Results of Electronic Ballot of RESNET Board of Directors on Authorizing Proposed Amendment of Chapter 8 of the RESNET Standards to be Submitted to the RESNET Public Review and Comment Process

February 18, 2011

Shall the RESNET Board of Directors authorize the proposed Chapter 8 amendment drafted by the RESNET Technical Committee (Attachment A) be submitted to the RESNET public review and comment process?

Yes (18)	No (0)	Abstain (0)	Not Voting (1)
Ben Adams			Greg Thomas
Dave Bell			
Steve Byers			
Dennis Creech			
Lance DeLaura			
Brett Dillon			
Charles Eley			
Philip Fairey			
David Goldstein			
Andy Gordon			
Mark Jansen			
Lee O'Neal			
Bill Prindel			
Javier Ruiz			
Eurihea Speciale			
Orlo Stitt			
Daran Wastchak			
Barb Yankie			

The proposed amendment was authorized to be submitted to the public review and comment.

Amendment: Add Chapter Eight to RESNET Standards

Proponent:
RESNET Technical Committee

Applies to:
2006 Mortgage Industry National Home Energy Rating Systems Standards

Proposed Amendment: Chapter Eight as follows:

DRAFT
Chapter 8
RESNET Standards

800 RESNET Standard for Performance Testing and Work Scope: Enclosure and Air Distribution Leakage Testing

801 BACKGROUND

This Standard will present a step-by-step approach for how to measure:

- enclosure air leakage for the inspection of low rise, three stories or less, residential and light commercial buildings, and
- duct leakage associated with HVAC systems, and
- air flows for ventilation systems

802 PROCEDURES FOR BUILDING ENCLOSURE AIRTIGHTNESS TESTING

The purpose of this test procedure is to determine the airtightness of a building enclosure measured in cubic feet per minute at a 50 Pa pressure difference (*CFM50)*.

802.1 On-Site Inspection Protocol:

There are three acceptable airtightness test procedures:

1- Single-point test: Measuring air leakage one time at a single pressure difference as described in section 802.5
2- Multi-point test: Measuring air leakage at multiple induced pressures differences as described in section 802.6
3- Repeated single-point test: The test is similar to the single point test, but the test is done multiple times for improved accuracy and estimating uncertainty as described in section 802.7

The building may be tested by applying a positive or negative pressure. Follow all manufacturers' instructions for set up and operation of all equipment. If certain requirements of this standard cannot be met, then all deviations from the standard shall be recorded and reported.

Note: Use caution when deciding how and whether to test homes with potential airborne contaminants (e.g. fireplace ash, mold or asbestos) and refer to local, state and national protocols/standards for methods to deal with these and other contaminants.

802.2 The following protocol shall be followed in preparing the building enclosure for testing:

1. **Doors and windows between conditioned space and the exterior or unconditioned spaces:** Shall be closed and latched.
2. **Attached garages:** All exterior garage doors and windows shall be closed and latched unless the blower door is installed between the house and the garage, in which case all exterior garage windows and doors shall be opened.
3. **Crawlspaces:** If conditioned, interior access doors and hatches between the house and the crawlspace shall be opened and crawlspace exterior access doors, vents and hatches shall be closed. If unconditioned, interior access doors and hatches shall be closed. For testing purposes, crawl-space vents shall be open.
4. **Attics:** If conditioned, interior access doors and hatches between the house and the conditioned attic shall be opened; and attic exterior access doors and windows shall be closed. If unconditioned, interior access doors and hatches shall be closed and exterior access doors, dampers or vents shall be left in their as found position and their position during testing shall be recorded on the test report.
5. **Interior Doors:** Shall be open within the Conditioned Space Boundary. See the definition of "Conditioned Space Boundary" for clarification.
6. **Suspended grid ceiling:** One tile shall be removed to provide pressure relief and avoid damage during induced pressure differences.
7. **Chimney dampers and combustion-air inlets on solid fuel appliances:** Shall be closed. Take precautions to prevent ashes or soot from entering the house during testing. Although the general intent of this standard is to test the building in its normal operating condition, it may be necessary to temporarily seal openings to avoid drawing soot or ashes into the house. Any temporary sealing shall be noted in the test report.
8. **Combustion appliance flue gas vents:** Shall be left in their normal appliance-off condition.
9. **Fans:** Any fan or appliance capable of inducing airflow across the building enclosure shall be turned off including, but not limited to, clothes dryers, attic fans, kitchen and bathroom exhaust fans, outdoor air ventilation fans, air handlers, and crawl space and attic ventilation fans. For continuously operating ventilation systems seal the air opening.
10. **Non-motorized dampers which connect the conditioned space to the exterior or to unconditioned spaces:** Dampers shall be left as found. If the damper will be forced open or closed by the induced test pressure, that fact shall be reported in the test report.
11. **Motorized dampers which connect the conditioned space to the exterior (or to unconditioned spaces):** The damper shall be placed in its closed position and shall not be further sealed.

