

#### Duct Leakage Tests Exempt or not Exempt?

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- RESNET Board of Directors
- Manage QA Provider Group
- Vice-Chair RESNET Standard Development Committee 900
- Chair RESNET Sampling Sub-Committee
- Developed a Home Energy Rating program in Tompkins County
- 2-year Study in Massachusetts on effectiveness of air conditioner Installation Rebate program

- Degree in Physics and Applied and Computational Mathematics
- Independent studies on Residential Power, Thesis on Wind Turbines for residential use
- RESNET HERS Rater
- RESNET and EPA Trainer
- RESNET Quality Assurance
  Designee
- BPI Analyst, Shell Specialist, HVAC, Multifamily
- ACCA Universal Refrigerant Handler



- Member RESNET QA
  Committee
- Developed TREAT energy modeling software
- Managed Home Performance Contracting Company
- Oversee PSD's relationships with Residential Energy-Related businesses

- Residential Carpenter/Contractor 1984 to 2003
- BPI "Super-Proctor"
- RESNET HERS Rater
- RESNET and EPA Trainer
- RESNET Quality Assurance
  Designee
- BPI Analyst, Shell Specialist, HVAC, IDL
- ICC Plan Reviewer and field
  inspector





### Standards? What Standards?







# **Duct Leakage Testing**

## If you're confused, you're not alone

## Duct Leakage – What is it?





*Brazil* - 1986



 Air moving through cracks, seams, joints in the ductwork to unintended locations.
 i.e. not through the register



The <u>Total Duct Leakage</u> test measures how much air is leaking through the entire duct system to anywhere.

The Leakage to Outside test measures how much of the duct air leakage is going to outside the conditioned space.

## **Total Leakage**





## Leakage to Outside









**Total Leakage** is ALWAYS at least as high as **Leakage to Outside**, and usually measurably higher.

Duct leaks inside the Conditioned Envelope is part of <u>Total Leakage</u>, but *not* part of <u>Leakage To</u> <u>Outside</u>



- Minimizing Total Leakage allows management of static pressures and controlling designed airflows
- Preventing Leakage to Outside keeps unconditioned air outside and conditioned air inside
- Controlling leakage allows control of induced pressure imbalances between conditioned and/or across primary pressure boundary



## IF **Total Leakage** equals ZERO CFM25 AND Location of ducts is *[wherever]* THEN Leakage to Outside equals ZERO



## IF Total Leakage equals [whatever] AND Location of ducts is INSIDE THE PRIMARY PRESSURE BOUNDARY AND The Envelope Leakage is ZERO CFM50 THEN Leakage to Outside equals ZERO



## Any other circumstances? Any other conditions with no leakage to outside?

How about if all the ducts are visible inside conditioned space at time of final testing ?

(implied before addendum D, clarified in addendum D)

## Duct Leakage



## Who Cares?



- RESNET HERS Index
- EPA ENERGY STAR Program
- IECC
- Humans



- Leakage to Outside is required for a Confirmed HERS Rating
- Rating Index is unaffected by Total Leakage inputs



- Certified New Home must be tested for Total Leakage
  - At Rough-in: 4 cfm25/100 sq ft
  - At Final: 8 cfm25/100 sq ft
- Leakage to Outside
  - At Final: 4 cfm25/100 sq ft



#### Maximum CFM25 per 100 sq. ft. conditioned floor area

	2009	2012	2015	
Post-construction test				
Leakage to Outdoors	8	NA <sup>1</sup>	NA <sup>1</sup>	
Total Leakage	12	4	4	
Rough-in test				
Total Leakage	6	4	4	
Total w/o air handler	4	3	3	

<sup>1</sup>Leakage to outdoors option eliminated.

## Doing all on one home?





## Now what?







IECC 2009	IECC 2012 - 2018	ENERGY STAR	<b>RESNET HERS</b>
TL or LTO	TL	TL & LTO	LTO



- Exception: a thing that is excluded from a general statement or does not follow a rule
- Exemption: the process of freeing or state of being free from an obligation or liability imposed on others

(none of the standards use "Exemption")



- "Alternatively [...] is permitted"
- "When [...] is not required"
- "[...] can be waived"



 No Duct leakage testing is required if the entire duct system is within the thermal boundary

## **Exceptions: ENERGY STAR**



- Total Duct Leakage is ALWAYS required
- IF Total Duct Leakage is low enough, and the envelope is tight enough, LTO may be waived for the checklist.

