

## **RESNET Interim Guidelines for Combustion Appliance Testing and Writing Work Scope**

September 1, 2010

These interim guidelines are provided for RESNET Building Performance Auditors (BPAs) or Comprehensive HERS Raters (CHERS Raters) who have been trained by a RESNET-accredited Training Provider on these protocols. These guidelines shall be followed by RESNET-accredited Raters and Auditors (hereinafter referred to collectively as "Auditors") performing combustion appliance testing or writing work scopes for repairs. If the Auditor has been trained and certified in accordance with a RESNET approved "equivalent home performance certification program" or the Building Performance Institute (BPI) Standards, the Auditor may follow protocols in accordance with those equivalent standards.

RESNET-accredited Training Providers shall train HERS Auditors on these protocols through either field exercise or through simulated conditions. A written exam administered by a RESNET-accredited Trainer is also required, provided by RESNET. The test shall cover the content of these guidelines with a minimum of 25 questions. A minimum score of 80% is required to pass.

Prior to conducting any test that affects the operating pressures in the home, the Auditor shall inquire whether a person that has environmental sensitivities (asthma, allergies, chemical sensitivity, etc.) is present in the home. If such a person is present, the Auditor shall not perform such tests without written disclosure from the affected party (or responsible adult). The written disclosure shall state (at a minimum) that "during the period of testing, some amount of dust, particles, or soil gases already present in the home may become airborne." Without a signed disclosure, the Auditor shall either reschedule the test for a time when they will not be present, or ask them to leave the home during the testing process. The Auditor shall also inquire as to the presence of pets that may potentially be affected by testing procedures.

### **Gas Leakage Testing**

If there is a noticeable odor indicating gas buildup within the home, the occupants and Auditor shall leave the house and the appropriate authorities and utility providers shall be notified from outside the home. The Auditor should use a gas detector upon entry into the home to detect the presence of natural gas. If gas is suspected or confirmed, ensure that switches are not operated while exiting and no ignition concerns are present. The audit shall not proceed until the proper authorities have deemed it safe to re-enter the home.

If there is no noticeable odor indicating gas buildup within the home, the Auditor shall determine if there are gas leaks in the fittings and connections of natural gas appliances within the home and natural gas/liquid propane supply lines following these protocols.

Equipment needed:

- Combustible gas detector capable of measuring 20 ppm
- Leak detection fluid (non-corrosive)

Inspect all fittings and joints in supply lines and appliance connectors and confirm suspected leaks with leak-detection fluid. Identify for repair or replacement any kinked, corroded or visibly worn flexible gas lines and any flexible connectors manufactured prior to 1974.

### **Worst Case Depressurization Test**

This test procedure measures the pressure in the Combustion Appliance Zone (CAZ) and provides visual evidence of spillage potential.

If there are any vented combustion appliances that use indoor air to vent combustion gases and which are not classified as a category 3 or 4 according to NFPA standard 54, then a worst case depressurization test shall be performed using the following protocol.

- 1.1. Check the combustion appliance zone for the presence of flammable or explosive material near a combustion source.
- 1.2. Visually inspect venting system for proper size and horizontal pitch and determine there is no blockage or restriction, leakage, corrosion or other deficiencies that could cause an unsafe condition.
  - 1.2.1. Inspect burners and crossovers for blockage and corrosion.
  - 1.2.2. Inspect furnace heat exchangers for cracks, openings or excessive corrosion.
- 1.3. Close all the exterior doors and windows of the home.
- 1.4. Close fireplace damper(s) if fireplace is present.
- 1.5. Close any interior doors between the CAZ and the remainder of the house, ensuring that all vented appliances and exhaust fans have been turned off.
- 1.6. Measure the baseline pressure difference between the CAZ with respect to (WRT) outside (ambient) and baseline CO levels. Set the gauge to read pressure and record the baseline pressure.
- 1.7. Turn on all exhaust fans in the home (kitchen range hood, bath exhaust, clothes dryer, etc.) that exhaust air outside the building envelope.
- 1.8. Record pressure in CAZ with respect to Outside.
- 1.9. Turn on the air handler. Record pressure in CAZ with respect to outside. If air handler makes the CAZ more positive (or less negative), turn it off. If the air handler is kept on, close interior doors to any rooms that have no return registers.
- 1.10. If fireplace is present install blower door and set to exhaust 300 CFM to simulate fireplace in operation.