12. **Un-dampered or fixed-damper intentional openings between conditioned space and the exterior or unconditioned spaces:** Shall be left open or fixed position, however, temporary blocking shall be removed. For example: fixed-damper ducts supplying outdoor air for intermittent ventilation systems (including central-fan-integrated distribution systems) shall be left in their fixed-damper position. ***Exception:*** Un-dampered supply-air or exhaust-air openings of *continuously operating* mechanical ventilation systems shall be sealed (preferably seal at the exterior of enclosure) and ventilation fans shall be turned off as specified above.
13. **Whole building fan louvers/shutters:** Shall be left as found. (If there is a seasonal cover, install it.)
14. **Evaporative coolers:** The opening to the exterior shall be covered or sealed.
15. **Operable window trickle-vents and through-the-wall vents:** Shall b**e closed.**
16. **Supply registers and return grilles: Shall be** left open and uncovered.
17. **Plumbing drains with p-traps:** Shall be sealed or filled with water if empty.
18. **Combustion appliances:** Shall remain off during the test.
    For test purposes, if a dryer is not attached the dryer exhaust opening should not be sealed off but this fact should be noted in the test report.

Maintain the above conditions throughout the test. If during the test, induced pressures affect operable dampers, seasonal covers, etc. then reestablish the set-up and consider reversing direction of fan flow.

After testing is complete, return the building to its as found conditions prior to the test. For example, make sure that any combustion appliance pilots that were on prior to testing remain lit after testing.

802.3 Accuracy levels for enclosure leakage testing

This standard defines two levels of accuracy:

1- ***Standard level of accuracy***- level of accuracy that produces test results that can be used in the modeling software or to assess compliance with a performance standard or program requirement. This is the level of accuracy that is normally attained unless there are adverse testing conditions such as high winds or very large baseline pressure adjustments.

2- ***Reduced level of accuracy***- during adverse testing conditions or in certain applications where testing time and costs are a factor, a test with a reduced level of accuracy may be used. Such applications may include demonstrating compliance with a performance threshold or a specific program requirement. Measurements made with a reduced level of accuracy may require surpassing the threshold value by an amount which will account for the added uncertainty as defined in the sections below. RESNET accredited software that uses test results with a reduced level of accuracy shall internally adjust the calculations in accordance with this chapter.

802.4 Installation of the blower door airtightness testing system:

1. Install the blower door system in an exterior doorway or window that has unrestricted access to the building and no obstructions to airflow within five feet of the fan inlet. Avoid installing the system in a doorway or window exposed to the wind.
    a. It is permissible to use a doorway or window between the conditioned space and unconditioned space as long as the unconditioned space has an unrestricted air pathway to the outdoors. For example, an attached garage or porch can be used as the unconditioned space; in that case, be sure to open all exterior windows and doors of the unconditioned space to the outdoors.
2. Install the pressure gauge(s), fans and tubing connections according to equipment manufacturer's instructions.
3. Record the indoor and outdoor temperatures in degrees F to an accuracy of 10 degrees F.
4. Record the elevation of the building site with an accuracy of 2000 feet; this may be omitted at elevations less than 5000 feet above sea level.
5. If ***ACH50***, i.e., air changes per hour @ 50 Pa, will be calculated, record the ***building volume.***

802.5 Procedure for conducting a one-point airtightness test (if a multi-point test will be conducted, skip to section 802.6):

1. Choose and record a ***time averaging period*** of at least 10 seconds to be used for measuring pressures: With the blower door fan sealed and off, measure and record 5, independent, ***average baseline building pressure readings*** with respect to outside to a resolution of 0.1 Pa.
2. Subtract the smallest baseline measurement from the largest recorded in Step 1 and record this as the ***baseline range***.
3. Airtightness tests with a baseline range less than 5.0 Pa, will be considered a ***Standard Level of Accuracy*** Test. Airtightness tests with a baseline range between 5.0 Pa and 10.0 Pa will be considered a ***Reduced Level of Accuracy*** Test and the results will be adjusted using Section 802.8. A one point test cannot be performed under this standard if the baseline range is greater than 10.0 Pa. Record the level of accuracy for the test as ***standard*** or ***reduced***, as appropriate**.** The baseline test may be repeated employing a longer time averaging period in order to meet the desired level of accuracy.
4. Re-measure the baseline building pressure using the same time averaging period recorded in Step 1. This measurement is defined as the ***Pre-Test Baseline Building Pressure***. If desired for greater accuracy, a longer time averaging period may be used. As an alternative, the median value of the 5 average baseline building pressure readings taken in Step 1 may be used in lieu of re-measuring the baseline building pressure. Record the ***Pre-Test Baseline Building Pressure***.
5. Unseal the blower door fan. Turn on and adjust the fan to create an induced building pressure of approximately 50 Pa. Induced building pressure shall be

defined as the (unadjusted) building pressure minus the pre-test baseline building pressure. If a 50 Pa induced building pressure cannot be achieved because the blower door fan does not have sufficient flow capacity, then achieve the highest induced building pressure possible with the equipment available.

6. A one-point test may only be performed if the maximum induced building pressure is at least 15 Pa or four times the baseline pressure, whichever is larger. If the maximum induced building pressure is less than 15 Pa, recheck that the house set up is correct and determine if any basic repairs are needed prior to further testing or modeling of the building. A multi-point test may be attempted, or multiple fans may be used. If using multiple fans, follow the manufacturer's instruction for measurement procedures.
7. Measure and record the unadjusted building pressure and nominal (not temperature and altitude corrected) fan flow using the same averaging period used in Step 4. Record the unadjusted building pressure (with 0.1 Pa resolution), nominal fan flow (with 1 CFM resolution), fan configuration (rings, pressurization or depressurization, etc), fan model and fan serial number.
8. Turn off the fan.
9. If your pressure gauge has the capability to display the induced building pressure (i.e. "baseline adjustment" feature) and adjust the fan flow value to an induced building pressure of 50 Pa (i.e. "@50 Pa" feature), then follow the manometer manufacturer's procedures for calculating the results of a one-point test and record the following values: induced building pressure, nominal CFM50, fan configuration, fan model and fan serial number. If needed Calculate the following values:
   - ***induced building pressure*** = measured building pressure minus the ***Pre-Test Baseline Building Pressure***

     Note: If a "baseline adjustment" feature of the manometer was used, then the induced building pressure is displayed on the pressure gauge.