## **ENERGY STAR Rater Field Checklist**



6. Duct Quality Installation - Applies to Heating, Cooling, Ventilation, Exhaust, & Pressure Balancing Ducts, Unless Noted in Footnote				
6.1 Ductwork installed without kinks, sharp bends, compressions, or excessive coiled flexible ductwork <sup>33</sup>				
6.2 Bedrooms pressure-balanced using any combination of transfer grills, jump ducts, dedicated return ducts, and / or undercut doors to achieve a Rater-measured pressure differential ≤ 3 Pa with respect to the main body of the house when all bedroom doors are closed and all air handlers are operating. See Footnote 34 for alternative. <sup>34</sup>			-	
6.3 All supply and return ducts in unconditioned space, including connections to trunk ducts, are insulated to ≥ R-6 35				

6.4 Rater-measured total duct leakage meets one of the following two options. See Footnote 37 for alternative: 36, 37, 38

6.4.1 <u>Rough-in</u>: The greater of ≤ 4 CFM25 per 100 sq. ft. of CFA or ≤ 40 CFM, with air handler & all ducts, building cavities used as ducts, & duct boots installed. In addition, <u>all</u> duct boots sealed to finished surface, Rater-verified at final. <sup>39</sup>

6.4.2 <u>Final</u>: The greater of ≤ 8 CFM25 per 100 sq. ft. of CFA or ≤ 80 CFM, with the air handler & all ducts, building cavities used as ducts, duct boots, & register grilles atop the finished surface (e.g., drywall, floor) installed <sup>40</sup>

6.5 Rater-measured duct leakage to outdoors the greater of ≤ 4 CFM25 per 100 sg. ft. of CFA or ≤ 40 CFM25<sup>36, 38, 41</sup>

\* Actual thresholds may vary, per footnotes describing certain system configurations



Testing of duct leakage to the outside *can be waived* if all ducts & air handling equipment are located within the home's air and thermal barriers AND infiltration does not exceed the following: CZ 1-2: 3 ACH50; CZ 3-4: 2.5 ACH50; CZ 5-7: 2 ACH50; CZ 8: 1.5 ACH50.

Alternatively, testing of duct leakage to the outside can be waived if total duct leakage is  $\leq$  4 CFM25 per 100 sq. ft. of conditioned floor area or 40 CFM, whichever is larger.



- If a Rater is performing a duct test only for code compliance and NOT performing a rating, then they can use the exemptions available in the relevant code for testing TL (or the LTO option for 2009).
- If a Rater is performing a HERS Rating for code compliance (or ENERGY STAR, or the HERS index, or a Utility Program, or for anything) then they need to follow the RESNET requirements for LTO and test LTO unless it meets the RESNET exemption.
- TL is not part of a rating, so they can always follow the particular code or program for TL



- Generally RESNET ratings require LTO, while code (almost exclusively) requires TL
- <u>Total Duct Leakage is required for code IECC 2012 and IECC</u> 2015 as a mandatory test unless it meets the Code exemption
  - 2015: No test limit requirement for <u>Simulated Performance and ERI approaches</u>, but test is required
    - "Exception: A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope."
  - <u>2012</u>: 4cfm/100sqft at final or 3cfm/100sqft at rough in if air handler not installed
    - "Exception: The total leakage test is not required for ducts and air handlers located entirely within the building thermal envelope"
- Leakage to Outside (or Total Leakage) is required for IECC 2009 as mandatory and must meet the following limits
  - At Final: 8cfm/100sqft Leakage to Outside OR 12cfm/100sqft total Leakage
  - At Rough In: 6cfm/100sqft Total Leakage OR 4cfm/100sqft Total leakage without air handler
  - Exception: "Duct tightness test is not required if the air handler and all ducts are located within *conditioned space*"



# HERS Index

Energy Code ENERGY STAR



- Minimum Rated Feature
  - Required to be measured for a Confirmed HERS Rating
- ENERGY STAR
- Code

