tests that are referenced in the 2009 and 2012 IECC. Important issues, such as how to prepare the house and ductwork, are detailed, along with guidance on key test procedures, such as where to measure duct pressure and where to connect the duct leakage testing system. And of course data collection and reporting requirements are spelled out in detail. Test accuracy calculations are not included in the duct leakage standards because these tests tend to be much less affected by wind conditions.

Provisions include specifying that DET tests can be performed by individuals certified as HERS raters, BPI Building Analysts, Home Performance with Energy Star contractors, or anyone being certified by a DET verifier course.

Equipment Accuracy and Calibration Chapter 8 of the RESNET standard also specifies both the accuracy and calibration requirements of the blower door and duct leakage testing equipment, so referencing the RESNET standard incorporates these important specifications into code language.

Other Factors

There are other factors to consider in applying the 2009 and 2012 IECC that are not addressed in the RESNET standard.

Multifamily Building Testing DET testing in multifamily buildings can greatly increase test complexity, so providing guidance to testers is important. Following are a few questions to ask yourself. Is envelope testing required at all? Should the entire building envelope be tested as a single zone? Or can individual apartments be tested for compartmentalization (that is, all leaks count, even leakage between units)? The Georgia code supplement strikes what we think is a good balance by allowing sample envelope testing of one in four dwelling units (compartmentalization) *or* a mandatory visual inspection on all units.

Mechanical Ventilation Commissioning For states that are moving to the 2012 IECC, mechanical ventilation in new houses will soon become the norm. While the 2012 IECC is silent on the issue of mechanical ventilation, the 2012 International Residential Code (IRC) does require whole-house mechanical ventilation for any new house with an airtightness test of less than 5 ACH_{50}. Whether or not your code jurisdiction enforces the 2012 IRC, most builders will very quickly understand that mechanical ventilation is a necessity in any house built to the 2012 IECC airtightness standard. Providing rules and standards for measuring airflow rates in these mechanical systems is a must if you want them to work properly.

Combustion Safety The new codes still allow natural-draft water- and space-heating appliances to be installed. This type of appliance will have significantly more problems venting properly when competing with exhaust devices (such as dryers and range hoods) in the much tighter houses that will be built under the 2009 and 2012 IECC. The only real solution will be to convince builders that they should stop installing this type of appliance in new houses. But when they are installed, DET testers should be aware of potential venting problems and be capable of testing for excessive depressurization, spillage, and backdrafting. RESNET, BPI, and the ANSI Z223.1 National Fuel Gas Code all have test procedures to check for proper appliance venting.

One more point concerning natural-draft appliances is that the RESNET envelope-testing procedure specifies that any undampered flues, makeup air openings, or combustion air openings must be left in their normally open state for the airtightness test. This means that building envelopes in houses with this type of appliance will need to be made tighter, to compensate for the increased leakage due to the intentional openings, in order to pass the airtightness standard.

Training Requirements for DET Testers Once again, we like the rules that Georgia has put in place. Each state will probably want to create its own approved DET training course that covers the specific testing requirements for that state. But it is also important to recognize the existing expertise in each state by grandfathering in certified HERS raters, BPI Building Analysts, and Home Performance with Energy Star contractors. And don't forget about training requirements for code officials who will be enforcing the performance standards.

Looking Ahead

Adopting better state energy codes is a very significant achievement. But having those codes enforced at the local level will be the hard part. There are many things that need to go right in order for code enforcement to become a reality. Making sure that proper test standards and procedures are in place will make this easier to achieve. Going forward, it is possible that the RESNET test standards (or some variation of them) will become part of future IECC revisions. RESNET is currently working on getting the Chapter 8 standard accredited by the American National Standards Institute. But until the IECC is amended to address these concerns, remember that the little details really do matter.

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For more on codes, see http://energycodesocean.org, www.southface.org/learning-center/library/georgia-energy-code-resources, and www.southface.org/learning-center/trainings/duct-and-envelope-tightness-verification-training.