- 1.11. Record net change in pressure difference within the CAZ WRT outside between baseline and worst case depressurization conditions. Record the position of doors and conditions of fans and air handler. When the net change in CAZ pressure is lower (more negative) than the limits specified below, the work scope shall specify remediation through pressure balancing, duct sealing, and/or other pressure-relief measures, as applicable.
- 1.12. Turn on vented combustion appliance with the smallest Btu capacity. Operate appliance for 5 minutes then measure CO levels according to the carbon monoxide test procedure below, and check appliance draft using a smoke pencil at the draft diverter. If the smoke is not fully drawn up the flue, the appliance has spillage under worst case depressurization. Record if there is any spillage and record CO levels. When spillage occurs or CO exceeds the limits specified below in section 9, the work scope shall specify remediation, including equipment repair or replacement, and/or building pressure remediation, as applicable. If both spillage and high CO are found during the test, the homeowner should be notified of the conditions and that it needs immediate remediation.
- 1.13. Turn on all the other combustion appliances, one at a time, within the CAZ and repeat step 1.12 on each of them.
- 1.14. If spillage or high CO occurs in any appliance(s) under worst case depressurization, retest that appliance(s) under natural conditions.
  - 1.14.1. Turn off the combustion appliances.
  - 1.14.2. Turn off the exhaust fans.
  - 1.14.3. Open the interior doors.
  - 1.14.4. Let the vent cool.
  - 1.14.5. Test CO and spillage under natural conditions. If the test failed under worst-case, but passes under natural conditions, the work scope shall specify building pressure remediation, as applicable.
  - 1.14.6. If an appliance fails under natural conditions, the RAuditor shall inform the homeowner of the problem, and the work scope shall specify remediation, including equipment or vent system repair or replacement, as applicable.

CAZ Pressure Limits:

- -15 Pa for pellet stoves with exhaust fans and sealed vents
- -5 Pa for Atmospheric vented oil or gas system (classified as a category 1 or 2 according to NFPA standard 54, such as oil power burner; fan-assisted or induced-draft gas; solid-fuel-burning appliance other than pellet stoves with exhaust fans and sealed vents)

If ambient CO levels exceed 35 ppm at any time, stop any testing and turn the combustion appliances off. Open all the exterior doors and windows. No one should enter the home until the CO levels drop below 35 ppm. The combustion appliance causing the increase in CO levels must be repaired by a qualified

technician prior to completing the combustion appliance tests, unless the work scope calls for replacement of the appliance(s).

### **Carbon Monoxide Testing**

Test all spaces (including attached garages, crawlspaces, basements) containing combustion appliances for carbon monoxide using the following protocols.

1. CO testing of ambient air shall be performed continuously while performing a Worst Case Depressurization Test and/or under natural conditions, as required by paragraph 1.14.
2. Equipment used shall:
  - Be capable of measuring carbon monoxide (CO) levels from 0 to 2,000 ppm (parts per million)
  - Have a resolution of 1 ppm
  - Have an accuracy rate of  $\pm 5$  ppm
  - Be calibrated annually by the manufacturer (or using manufacturer's instructions) and evidence of the calibration shall be submitted to the Rating Provider Quality Assurance Designee
4. Zero the carbon monoxide meter outside the building away from any combustion outlets or automobile traffic areas.
5. Take a measurement of CO levels within the home upon entering to establish a baseline. Do not measure near combustion appliances while they are operating.  
If ambient CO levels are higher than 35 ppm during normal appliance operation, turn off the appliance, ventilate the space, and evacuate the building. The building may be reentered once ambient CO levels have gone below 35 ppm.
6. For atmospherically-vented appliances:
  - 6.1. Take a measurement of vent gases upstream of (before they reach) the draft diverter.
  - 6.2. Appliance must operate for at least 5 minutes before taking sample.
  - 6.3. Take sample during worst-case depressurization test and/or under natural conditions, as required by paragraph 1.14. Record the CO level.
7. For direct- or power-vented appliances:
  - 7.1. Sample must be taken at vent termination.
  - 7.2. Appliance must operate for at least 5 minutes before taking sample.
  - 7.3. Take sample during worst-case depressurization test and/or under natural conditions, as required by paragraph 1.14. Record the CO level.
8. For LP- or natural gas ovens:
  - 8.1. Open a window or door to the outside.
  - 8.2. Remove any foil or cooking utensils within the oven.
  - 8.3. Verify that the oven is not in self-cleaning mode.