   - ***nominal CFM50*** = (50 / induced building pressure) $^{0.65}$ x recorded fan flow

     Note: If both a "baseline adjustment" feature and an "@50 Pa" feature were used, the nominal CFM50 is displayed directly on the pressure gauge.

   If the altitude is above 5,000 feet or the difference between the inside and outside temperature is more than 30 degrees Fahrenheit then calculate the corrected CFM50 as defined below:

   - ***corrected CFM50*** =

nominal CFM50 x altitude correction factor x temperature correction factor

where

altitude correction factor = 1 + .000006 x altitude,
altitude is in feet

temperature correction factors
are listed in Table 802.10

- ***ACH50*** = corrected CFM50 x 60 / building volume (in cubic feet). (This calculation may be omitted if the ACH50 metric is not needed.)

802.6 Procedure for conducting a multi-point airtightness test:

1. Equipment that can automatically perform a multi-point test may be used to perform the steps below.
2. With the blower door fan sealed and off, measure and record the pre-test baseline building pressure reading with respect to outside. This measurement shall be taken over a time-averaging period of at least 10 seconds and shall have a resolution of 0.1 Pa. Record the pre-test baseline building pressure measurement.
3. Unseal the blower door fan. Turn on and adjust the fan to create an induced building pressure of approximately 60 Pa. If a 60 Pa induced building pressure cannot be achieved because the blower door fan does not have sufficient flow capacity, then adjust the fan to achieve the highest induced building pressure possible.

   Measure the ***unadjusted building pressure*** (not baseline adjusted) and nominal fan flow (neither temperature nor altitude corrected) using the same time-averaging period used in Step 2 in section 802.6. Record the unadjusted building pressure (with 0.1 Pa resolution), nominal fan flow (with 1 CFM resolution), fan configuration, fan model and fan serial number. Assure that the fan is being operated according to the manufacturer's instructions.

   Note: since both pre- and post-test baseline measurements are required, do not use any baseline-adjustment feature of the manometer. In addition, do not use an "@50 Pa" feature because the nominal fan flow shall be recorded.

4. Take and record a minimum of 7 additional unadjusted building pressure and nominal fan flow measurements at ***target induced pressures*** which are approximately equally-spaced between 60 Pa (or the highest achievable induced building pressure) and 15 Pa. In very leaky buildings, the low end of this range may be reduced to as little as 4 Pa plus the absolute value of the baseline pressure.
5. Turn off and seal the blower door fan.

6. Measure and record the ***post-test baseline building pressure*** reading with respect to outside. This measurement shall be taken over the same time-averaging period used in Step 2 and shall have a resolution of 0.1 Pa. Record the post-test baseline building pressure measurement.
7. Enter the recorded test values, temperatures and altitude into a software program that can perform the necessary calculations in accordance with ASTM E779.

   The software program shall calculate and report: corrected CFM50 and the percent uncertainty in the corrected CFM50, at the 95% confidence level, as defined in ASTM E779.

   Although ACH50 may be reported, this calculation may be omitted if the ACH50 metric is not needed.

   Note: To avoid a higher percent uncertainty than desired, the testing technician may choose a larger, time-averaging period and start over at Step 2 in section 802.6.

8. If the reported uncertainty in the corrected CFM50 is less than or equal to 10.0%, then the airtightness test shall be classified as a ***Standard Level of Accuracy*** test. If the reported uncertainly in the corrected CFM50 is greater than 10.0%, the airtightness test shall be classified as a ***Reduced Level of Accuracy*** test and the results will be adjusted using Section 802.8.

802.7 Procedure for conducting a repeated single point test:

1. With the blower door fan sealed and off, measure and record the pre-test baseline building pressure reading with respect to outside. This measurement shall be taken over a time-averaging period of at least 10 seconds and shall have a resolution of 0.1 Pa. Record this value as the pre-test baseline building pressure measurement.

2. Unseal the blower door fan. Turn on and adjust the fan to create an induced building pressure of approximately 50 Pa. If a 50 Pa induced building pressure can not be achieved because the blower door fan does not have sufficient flow capacity, then achieve the highest induced building pressure possible with the equipment available.

3. If during any single repeat of this test, the induced building pressure is less than 15 Pa, recheck that the house set up is correct and determine if any basic repairs are needed prior to further testing or modeling of the building. Following any repairs or changes to the set up, the test shall be restarted from the beginning. If you can not reach at least 15 Pa every time, then use the procedures in sections 802.5 or 802.6.

4. Measure and record the unadjusted building pressure and nominal (not temperature and altitude corrected) fan flow using the same time-averaging period used in Step 1 in section 802.6 above. Record the unadjusted building pressure (with 0.1 Pa resolution), nominal fan flow (with 1 CFM resolution), fan configuration (rings, pressurization or depressurization, etc), fan model and fan serial number.

   Note: If your pressure gauge has the capability to display the induced building pressure (i.e. baseline adjustment feature) and the capability to adjust the fan flow value to an induced building pressure of 50 Pa (i.e. "@50 Pa" feature), then follow the manufacturer's procedures for calculating the results of a one-point test and record the following values: induced building pressure, nominal CFM50, fan configuration, fan model and fan serial number.

