RE112-19

IECC: R403.3.3 (IRC N1103.3.3), R403.3.4 (IRC N1103.3.4)

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2018 International Energy Conservation Code

R403.3 (IRC N1103.3) Ducts. Ducts and air handlers shall be installed in accordance with Sections R403.3.1 through R403.3.7.

R403.3.1 (IRC N1103.3.1) Insulation (Prescriptive). Supply and return ducts in attics shall be insulated to an *R*-value of not less than R-8 for ducts 3 inches (76 mm) in diameter and larger and not less than R-6 for ducts smaller than 3 inches (76 mm) in diameter. Supply and return ducts in other portions of the *building* shall be insulated to not less than R-6 for ducts 3 inches (76 mm) in diameter and not less than R-4.2 for ducts smaller than 3 inches (76 mm) in diameter.

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

R403.3.2 (IRC N1103.3.2) Sealing (Mandatory). Ducts, air handlers and filter boxes shall be sealed. Joints and seams shall comply with either the International Mechanical Code or International Residential Code , as applicable.

R403.3.2.1 (IRC N1103.3.2.1) Sealed air handler. Air handlers shall have a manufacturer's designation for an air leakage of not greater than 2 percent of the design airflow rate when tested in accordance with ASHRAE 193.

Revise as follows:

R403.3.3 (IRC N1103.3.3) Duct testing (Mandatory). Ducts shall be pressure tested to determine air leakage by one of the following methods:

1. Rough-in test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the system, including the manufacturer's air handler enclosure if installed at the time of the test. Registers shall be taped or otherwise sealed during the test.
2. Postconstruction test: Total leakage shall be measured with a pressure differential of 0.1 inch w.g. (25 Pa) across the entire system, including the manufacturer's air handler enclosure. Registers shall be taped or otherwise sealed during the test.

~~**Exceptions**~~ **Exception:**

~~1. A duct air-leakage test shall not be required where the ducts and air handlers are located entirely within the *building thermal envelope.*~~

~~2.~~ A duct air-leakage test shall not be required for ducts serving heat or energy recovery ventilators that are not integrated with ducts serving heating or cooling systems.

A written report of the results of the test shall be signed by the party conducting the test and provided to the *code official*.

R403.3.4 (IRC N1103.3.4) Duct leakage (Prescriptive). The total leakage of the ducts, where measured in accordance with Section R403.3.3, shall be as follows:

1. Rough-in test: The total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m^2) of conditioned floor area where the air handler is installed at the time of the test. Where the air handler is not installed at the time of the test, the total leakage shall be less than or equal to 3 cubic feet per minute (85 L/min) per 100 square feet (9.29 m^2) of conditioned floor area.
2. Postconstruction test: Total leakage shall be less than or equal to 4 cubic feet per minute (113.3 L/min) per 100 square feet (9.29 m^2) of conditioned floor area.

   3. Test for ducts within thermal envelope: Where all ducts and air handlers are located entirely within the building thermal envelope, total leakage shall be less than or equal to 8.0 cubic feet per minute (226.6 L/min) per 100 square feet (9.29 m^2) of conditioned floor area.

Reason: The purpose of this code change proposal is to help ensure occupant comfort, proper heating and cooling system performance, and resulting long-term energy savings by requiring a duct leakage test for all new homes, including homes with all ducts inside conditioned space. This action will also help reduce the likelihood of builder callbacks for poorly-functioning, uncomfortable HVAC systems. The IECC currently exempts homes from duct testing requirements where the air handler and all ducts are located inside conditioned space. Although moving all ducts inside conditioned space may have a positive impact on energy efficiency overall, this practice alone cannot guarantee that the ducts will be tight enough to deliver conditioned air to all occupied areas of the home. Uncomfortable occupants commonly adjust thermostat settings to counteract the effect of poor delivery of conditioned air, leading to huge losses in energy efficiency. And these homes are at far greater risk for builder callback. This proposal will improve building quality and keep occupants more comfortable by requiring a duct test for all new homes, although the allowable