- 8.4. Turn oven on to highest temperature setting.
- 8.5. Close the oven door and begin monitoring the CO levels in the kitchen, 5 feet from the oven at countertop height. Record CO levels.
- 8.6. Measure the CO levels within the oven vent.
  - 8.6.1. Samples must be taken while burner is firing.
  - 8.6.2. Operate burner for at least 5 minutes while sampling flue gases.
  - 8.6.3. If CO levels are higher than 100 ppm, repeat the flue gas sampling until the CO levels stop falling.
  - 8.6.4. Record the steady state CO reading in ppm and turn off oven.

9. If measured CO levels are higher than 100 ppm (200 for oven), or an appliance fails to meet manufacturer's specifications for CO production (whichever is higher), the work scope shall specify replacement or repair of the appliance, and the homeowner shall be notified of the need for service by a qualified technician.

10. If ambient CO levels exceed 35 ppm at any time, stop any testing and turn the combustion appliances off. Open all the exterior doors and windows. No one should enter the home until the CO levels drop below 35 ppm. The combustion appliance causing the increase in CO levels must be repaired by a qualified technician prior to completing the combustion appliance tests, unless the work scope calls for replacement of the appliance(s).

## **Work Scope for contractors**

All work must meet applicable codes and regulations for the jurisdiction.

When air sealing is being performed the work scope shall specify CAZ depressurization testing to be performed at the end of each workday.

The work scope for recommended improvements will be determined by the Auditor and shall be based upon the findings of the assessment, the client's needs and budget, and priorities identified during combustion appliance testing, subject to health and safety requirements.

The work scope shall clearly identify for the client any remedial actions which require prompt attention, affect safety, or require a licensed trade.

The work scope shall provide sufficient specification that the client may obtain reasonably comparable bids from alternative sources for making recommended improvements.

All scopes of work shall include this statement: **"The estimated energy use and savings information contained in the audit report does not constitute a guarantee or warranty of actual energy cost or usage."**

The work scope shall be developed based on the RAuditor's diagnosis and analysis. Emphasis shall be on:

- bringing air distribution system components inside the building enclosure when it is feasible, or sealing and insulating ducts when it is not
- improving airflow and total HVAC system efficiency as applicable
- upgrades to the building enclosure as applicable
- improvements to lighting and appliances as applicable

The scopes shall reflect the "house as a system" approach, recognizing measure interaction. The following statement shall be included whenever a fireplace or combustion appliance is located within the building enclosure:

"This work scope is not a list of recommendations that may be implemented independently; any exclusions or variations to this scope may increase the risk of flue gas spillage, back-drafting, carbon monoxide production and/or moisture problems within the home."

When specifying equipment replacement, new equipment sizing shall be based on the proposed, upgraded condition of the building enclosure and duct system.

The work scope shall call for post-work combustion appliance testing in accordance with these guidelines when any work affecting enclosure or duct tightness, or building pressures, is specified.

### **Work Scope: Carbon Monoxide**

The source of the CO must be repaired or replaced and the problem corrected prior to commencing work on other tasks on the work scope, unless remediation of the CO production is specifically related to one or more of those tasks (such as duct repairs that will correct a large negative pressure in the CAZ).

If there are combustion appliances within the building envelope, a carbon monoxide detector should be specified in the main area of each floor according to manufacturer's recommendations, typically in the hallway outside each bedroom area.

If measured CO levels are higher than 100 ppm (200 for oven), or an appliance fails to meet manufacturer's specifications for CO production (whichever is higher), the work scope shall specify replacement or repair of the appliance, and the homeowner shall be notified of the need for service by a qualified technician.

### **Work Scope: Worst Case Depressurization**

If the results of the Worst Case Depressurization Test indicate the potential for backdrafting by failing the CAZ pressure limits or spillage test, remediation of the failure must be addressed in the work scope, through one or more of the following (as applicable): targeted air- and duct-sealing, room pressure balancing, exhaust fan makeup air, or appliance replacement (with power- or direct-vented equipment). As an alternative, the combustion appliance zone may be isolated by creating a

sealed combustion closet containing the combustion appliances that has the proper amount of combustion air supplied to it according to the applicable version of the IRC. Adequate sealing for isolation purposes shall include air sealing and duct sealing (especially of adjacent platform or cavity return ducts) and confirmed by another CAZ depressurization test.

The work scope should specify replacement of atmospheric-vented combustion appliances with high-efficiency sealed combustion, direct vent, or power vented appliances when feasible.