5. Turn off the fan.

6. Calculate the following values:

   - ***induced building pressure*** = unadjusted building pressure (Pa) minus pre-test baseline building pressure (Pa). **Note:** If a baseline adjustment feature was used, then the induced building pressure is displayed on the pressure gauge.

   - nominal CFM50 = (50 Pa / Induced building pressure) $^{0.65}$ x nominal fan flow.

   Note: If both a baseline adjustment feature and an "@50 Pa" feature were used, the nominal CFM50 is displayed directly on the pressure gauge.

7. Repeat Steps 1-5 of section 802.7 until a minimum of 5 nominal CFM50 estimates have been recorded. The same fan configuration shall be used for each repeat.
8. Calculate the ***Average Nominal CFM50*** by summing the individual nominal CFM50 readings and dividing by the number of readings.
9. If the altitude is above 5,000 feet or the difference between the inside and outside temperature is more than 30 degrees Fahrenheit then calculate the corrected CFM50 as defined below:
   Calculate the ***Average Corrected CFM50*** =
   Average Nominal CFM50 x altitude correction factor x temperature correction factor
   where
   altitude correction factor = 1 + .000006 x altitude,
   altitude is in feet
   temperature correction factors
   are listed in Table 802.1

Table 802.1 Temperature Correction Factors for Pressurization and Depressurization Testing- Calculated according to ASTM E779-2003

Correction Factors for Pressurization Testing

OUTSIDE TEMP (F) \ INSIDE TEMPERATURE (F)	50	55	60	65	70	75	80	85	90
-20	1.062	1.072	1.081	1.090	1.099	1.108	1.117	1.127	1.136
-15	1.056	1.066	1.075	1.084	1.093	1.102	1.111	1.120	1.129
-10	1.051	1.060	1.069	1.078	1.087	1.096	1.105	1.114	1.123
-5	1.045	1.054	1.063	1.072	1.081	1.090	1.099	1.108	1.117
0	1.039	1.048	1.057	1.066	1.075	1.084	1.093	1.102	1.111
5	1.033	1.042	1.051	1.060	1.069	1.078	1.087	1.096	1.105
10	1.028	1.037	1.046	1.055	1.064	1.072	1.081	1.090	1.099
15	1.023	1.031	1.040	1.049	1.058	1.067	1.076	1.084	1.093
20	1.017	1.026	1.035	1.044	1.058	1.061	1.070	1.079	1.087
25	1.012	1.021	1.029	1.038	1.047	1.056	1.064	1.073	1.082
30	1.007	1.015	1.024	1.033	1.041	1.050	1.059	1.067	1.076
35	1.002	1.010	1.019	1.028	1.036	1.045	1.054	1.062	1.071
40	0.997	1.005	1.014	1.023	1.031	1.040	1.048	1.057	1.065
45	0.992	1.000	1.009	1.017	1.026	1.035	1.043	1.051	1.060
50	0.987	0.995	1.004	1.012	1.021	1.029	1.038	1.046	1.055
55	0.982	0.990	0.999	1.008	1.016	1.024	1.033	1.040	1.050
60	0.977	0.986	0.994	1.003	1.011	1.019	1.028	1.036	1.045
65	0.973	0.981	0.989	0.100	1.006	1.015	1.023	1.031	1.040
70	0.968	0.976	0.985	0.993	1.001	1.010	1.018	1.026	1.035
75	0.963	0.972	0.980	0.988	0.997	1.005	1.013	1.022	1.030
80	0.959	0.967	0.976	0.984	0.992	1.000	1.009	1.017	1.025
85	0.955	0.963	0.971	0.979	0.988	0.996	1.004	1.012	1.020
90	0.950	0.958	0.967	0.975	0.983	0.991	0.999	1.008	1.016
95	0.946	0.954	0.962	0.970	0.979	0.987	0.995	1.003	1.011
100	0.942	0.950	0.958	0.966	0.970	0.982	0.990	0.998	1.007
105	0.938	0.946	0.954	0.962	0.970	0.978	0.986	0.994	1.002
110	0.933	0.942	0.950	0.952	0.966	0.974	0.982	0.990	0.998