## RESNET – ANSI 301 requirement



1	Iuna comperante. 1201	Same as Linergy Raung
		Reference Home
Thermal distribution	Thermal distribution system	For forced air distribution
systems:	efficiency (DSE) of 0.80 shall	systems: Tested in
	be applied to both the heating	accordance with
	and cooling system efficiencies.	requirements equivalent to
		Section 803 of the
		Mortgage Industry National
		Home Energy Rating
		Systems Standards <sup>(o)</sup> , and
		then either calculated
		through hourly simulation
		or calculated in accordance
		with ASHRAE Standard
		152-2004 with the ducts
		located and insulated as in
		the Rated Home.
		For ductless distribution
		systems: DSE=1.00
		For hydronic distribution
		systems: DSE=1.00
	L TT 1	


# What is the RESNET Exemption?



#### ANSI/RESNET/ICC 301-2014 Addendum D-2017

#### Effective Date: January 1<sup>st</sup> 2018

#### ANSI/RESNET/ICC 301-2014 Addendum L-2018

Effective Date: January 1<sup>st</sup> 2019



**Effective Date** 

### **Transition Period**

# **Transition Period End Date**



# Many people were not aware of the exception requirements in 2018



Addendum D to ANSI/RESNET/ICC Std 301-2014:

"Exception: The requirement to test for duct leakage to the outside shall be waived, and the ducts shall be assigned 0 (zero) leakage to the outside, if **both** of the following conditions are visually verified by an Approved Tester at the final stage of construction

- All ductwork and the air handler unit are <u>completely within the Infiltration Volume</u> of the home.
- All ductwork is visible"

#### Addendum D



ANSI/RESNET/ICC 301-2014 Addendum D-2017

#### ANSI/RESNET/ICC 301-2014 Addendum D-2017 Amendment on Adoption of Standard ANSI/RESNET/ICC 380-2016 Effective Date January 1, 2018

#### Standard for the Calculation and Labeling of the Energy Performance of Low-Rise Residential Buildings using an Energy Rating Index

#### Forward (Informative)

This Standard provides a consistent, uniform methodology for evaluating and labeling the energy performance of residences. The methodology compares the energy performance of an actual home with the energy performance of a reference home of the same geometry, resulting in a relative energy rating called the Energy Rating Index. Where the energy performance of the actual home and the reference home are equal, the Energy Rating Index is 100 and where the actual home requires no net purchased energy annually, the Energy Rating Index is 0 (zero).

The Energy Rating Reference Home used for this comparative analysis has the energy attributes of the 2006 International Energy Conservation Code (IECC) *Standard Reference Design*. Thus, the Energy Rating Index is relative to the minimum building energy efficiency requirements of the 2006 IECC. As a result, the Energy Rating Reference Home performance will not comport with state or local building codes that differ in stringency from the 2006 IECC. Where local building energy codes are less stringent than the 2006 IECC, the Energy Rating Index for the local standard will be greater than 100 and where local building energy codes that are more stringent than the 2006 IECC, the Energy Rating Index for the local standard will be greater than 100 and where local building energy codes that are more stringent than the 2006 IECC, the Energy Rating Index for the local standard will be less than 100. Because the Energy Rating Index score accounts for all lighting, appliances and miscellaneous energy loads, there is never a 1-to-1 correspondence between code compliance (even under the 2006 IECC) and an Energy Rating Index score of 100.

This Standard contains both normative and informative material. The body of the Standard is normative and must be complied with to conform to the Standard. Informative materials are not mandatory and are limited to this forward, footnotes, references and annexes, all of which are clearly marked as informative.





### Addendum L



ANSI/RESNET/ICC 301-2014 Addendum L-2018

#### ANSI/RESNET/ICC 301-2014 Addendum L-2018 Exception to Duct Leakage to Outside Testing

ANSI Approved Date December 3, 2018 Effective Date January 2, 2019 Transition Period End Date July 1, 2019

Add definitions and acronyms as follows:

<u>Attached Dwelling Unit – A Dwelling Unit sharing demising walls, floors, ceilings, or common</u> corridors with another Dwelling Unit or Occupiable Space.

Detached Dwelling Unit – A Dwelling Unit that does not meet the definition of Attached Dwelling Unit.

**Dwelling** – Any building that contains one or two Dwelling Units used, intended, or designed to be built, used, rented, leased, let or hired out to be occupied, or that are occupied for living purposes.