If the home has unvented combustion appliances, the Auditor shall recommend they be disconnected and replaced with vented combustion appliances.

If unvented combustion appliances are not removed or replaced with vented combustion appliances or electric appliances, the work scope shall not specify measures that affect the air tightness of the envelope, including air sealing, duct sealing, sidewall insulation, or window replacements. Duct sealing outside the thermal envelope may be specified in IECC climate zones 1-3.

## Auditor Referenced Standards

These referenced standards provide guidance for the Auditor in the performance of their role as an auditor or home energy rater (diagnostic testing, analysis, writing scopes of work).

1. 2006 Mortgage Industry National Home Energy Rating Systems Standards, published by the Residential Energy Services Network, latest version, [www.resnet.us](http://www.resnet.us)
2. ASHRAE/ANSI Standard 119-1998 RA-2004 Air Leakage Performance for Detached Single-Family Residential Buildings, published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., [www.ashrae.org](http://www.ashrae.org)
3. ASHRAE/ANSI Standard 152-2004 Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems, published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., [www.ashrae.org](http://www.ashrae.org)
4. ASTM E1998-02(2007) "Standard Guide for Assessing Depressurization-Induced Backdrafting and Spillage from Vented Combustion Appliances", published by ASTM International, [www.astm.org](http://www.astm.org)
5. ASTM E1827-96(2007) "Standard Test Methods for Determining Airtightness of Buildings Using an Orifice Blower Door", published by ASTM International, [www.astm.org](http://www.astm.org)
6. ASTM E1554-07 "Standard Test Methods for Determining Air Leakage of Air Distribution Systems by Fan Pressurization", published by ASTM International, [www.astm.org](http://www.astm.org)
7. Reflective Insulation, Radiant Barriers and Radiation Control Coatings, published by the Reflective Insulation Manufacturers Association- International, [www.rimainternational.org](http://www.rimainternational.org)

8. Protocols for Verifying HVAC Systems to the ACCA Quality Installation Standard, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org) (currently in draft)
9. Verifying ACCA Manual J® Procedures, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
10. Verifying ACCA Manual S® Procedures, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
11. Verifying ACCA Manual D® Procedures, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
12. NAIMA Fibrous Glass Duct Installation Check List, published by the North American Insulation Manufacturers Association, [www.naima.org](http://www.naima.org)
13. AHRI Certification Directory, published by the Air-conditioning, Heating and Refrigeration Institute, [www.ahrirectory.org](http://www.ahrirectory.org)

## **Contractor Work Scope Referenced Standards**

These referenced standards should be referenced in the work scope, as applicable to provide guidance for the contractor to perform the work scope.

1. International Residential Code for One- and Two-Family Dwellings- 2006, published by the International Code Council, Inc., [www.iccsafe.org](http://www.iccsafe.org)
2. International Energy Conservation Code- 2006, published by the International Code Council, Inc., [www.iccsafe.org](http://www.iccsafe.org)
3. International Mechanical Code- 2006, published by the International Code Council, Inc., [www.iccsafe.org](http://www.iccsafe.org)
4. International Fuel Gas Code- 2006, published by the International Code Council, Inc., [www.iccsafe.org](http://www.iccsafe.org)
5. ANSI/ACCA Standard 5 QI-2007 HVAC Quality Installation Specification, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
6. Manual J, Residential Load Calculation, 8<sup>th</sup> edition, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
7. Manual D, Residential Duct Systems, 3<sup>rd</sup> edition, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
8. Manual S, Residential Equipment Selection, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
9. Manual RS, Comfort, Air Quality, & Efficiency by Design, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
10. Manual T, Air Distribution Basics, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
11. Manual H, Heat Pump Systems, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
12. Manual G, Selection of Distribution Systems, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
13. ASHRAE Standard 62.2 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., [www.ashrae.org](http://www.ashrae.org)