Correction Factors for Depressurization Testing

OUTSIDE TEMP (F) \ INSIDE TEMPERATURE (F)	50	55	60	65	70	75	80	85	90
-20	0.865	0.861	0.857	0.853	0.849	0.845	0.841	0.837	0.833
-15	0.874	0.870	0.866	0.862	0.858	0.854	0.850	0.846	0.842
-10	0.883	0.879	0.874	0.870	0.866	0.862	0.858	0.854	0.850
-5	0.892	0.887	0.883	0.879	0.875	0.871	0.867	0.863	0.859
0	0.900	0.896	0.892	0.887	0.883	0.879	0.875	0.871	0.867
5	0.909	0.905	0.900	0.896	0.892	0.888	0.883	0.879	0.875
10	0.918	0.913	0.909	0.905	0.900	0.896	0.892	0.888	0.884
15	0.927	0.922	0.918	0.913	0.909	0.905	0.900	0.896	0.892
20	0.935	0.931	0.926	0.922	0.917	0.913	0.909	0.905	0.900
25	0.944	0.939	0.935	0.930	0.926	0.922	0.917	0.913	0.909
30	0.952	0.942	0.943	0.939	0.934	0.930	0.926	0.921	0.917
35	0.961	0.956	0.952	0.947	0.943	0.938	0.934	0.930	0.925
40	0.970	0.965	0.960	0.956	0.951	0.947	0.942	0.938	0.934
45	0.978	0.974	0.969	0.964	0.960	0.955	0.951	0.946	0.942
50	0.987	0.982	0.977	0.973	0.968	0.963	0.959	0.955	0.950
55	0.995	0.990	0.986	0.981	0.976	0.972	0.967	0.963	0.958
60	1.004	0.999	0.994	0.989	0.985	0.980	0.976	0.971	0.967
65	1.012	1.008	1.003	0.998	0.993	0.988	0.984	0.979	0.975
70	1.021	1.016	1.011	1.006	1.001	0.997	0.992	0.988	0.983
75	1.029	1.024	1.019	1.015	1.010	1.005	1.000	0.996	0.991
80	1.038	1.033	1.028	1.023	1.018	1.013	1.009	1.004	0.999
85	1.046	1.041	1.036	1.031	1.026	1.022	1.017	1.012	1.008
90	1.055	1.050	1.045	1.040	1.035	1.030	1.025	1.020	1.016
95	1.063	1.058	1.053	1.048	1.043	1.038	1.033	1.028	1.024
100	1.072	1.066	1.061	1.056	1.051	1.046	1.041	1.037	1.032
105	1.080	1.075	1.070	1.064	1.059	1.054	1.050	1.045	1.040
110	1.088	1.083	1.078	1.073	1.068	1.063	1.058	1.053	1.048

10. ACH50 (air changes per hour @ 50 Pa) = (Average Corrected CFM50 x 60) / building volume (in cubic feet). This calculation may be omitted if the ACH50 metric is not needed.

11. Estimate the precision uncertainty using one of the two following methods

    a. Standard Statistical Process – Use a calculator or computer to compute the Standard Deviation of the repeated Nominal CFM50 readings. Divide this Standard Deviation by the square root of the number of readings. Multiply the result by the t-statistic in table 802.2 corresponding to the number of readings taken. Convert this result to a percentage of the Average Nominal CFM50.

Table 802.2 Precision Uncertainty: Values of t-statistic	
Number of readings	t-statistic
5	2.78
6	2.57
7	2.45
8	2.37
9	2.31

12. If a software program is used, it shall at a minimum calculate and report:

    1. Average CFM50, corrected for altitude and temperature
    2. The percent uncertainty in the CFM50, at the 95% confidence level, as calculated in step 11.
    3. ACH50 (air changes per hour @ 50 Pa) = (CFM50 x 60) / building volume (in cubic feet). This calculation may be omitted if the ACH50 metric is not needed.

13. If the reported uncertainty in the CFM50 is less than or equal to 10.0%, then the airtightness test shall be classified as a Standard Level of Accuracy test as defined in section 802.3. If the reported uncertainly in the CFM50 is greater than 10.0%, the airtightness test shall be classified as a Reduced Level of Accuracy test as defined in section 802.3.

802.8 Application of Results

802.8.1 **Adjusting CFM50 for tests with a Reduced Level of Accuracy**

When using results classified as having a Reduced Level of Accuracy, an adjustment shall be used in certain situations. The adjustment is done to improve the probability that the tested building meets the required performance threshold. The adjusted CFM50 in these situations is defined as:

adjusted CFM50 = extending factor x corrected CFM50,
where:
For a One-point Test, classified as Reduced Level of Accuracy:
extending factor = 1 + 0.1 x (50 / the induced pressure)

For a Multi-point Test, classified as Reduced Level of Accuracy:
extending factor = 1 + (% uncertainty / 100)

adjusted CFM50 value shall be used when:

- determining whether or not a building meets an airtightness threshold, and

- calculating a Home Energy Rating for the purpose of compliance with any standard or program.

adjusted CFM50 value shall NOT be used when:

- calculating the expected energy savings from retrofit,
- conducting an energy audit, or
- assessing the relative airtightness of a group of buildings.

802.8.2 Other leakage metrics:

ELA may be calculated by: ***ELA*** = 0.055 x CFM50

Where ELA is in square inches

ACH50 = corrected CFM50 x 60 / building volume (in cubic feet)

Specific Leakage Area may be calculated by:
SLA = 69.4 x ELA/ building floor area (square feet)

Where ELA is in square inches

Normalized Leakage Area may be calculated by:
NLA = SLA x $(S)^{0.3}$, where S is the number of stories above grade

802.9 Equipment Accuracy and Requirements

Equipment accuracy: blower door fans used for building air leakage testing shall measure airflow (after making any necessary air density corrections) with an accuracy of +/- 5%. Pressure gauges shall measure pressure differences with a resolution of 0.1 Pa and have an accuracy of +/- 1% of reading or 0.5Pa, whichever is greater.

Blower door and associated pressure testing instruments shall be tested annually for calibration by the HERS Rating Provider or Certified Rater. The provider shall use a standard for field testing of calibration provided by the equipment manufacturer. Magnehelic Gauges cannot be field tested and shall be recalibrated by the Blower Door manufacturer annually. Field check the fan and flow measuring systems for defects and maintain them according to manufacturers recommendations. The HERS Rating Provider or Certified Rater shall maintain a written log of the annual calibration check to verify all equipment accuracy for a period of three (3) years. These records shall be made available within 3 business days to the RESNET Quality Assurance Administrator upon request.