leakage rate will be set at twice the prescriptive rate when all ducts are located inside conditioned space.
Duct leakage rates can be extremely high when ducts are not tested. We do not believe that builders intentionally cut corners in duct sealing when they know that the system will not be tested. However, without an objective test as a means of quality assurance, even careful builders may not be aware of missed connections or poor sealing. In a recent DOE field study of residential homes in Kentucky, homes received duct leakage tests even where all supply and return ducts were located inside conditioned space. The results were striking – **of the 24 homes tested (that would have qualified for the test exemption under the IECC), all 24 homes had higher leakage rates than the 2018 IECC requirement. Tested duct leakage for these homes averaged 18.5 cfm/sq.ft., with individual homes ranging from 6.26 cfm/sq.ft. to as high as 40.36 cfm/sq.ft.** *See* https://www.energycodes.gov/compliance/energy-code-field-studies. We note that 40 other homes in the same study were required to be tested (because at least some ducts were located outside conditioned space), and these homes achieved leakage rates of 9.7 cfm/sq.ft., on average – roughly half the leakage rate of homes that qualified for the exemption. Obviously, this is a small sample size, but the Field Studies found similar results in Pennsylvania, where "exempt" homes (with all ducts inside conditioned space) averaged almost 31 cfm/sq.ft. leakage, while homes required to be tested averaged almost 18 cfm/sq.ft. leakage.

Results of DOE Field Study Data Collection on Duct Tightness				
	Ducts in Conditioned Space (Exempt from Test)		Ducts Outside Conditioned Space (Testing Required)	
Kentucky	# Samples	24	# Samples	40
	Max Test Result	40.36	Max Test Result	18.90
	Min Test Result	6.26	Min Test Result	3.10
	Avg Test Result	18.46	Avg Test Result	9.71
Pennsylvania	# Samples	18	# Samples	52
	Max Test Result	77.10	Max Test Result	69.00
	Min Test Result	12.60	Min Test Result	2.44
	Avg Test Result	30.95	Avg Test Result	17.95

Although the results vary across the states sampled, these results point to a shortcoming in the IECC's "complete exemption" approach to homes with all ducts inside conditioned space.

Although most energy modeling software does not capture the occupant-level impact of poorly-sealed ducts, anyone who has lived or worked in a building with leaky ducts understands that discomfort can lead occupants to adjust the thermostat. The energy impact of adjusting the thermostat is huge. The following table shows the increased energy use that results from adjusting the thermostat up or down a single degree in a code-compliant house in each climate zone.

Increased Energy Use Resulting from Thermostat Adjustment									
Measure	**Weighted**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
+1 Degree Heating	4.1%	0.5%	3.0%	4.2%	4.4%	4.7%	4.5%	4.0%	2.9%
-1 Degree Cooling	3.0%	7.8%	5.3%	3.9%	2.6%	1.8%	1.4%	0.7%	0.4%

Obviously, if an uncomfortable occupant adjusts the thermostat 2 or 3 degrees, the impact will be far higher, and could essentially negate many of the efficiency gains made in the IECC over the last decade.

The concept of requiring a test for all new homes is not new. DOE's Building America Program recommends that "[e]ven in conditioned space, ducts should be insulated to reduce the risk of condensation and mold. They should be tightly sealed and tested for leakage." *See* https://www.energy.gov/sites/prod/files/2014/01/f6/1_1g_ba_innov_ductsconditionedspace_011713.pdf. Likewise, the International Association of Certified Home Inspectors recommends that ducts be located entirely within conditioned space and tested to ensure air tightness. Air leakage rates at air handlers, even when all ducts are located in conditioned space, can lead to significant reduction in comfort, leading homeowners to adjust the thermostat and significantly increase energy use. *See* https://www.nachi.org/inspecting-hvac-cabinet-seams-air-leakage-sealing.htm.

Bibliography: *Insulation*, U.S. Dep't of Energy, https://www.energy.gov/energysaver/weatherize/insulation (last accessed Dec. 30, 2018).
U.S. Dep't of Energy, Methodology for Evaluating Cost-Effectiveness of Residential Energy Code Changes (Aug. 2015), *available at* https://www.energycodes.gov/residential-energy-and-cost-analysis-methodology.

Cost Impact: The code change proposal will increase the cost of construction
This proposal will require duct testing and meeting a modest duct tightness level in the limited subset of homes that are currently exempt from the test requirement in the IECC. However, we believe the added value in quality control for builders and the likely positive impact on occupant comfort

and energy savings will easily outweigh the cost of the test and any remedial efforts to improve duct tightness.