Occupiable Space - A room or enclosed space designed for human occupancy in which individuals congregate for amusement, educational or similar purposes or in which occupants are engaged at labor, and which is equipped with means of egress and light and ventilation facilities meeting the requirements of this standard.

**Townhouse** - A single-family Dwelling Unit constructed in a group of three or more attached units in which each unit extends from the foundation to roof and with open space on at least two sides.

3.3 Acronyms

ACH50 - Air Changes per Hour at 50 Pascals



**Dwelling Unit -** A single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

Attached Dwelling Unit – A Dwelling Unit sharing demising walls, floors, ceilings, or common corridors with another Dwelling Unit or Occupiable Space.

**Detached Dwelling Unit** – A Dwelling Unit that does not meet the definition of Attached Dwelling Unit.

**Dwelling** – Any building that contains one or two Dwelling Units used, intended, or designed to be built, used, rented, leased, let or hired out to be occupied, or that are occupied for living purposes.

# **Dwelling Unit**











#### Attached Dwelling Unit









### Detached Dwelling Unit









# Dwelling











# **Three Basic Options**

- 1) Any Dwelling Unit
  - 88% DSE
- 2) Dwellings or Townhouses
  - ½ Total Leakage
- 3) Attached Dwellings (3+ units)
  - % of Total Leakage based on duct and air handler location



# Option 1



When both of the following conditions are met and documented, duct leakage testing is not required.

- At a pre-drywall stage of construction, 100% of the ductwork and air handler shall be visible and visually verified to be contained inside the Conditioned Space Volume. At a final stage of construction, ductwork that is visible and the air handler shall again be verified to be contained in the Conditioned Space Volume.
- At a pre-drywall stage of construction, the ductwork shall be visually verified to be 100% fully ducted, with no building cavities used as supply or return ducts.

To calculate the energy impacts on the Rated Home, a DSE of 0.88 shall be applied to both the heating and cooling system efficiencies.

### Building cavity used as return duct











Rated Home: DSE of 0.88 shall be applied to both the heating and cooling system efficiencies.

Reference Home: Thermal distribution system efficiency (DSE) of 0.80 shall be applied to both the heating and cooling system efficiencies.

Waiving the test is slightly better than the reference home, but not the same as 0 duct leakage to outside

If you want to claim no leakage, you need to test and verify no leakage



# WHY CAN'T IT BE ZERO??

# All ducts within thermal envelope predrywall







Connected Zones will allow leakage to outside – if there are any duct leaks into that zone



# CONDITIONED SPACE VOLUME vs INFILTRATION VOLUME





Space Type	Included In the Following Categories?			
	Conditioned Space Volume	Un-Conditioned Space Volume	Conditioned Floor Area	Infiltration Volume
Space conditioned to 68/78F (excluding attics, basements, crawlspaces, garages, and sunrooms, which are addressed below)	<u>Yes</u>		<u>Yes</u>	<u>Yes</u>
Attic air sealed & insulated at roof deck, and conditioned 1	Yes			Sometimes
Attic air sealed & insulated at roof deck, but not conditioned		<u>Yes</u>		Sometimes
Attic not air sealed & insulated at roof deck		<u>Yes</u>		
Wall cavity, with at least one horizontally- adjacent space conditioned	<u>Yes</u>		<u>Yes</u>	<u>Yes</u>
Wall cavity, with both horizontally-adjacent spaces unconditioned		Yes		
Floor cavity, with volume above & below_ conditioned	Yes			<u>Yes</u>
Floor cavity, with either volume above or below unconditioned		<u>Yes</u>		<u>Yes</u>
Floor cavity, with both volume above and below unconditioned		Yes		
Unvented crawlspace, conditioned <sup>1</sup>	Yes			Sometimes 3
Unvented crawlspace, not conditioned		Yes		Sometimes <u>3</u>
Vented crawlspace		Yes		
Basement, conditioned <sup>2</sup>	Yes		Yes	Sometimes 3
All other basements		Yes		Sometime 3
Garage, even if conditioned		Yes		
Thermally isolated sunroom		Yes		



# Option 2

# Option 2



"Alternatively, for <u>Dwellings and Townhouses</u> only, when all of the following conditions are met and documented, total duct leakage testing is permitted to be conducted in lieu of duct leakage to outside testing and half of the measured total leakage shall be assigned duct leakage to outside."