803 ON-SITE INSPECTION PROCEDURES FOR DUCT LEAKAGE TESTING

The purpose of these test procedures is to make a determination of the amount of leakage of a duct system, either total system leakage or leakage to outside of the conditioned space. Because total duct leakage (to both inside and outside the conditioned space) at 25 Pascals should always be greater than the leakage to outside, the total leakage may be used instead of leakage to outside for determining that a system meets a required threshold. Table 803.1 summarizes the test methods approved for use in the RESNET Standards.

803.1 Air Handler Flow

For the purposes of determining if a total duct leakage test method may be used (see table 803.1), the Air handler flow can be measured in accordance with ASHRAE Standard152-2004, ASTM E1554-2007, or by using the following default values: 400 CFM per ton of air conditioner or heat pump capacity or 200 CFM per 12,000 Btu/h of furnace capacity whichever is greater.

Table 803.1- Duct Leakage Test Methods

Test Method	Test pressure	Conversion to operating pressure	Supply/Return	Notes
Leakage to the Outside Tests				
RESNET Standard Section 803.7	**25 Pa**	**No conversion**	**Assume ½ supply and ½ return**	
ASHRAE 152 Annex B	**25 Pa**	**½ plenum pressure for supply and return individually**	**Separate**	
ASTM E1554-07 Method A: "DeltaQ"	**Normal Operation**	**n/a**	**Separate**	**Can be used for energy auditing but not compliance testing. To limit precision errors this test is only allowed in this RESNET Standard if the Building Enclosure Leakage is less than 2500 cfm @ 50 Pa**
ASTM E1554 Method B	**25 Pa**	**½ plenum pressure for supply and return individually**	**Separate**	
Total Duct Leakage Tests				**The total leakage may be used instead of leakage to outside for compliance testing or if total leakage is less than 10% of air handler flow**
RESNET Standard Section 803.5	**25 Pa**	**No conversion**	**Assume ½ supply and ½ return**	
ASHRAE 152 Annex C	**25 Pa**	**½ plenum pressure or assume 62.5 Pa**	**Assumes ½ supply and ½ return**	**2.5% of air handler flow added if testing done without air handler. 2.5% added if testing done without registers/grilles.**

803.2 RESNET Simplified Test Procedures:
For purposes of this chapter, duct leakage may be measured by either pressurizing or depressurizing the duct system. Tests measure either total leakage or leakage to the outside. Total leakage includes all leaks in the air distribution system and leakage to the outside only refers to leaks to outside the conditioned space. The following text mentions only pressurization, but depressurization may also be used.

Testing of the duct system(s) of a building is accomplished by use of a duct leakage testing device and, when testing leakage to outside, a blower door. For total duct leakage, the duct leakage tester is attached and used to pressurize the duct system to 25 Pa. This test measures all duct leakage including leakage between the ducts and the conditioned space and leakage between the ducts and any unconditioned space or outside.

When performing a duct leakage to outside test, a blower door is also used to pressurize the building to 25 Pa while the duct leakage tester is used to equalize the pressure inside the duct system with the building pressure induced by the blower door (e.g 25 Pa). Because the ducts and the conditioned space of the building are theoretically at the same pressure, little or no air flows through leaks between the ducts and the conditioned space and the duct leakage tester only measures the leakage between the ducts and spaces outside the conditioned space. When ducts are in conditioned space, 100% of the system is visible and the system is fully ducted (i.e., no building cavities are used to transport air) the ducts do not have to be tested and the ducts may be assumed to have no leakage to outside the conditioned space.

803.2.1 Multifamily Buildings
For multifamily buildings where each unit has its own duct system, each unit may be tested individually using the procedures in this RESNET standard (Sections 805.4 and 805.6). Each unit should be treated as if it is a single family dwelling. The leakage to outside test is performed using a blower door in the main entry to the unit to pressurize the individual unit with reference to outside. If the main entry door is in an interior hallway then the hallway needs to be well connected to outside through open windows or doors or an exterior window or door (such as to deck or patio) may be used. Similarly, only the ducts in the unit under test are pressurized. For compliance testing use leakage to outside and for energy audits, it is assumed that the leakage to outside is one-half the result of this measurement and that the supply and return leakage are each equal to one-half of the leakage to outside. For compliance testing, the total leakage test method may be used instead of leakage to outside.

803.3 Protocol for preparing the building and the duct system for a duct leakage test (Items 1-8 are used for both Total and Outside Leakage tests):

1. Adjust the HVAC system controls so that the air handler fan does not turn on during the test.

2. Turn off any fans that could change the pressure in either the conditioned space or any spaces containing ducts or air handlers (bathroom fans, clothes dryers, kitchen vent hood, attic fan, etc.).
3. Turn off all vented combustion appliances if there is a possibility that the space containing the appliance will be depressurized during the test procedure.
4. Remove all filters from the duct system and air handler cabinet. If the duct leakage testing system is installed at a central return grille, also remove the filter from that grille.
5. Any intentional openings into the duct system such as combustion air or ventilation ducts shall be left in their normal non-ventilation operating position. Motorized dampers should be closed.
6. If ducts run through unconditioned spaces such as attics, garages or crawlspaces, open vents, access panels, doors, or windows between those spaces and the outside to eliminate pressure changes due to duct leakage during the test procedure.
7. Supply registers and return grilles shall be temporarily sealed in some manner so as to allow for the pressurization of the duct system.
8. Zone and bypass (not balancing) dampers shall be set to the open position to allow uniform pressures throughout the duct system.