14. ASHRAE Standard 52.2 Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size, published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., [www.ashrae.org](http://www.ashrae.org)
15. ASTM Standard C1015-06 "Standard Practice for Installation of Cellulosic and Mineral Fiber Loose-Fill Thermal Insulation", published by ASTM International, [www.astm.org](http://www.astm.org)
16. ASTM Standard C1320-05 "Standard Practice for Installation of Mineral Fiber Batt and Blanket Thermal Insulation for Light Frame Construction", published by ASTM International, [www.astm.org](http://www.astm.org)
17. ASTM Standard C727-01 (2007)e1 "Standard Practice for Installation and Use of Reflective Insulation in Building Constructions", published by ASTM International, [www.astm.org](http://www.astm.org)
18. ASTM Standard C1158-05 "Standard Practice for Installation and Use of Radiant Barrier Systems in Building Constructions", published by ASTM International, [www.astm.org](http://www.astm.org)
19. ASTM Standard E2112-07 "Standard Practice for Installation of Exterior Windows, Doors and Skylights", published by ASTM International, [www.astm.org](http://www.astm.org)
20. Flexible Duct Performance and Installation Standards 4<sup>th</sup> edition, published by the Air Diffusion Council, [www.flexibleduct.org](http://www.flexibleduct.org)
21. Fibrous Glass Duct Construction Standards, 5<sup>th</sup> edition, published by the North American Insulation Manufacturers Association, [www.naima.org](http://www.naima.org)
22. FTC Trade Regulation Rule 16 CFR 460, Labeling and Advertising of Home Insulation, published by the Federal Trade Commission, [www.ftc.gov](http://www.ftc.gov)

## Sample Work Scope Form

(This is informative and does not contain requirements necessary for conformance to these guidelines.)

### Work Scope for \_\_\_\_\_

#### All work will be performed according the following checked standards

This work scope is not a list of recommendations that may be implemented independently; any exclusions to this scope may increase the risk of flue gas spillage, back-drafting, carbon monoxide production or moisture problems within the home.

#### Standards

- International Residential Code for One- and Two-Family Dwellings- 2003, published by the International Code Council, Inc., [www.iccsafe.org](http://www.iccsafe.org)
- International Energy Conservation Code- 2006, published by the International Code Council, Inc., [www.iccsafe.org](http://www.iccsafe.org)
- International Mechanical Code- 2003, published by the International Code Council, Inc., [www.iccsafe.org](http://www.iccsafe.org)
- International Fuel Gas Code- 2003, published by the International Code Council, Inc., [www.iccsafe.org](http://www.iccsafe.org)
- ANSI/ACCA Standard 5 QI-2007 HVAC Quality Installation Specification, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
- Manual J, Residential Load Calculation, 8th edition, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
- Manual D, Residential Duct Systems, 3rd edition, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
- Manual S, Residential Equipment Selection, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
- Manual RS, Comfort, Air Quality, & Efficiency by Design, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
- Manual T, Air Distribution Basics, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
- Manual H, Heat Pump Systems, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
- Manual G, Selection of Distribution Systems, published by the Air Conditioning Contractors of America, [www.acca.org](http://www.acca.org)
- ASHRAE Standard 62.2 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., [www.ashrae.org](http://www.ashrae.org)
- ASHRAE Standard 52.2, published by the American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc., [www.ashrae.org](http://www.ashrae.org)
- ASTM Standard C1015-06 "Standard Practice for Installation of Cellulosic and Mineral Fiber Loose-Fill Thermal Insulation", published by ASTM International, [www.astm.org](http://www.astm.org)
- ASTM Standard C1320-05 "Standard Practice for Installation of Mineral Fiber Batt and Blanket Thermal Insulation for Light Frame Construction", published by ASTM International, [www.astm.org](http://www.astm.org)
- ASTM Standard C727-01 (2007)e1 "Standard Practice for Installation and Use of Reflective Insulation in Building Constructions", published by ASTM International, [www.astm.org](http://www.astm.org)
- ASTM Standard C1158-05 "Standard Practice for Installation and Use of Radiant Barrier Systems in Building Constructions", published by ASTM International, [www.astm.org](http://www.astm.org)
- ASTM Standard E2112-07 "Standard Practice for Installation of Exterior Windows, Doors and Skylights", published by ASTM International, [www.astm.org](http://www.astm.org)

- Flexible Duct Performance and Installation Standards 4th edition, published by the Air Diffusion Council, [www.flexibleduct.org](http://www.flexibleduct.org)
- Fibrous Glass Duct Construction Standards, 5th edition, published by the North American Insulation Manufacturers Association, [www.naima.org](http://www.naima.org)
- FTC Trade Regulation Rule 16 CFR 460, Labeling and Advertising of Home Insulation, published by the Federal Trade Commission, [www.ftc.gov](http://www.ftc.gov)

**What qualifications are required from contractors/technicians conducting the work:**

**What work needs to be performed:**

**Where the work needs to be performed:**

**How the work is to be performed (referenced Standard(s)):**