#### Unless

"At a final stage of construction, if visible ductwork or the air handler is observed outside the Infiltration Volume or ductwork is no longer 100% fully ducted, duct leakage to outside testing is required:"

# 4 Conditions for option 2



1. At a pre-drywall stage of construction, 100% of the ductwork and air handler shall be visible and visually verified to be contained inside the Infiltration Volume. At a final stage of construction, ductwork that is visible and the air handler shall again be verified to be contained in the Infiltration Volume.

2. At a pre-drywall stage of construction, the ductwork shall be visually verified to be 100% fully ducted, with no building cavities used as supply or return ducts.

# 4 Conditions for option 2



3. At either a pre-drywall stage of construction or a final stage of construction, airtightness of the duct system shall be tested in accordance with requirements of Standard ANSI/RESNET/ICC 380 Total Duct Leakage Test (Section 4.4.1). The total leakage shall be less than or equal to the greater of: <u>4 cfm per 100 ft2</u> of Conditioned Floor Area served by the duct system being tested, or 40 cfm. For duct systems with 3 or more returns, the total leakage shall be less than or equal to the greater of: <u>6 cfm per 100 ft2</u> of Conditioned Floor Area served by the duct system being tested, or 40 cfm. For duct systems with 3 or more returns, the total leakage shall be less than or equal to the greater of: <u>6 cfm per 100 ft2</u> of Conditioned Floor Area served by the duct system being tested, or 60 cfm.

4. Airtightness of the Rated Home shall be tested in accordance with requirements of Standard ANSI/RESNET/ICC 380 and shall be less than or equal to 3 ACH50.



- Duct system is 100% in Infiltration Volume
- System is fully ducted no building cavities used
- Measured Total Leakage is less than
  - 4 cfm/100sqft CFA, or
  - 6 cfm/100sqft CFA for 3 or more returns
- Home Infiltration ≤ 3 ACH 50pa



### **OPTION 3**



"Alternatively, for Attached Dwelling Units, excluding Dwellings and Townhouses, total duct leakage testing, at either pre-drywall or final stage of construction, is permitted to be conducted in lieu of duct leakage to outside testing.

Software shall calculate the energy impact using the total duct leakage results and prorating based on the percent of duct surface area that is not in Rated Home Conditioned Space Volume, plus a contribution from the associated air handler if located outside the Rated Home Conditioned Space Volume. The air handler contribution shall be a minimum of 2.5% of the supply airflow, where supply airflow is calculated as 400 cfm per 12,000 Btu/h of output capacity of the heating or cooling equipment. The sum of the duct leakage associated with duct surface area outside the Conditioned Space Volume and the air handler leakage shall not exceed the measured duct leakage from the entire duct system. "



#### Basics:

- LTO = %TL
- % of ductwork NOT in CSV
- + air handler contribution if located outside CSV
  - 2.5% of supply flow (400cfm/12,000Btu/h)
- Software calculated (But not yet)



- Rater measures total duct leakage to be 160 cfm25pa
- 20% of ductwork is outside CSV
- Air handler is outside CSV and system is 24,000 Btu/h capacity

LTO = (160 cfm)(0.20) + (.025)(800 cfm)LTO = 32+20 = 52CFM25pa

#### Addendum L - Transition





You MAY use the Addendum L exemption NOW. For homes permitted AFTER July 1, 2019, you MUST use Addendum L (when using the exception)




## Handling exceptions in Rating software



4 Location Leakage	Þ
Input Type: Measured Units of Measure: CFM @ 25 Pascals	Test Exemptions   IECC   RESNET LtO   ENERGY STAR LtO
CFM @ 25 CFM @ 25 CFM @ 25 CFM @ 25 Pascals Return 72.00	Total Duct Leakage Duct Test Conditions: Postconstruction Test Total: 200.00 CFM @ 25 Pascals

## Ekotrope



	Distrib
Distribution System System Type	Forced Air •
Untested OTested	Threshold / Sampled
Heating Equipment Served	Fuel-fired air dist •
Cooling Equipment Served	Air conditioner (2 ▼
All Equipment in Conditioned Space?	
Leakage Default	HERS Default Le 🔻
Overall Distribution System Efficiency	0.88
Remove	Сору



## **THANK YOU**

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