   Total leakage test only: Fully open at least one door, window or comparable opening between the building and outside to prevent changes in building pressure when the duct leakage testing system is running.

   Leakage to the outside test only: All exterior doors and windows between the building and outside shall be closed, and other openings to the outside that may hinder the ability of a blower door fan to pressurize the building to 25 Pa with reference to outside should be closed or covered in some manner. Interior doors shall be open.

803.4 Installation of the duct leakage testing system (used for both total leakage and leakage to outside tests):

1. Attach the duct leakage tester system to the largest return grille closest to the air handler. Use the manufacturer's recommended installation procedure that is consistent with the mode (i.e. pressurization vs. depressurization) of the test being performed. Be sure the remaining opening in the return grille is temporarily sealed.

   When testing a duct system with 3 or more returns, installation of the duct leakage tester at the air handler cabinet may be a better attachment location.

   Document the attachment location of the duct leakage testing system.

2. Select a location to measure duct pressure. Choose one of the following three locations to measure duct pressure:

- The largest supply register closest to the air handler, or
- The main supply trunk line, or
- The supply plenum can be used if the duct leakage tester is installed at a central return.

Document the duct pressure measurement location.

3. Insert a pressure probe into the duct system at the chosen measurement location. If measuring at the supply trunk line or supply plenum, you shall use a static pressure probe (be sure the probe is pointing into the air stream). If measuring at a supply register, you may use a static pressure probe, or you may simply insert a straight pressure probe or the end of a piece of flexible tubing.
4. Install the pressure gauge and tubing connections in accordance with the manufacturer's instructions and the test mode (pressurization vs. depressurization) being used. The duct system pressure should be measured with reference to the inside of the building. Turn on and configure the pressure gauge for the test procedure being performed.

803.5 Procedure for conducting a total duct leakage test:

1. Select the appropriate range (e.g. flow ring) of the duct leakage testing fan and configure the flow gauge to match the selected range.
2. Turn on the duct leakage testing fan and increase fan speed until the duct system has been pressurized to 25 Pa (+/- 0.5 Pa). Measure and record the duct pressure reading (0.1 Pa resolution) and the fan flow reading (1 CFM resolution) using a 5 second averaging period. Also record the fan configuration (range), fan model and fan serial number. Be sure the fan is being operated according to the manufacturer's instructions.

   If 25 Pa of duct pressure cannot be achieved because the duct testing fan does not have sufficient flow capacity, then achieve the highest duct pressure possible with the equipment available and record the values above.

   Note: If your pressure gauge has the capability to adjust the fan flow value to a duct pressure of 25 Pa (i.e. @25 Pa feature), then follow the manufacturer's procedures for conducting a one-point total leakage test, and record the following values: duct pressure, CFM25 (or fan flow in CFM and pressure in Pa if 25 Pa not achieved), fan configuration, fan model and fan serial number. If your gauge does not have an @25 feature and the measured duct pressure was not exactly 25 Pa, calculate and record CFM25 as: CFM25 = (25 Pa/ duct pressure)$^{0.6}$ x fan flow.

3. Turn off the duct testing fan.

803.6 Installation of the blower door system (used for leakage to outside test only):

1. Install the blower door system in an exterior doorway that has unrestricted access to the building and no obstructions to air flow within five feet of the fan inlet. The blower door fan should be installed in a configuration that is consistent with the mode of the duct leakage test (i.e. pressurization vs. depressurization).
2. Install the pressure gauge(s), fan and tubing connections as per manufacturer's instructions.

803.7 Procedure for conducting a duct leakage to outside test:

1. With both the blower door and duct leakage fans sealed, measure the baseline building pressure with reference to outside using a 5 second averaging period.
2. Unseal the blower door fan. Turn on the blower door fan and pressurize the building by 25 Pa (+/- 0.5 Pa) from the measured baseline building pressure (i.e. change the building pressure by 25 Pa). **Note:** If your pressure gauge has the capability to display the induced building pressure (i.e. baseline adjustment feature), then follow the manufacturer's procedures for pressurizing the building by 25 Pa.
3. With the blower door fan continuing to run, unseal the duct leakage testing fan and select the appropriate range on the duct leakage testing fan. Configure the duct leakage testing system gauge to match the selected range.
4. Turn on the duct leakage testing fan and increase fan speed until the duct system pressure reads 0.0 (+/- 0.1 Pa). **Note:** The duct system pressure should be measured with reference to the inside of the building.
5. Re-check the blower door pressure gauge and if necessary, re-adjust the blower door fan to maintain a 25 Pa pressurization. **Note:** If the blower door fan is being operated with a "cruise control" feature, it is not necessary to recheck the blower door pressure gauge.
6. Return to the duct leakage pressure gauge and if necessary, re-adjust the duct leakage testing fan until the duct system pressure reads 0.0.
7. Record the following values: building pressure, duct pressure, CFM of flow through the duct testing fan, duct testing fan configuration, duct testing fan model and serial number. Calculate and record CFM25: CFM25 = (25 Pa/ building pressure)$^{.6}$ x duct leakage fan flow.
8. Turn off both the blower door and duct leakage testing fans.

   Note: If the blower door system is unable to pressurize the building to 25 Pa because the blower door fan does not have sufficient flow capacity, then you will need to conduct the test at the highest achievable building pressure and adjust the measured duct leakage as described in step 7.

   Note: If the duct testing fan was unable to create a pressure difference of zero between the duct system and the building (while the blower door is pressurizing the building to 25 Pa) because the duct testing fan does not have sufficient flow capacity,

then the test will need to be performed at a lower building pressure and adjust the measured duct leakage as described in step 7.

803.8 Application of Results

1. The results of the total duct leakage test represent the total amount of duct leakage both to the inside and to the outside of the conditioned space and represent the overall leakage of the entire system. The total leakage may be of use in some programs where the total system duct leakage is required.
2. The duct leakage to the outside test is designed to measure only the duct leakage occurring to the outside of the conditioned space. Many programs use this measurement as the determining factor as to whether a duct system fails or passes.
3. If rating software requires separate input of supply and return leakage that have not individually been measured you shall assume that ½ of the total measured leakage is in the supply and ½ is in the return.

803.9 Equipment Accuracy and Requirements

Equipment Accuracy: Duct testing fans used for determining either total leakage or leakage to outside shall measure airflow with an accuracy of +/-5%. Pressure gauges shall measure pressure differences with a resolution of 0.1 Pa and have an accuracy of +/-1% of the reading or 0.5 Pa, whichever is greater.

Blower doors, duct testers, and associated pressure testing instruments shall be field-tested annually for calibration. The calibration procedure shall follow the equipment manufacturer's recommendations.

A written log of the annual calibration check to verify all equipment accuracy shall be maintained for a period or three (3) years by the Rating Provider or Certified Rater.

804 ON-SITE INSPECTION PROCEDURES FOR VENTILATION AIR FLOW TESTING

The purpose of these test procedures are to measure the air flows through whole house ventilation systems and local exhausts. The test procedures treat the air flows into and out of the grille being measured separately. The Air Flow Resistance method may only be used on systems that do not have multiple branches in the ventilation air duct system.

804.1 Air flows into grilles

804.1.1 Powered Flow Hood

A powered flow hood consists of:

- A flow capture device that is to be placed over the grille to be measured. The flow capture element needs to be large enough to cover the whole grille and be airtight.
- A pressure measuring system inside the flow capture element that is designed and installed to measure the static pressure inside the flow capture element.
- A manometer to measure the pressure difference between inside the flow capture element and the room.
- An air flow meter to measure the air flow through the air flow capture element. The air flow meter shall measure airflow with an accuracy of +/- 5%.
- A variable-speed fan to move air through the flow capture element and the flow meter.

1. Place the flow capture element over the grille to be measured.
2. Turn on the air flow assisting fan and adjust the airflow until zero pressure difference is measured between the flow capture element and the room.
3. Record the air flow through the air flow meter.

804.1.2 Air Flow Resistance

The Air Flow Resistance method measures the pressure difference across a flow capture element with a known air flow resistance. A rectangular user fabricated box can be used if the size of the hole is not greater than half the size of the box in each direction and the distance from the hole to the grill is at least as large as the larger dimension of the hole.

1. Place the flow capture element over the grille to be measured. Ensure there is air tight seal around the grille and the flow device so that all of the air entering the grill goes through the device.
2. Measure the pressure difference (ΔP) between the flow capture element and the room at a corner of the inlet side of the box. The hole in the flow capture device should be sized so that the pressure difference is between 1 and 5 Pa.
3. Calculate the air flow using the manufacturer's calibration of the air flow resistance device.

For user fabricated devices that do not have a manufacturer's calibration, the following equations may be used to calculate the air flow.

Air Flow (cfm) = Open Area$\times 1.07 \times (\Delta P)^{0.5}$; for Area in in^2, ΔP in Pa
Air Flow (L/s) = Open Area$\times 0.078 \times (\Delta P)^{0.5}$; for Area in cm^2, ΔP in Pa

804.2 Air flows out of grilles

804.2.1 Powered flow hood

The measurement procedure is the same as for air flow into grilles (Section 804.1.1) but with the fan and flowmeter arranged to have flow out of the grille.

804.2.2 Bag Inflation

The Bag Inflation method requires the use of a bag of a known volume, a method to hold the bag open (typically a lightweight frame of wood, plastic or metal wire), a shutter to start the air flow and a stopwatch.

1. Completely empty the bag of air and place a shutter over its opening.
2. Rapidly withdraw the shutter and start the stopwatch.
3. When the bag is completely full stop the stopwatch.
4. Calculate the airflow by dividing the bag volume by the elapsed time. Calculate the air flow in cfm as 8 X bag volume in gallons/number of seconds
5. Repeat measurement one or more times and average the results.

804.2.2.1 How to choose a bag

Plastic thickness. Bags made from thinner material often do not fill uniformly because the air flow from the register blows them about too much. If the bag sides flap a lot and measuring the same register twice gives results that differ by more than 20%, then try a bag with thicker material.

Use the right sized bags. Bags that fill in under two seconds will have increased errors because of resolution issues in timing how fast the bag is filled. Conversely, bags that are too large for a given register flow will have increased leakage around the edges of the bag before it fills completely and may not generate enough pressure to push a bag into its final shape. Aim for a fill time of 2 to 20 seconds.

803.8 Equipment Accuracy Requirements and Specification

The manometer shall measure pressure differences with a resolution of 0.1 Pa and have an accuracy of +/-1% of the reading or 0.5 Pa, whichever is greater.

User fabricated air flow resistance and bag filling devices have an uncertainty of +/- 10%.

Background/Rationale:

This proposed amendment is necessary to improve the accuracy of the testing procedures for building infiltration and duct leakage, and to provide standardized methods for measuring ventilation airflows which are a requirement under the new version of ENERGY STAR.

Attachment A