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Multifamily Home Energy Retrofit Coordinating Committee

MF HERCC CAS Protocols Sub-committee

[MF HERCC COMBUSTION SAFETY TESTING PROTOCOLS]

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1 OVERVIEW

The following MF HERCC Combustion Safety Testing Protocols for Multifamily Buildings are intended to be used in conjunction with the Building Performance Institute's (BPI) Technical Standards for the Building Analyst Professional (BA). The BPI BA Standard addresses the process and procedures for how to perform Combustion Appliance Safety (CAS) testing within the context of single family home retrofit projects. While the test procedures and action levels do not differ for multifamily buildings, the wide variety of building types, system types, sizes, and configurations of multifamily properties complicate the *process* of performing the tests, and therefore necessitate some clarifications to the standards. Therefore, these protocols are intended to provide clarity in how to apply the BPI Test Procedures in multifamily building projects and primarily focus on addressing the following:

- Defining all aspects of the sampling process
- Clarifying when and how to apply the standard to new construction projects
- Clarifying which failures trigger which actions
- Defining limitations and exclusions to testing
- Clarifying range and oven testing requirements
- Defining pressure dynamics

1.1 COMBUSTION APPLIANCE SAFETY TESTS (CAS)

CAS testing consists of visual inspections, gas leak detection, ambient CO measurement, flue CO measurement, and spillage test.

1.2 PRESSURE DYNAMICS

Pressure dynamics can be defined as any changes in air pressure that could have an impact on combustion appliance safety, air leakage through the shell, or moisture migration through building cavities.

1.2.1 **Determination of Changes to Pressure Dynamics**: The BPI Professional shall evaluate and determine whether the scope of work will affect the pressure dynamics within individual combustion appliance zones.

1.3 SAMPLING

With large numbers of units or spaces with similar equipment, sampling can be used to identify CAS issues on test-in, and only in the case of new construction projects, on test out. The BPI Professional must define their Sample Groups, and then determine the Sample Rate (total number of units/spaces to be tested within each Sample Group).

1.3.1 **Sample Group:** Sample groups should be comprised of a representative sample of units or spaces that contain the same type of combustion equipment (wall furnaces, forced air furnaces, natural draft water heaters etc.).

For example, in a 100 unit building containing 50 units that have 2 wall furnaces in each, and 50 units that have 1 wall furnace in each, the BPI

Professional would create **1** Sample Group. All combustion equipment is of the same type. The number of combustion appliances in the units does not affect the number of sample groups.

If in that same 100 unit building 50 units had wall furnaces, and 50 units had natural draft ducted FAU's the BPI Professional would create **2** Sample Groups comprised of 50 units each.

1.3.2 **Sample Rate:** For the purposes of this protocol, Sample Rate is defined as the number of apartments or spaces within a Sample Group containing Combustion Appliance Zones (CAZ) that are required to be tested.

Table 1- Sampling Rate

Sample Group Size	Number of Spaces to Sample	
(total number of spaces)	**Minimum**	**Recommended**
5 – 9	2	3
10 – 19	3	5
20 – 29	4	7
30 – 49	5	9
50 – 74	6	11
75 – 99	7	13
100 – 149	8	16
150 – 200	9	20
>200	10	25

1.3.3 **Dwelling Units**: The number of dwelling units within each sample group that must be tested shall be determined using *Table 1 -Sampling Rate*[1] above.

1.3.4 **Central Mechanical Rooms:** The number of similar central mechanical rooms that must be tested shall be determined using the **Table 1 - Sample Rate** above.

[1] The sampling protocols outlined within this document align with Technical Guidelines for Multifamily Building Energy Audits pending publication. MacDonald, Michael; Mini Malhotra; and Mark Ternes. *"Technical Guidelines for Multifamily Building Energy Audits." ORNL/TM-2014/0297 (DRAFT). Oak Ridge National Laboratory. April 2014 (Draft).*

Apartment Sampling Example:

- *100 unit multifamily building with the same combustion equipment in all units.*
  - *(20) studio apts*
  - *(40) 1-bedroom apts*
  - *(40) 2-bedroom apts*
- *Number of Sample Groups: 1 (because all combustion equipment is the same)*
- *Number of units in Sample Group = 100.*
- *Sample Rate (number of units to be tested): minimum of 8 units, recommended 16 units (see Table 1).*
- *Representative Sample: The sample group must contain studio, 1 bedroom, and 2 bedroom apts which are located in various parts of the building.*
- *A minimum sample set for this example would consist of:*
  - *(2) studio apts*
  - *(3) 1-bedroom apts*
  - *(3) 2-bedroom apts*

1.4 FAILURE

For the purposes of this protocol the following CAS issues are considered "failures".

- All CAS issues that are characterized by the BPI Gold Sheet as "Stop Work" or "Emergency" conditions
- Ovens with CO levels greater than 300 ppm
- Gas leaks
- Combustion Ventilation Issues (see Appendix B)
- Visual inspection failures – If the BPI Professional observes installation conditions that do not meet the manufactures requirements and/or pose a health and safety risk. Some examples may include:
  - Improper flue/vent material or installation quality (disconnections, improper pitch, etc.)
  - Proximity of flue/vent to combustible materials
  - Visible signs of spillage
  - Visible combustion ventilation air blockages or deficiencies

When Failures are identified the BPI Professional shall:

1.4.1 Notify the property owner, manager, or their authorized agent.

1.4.1.1 It is advisable for the BPI Professional to obtain signed documentation from the authorized agent indicating acknowledgement of the combustion safety issues while on site.

1.4.2 Provide recommendations in the scope of work that the owner have all failed equipment repaired prior to project completion. All equipment that failed at test-in will undergo test-out upon project completion.

1.4.3 Include specific recommendations for how to address each issue.

1.5 SYSTEMIC FAILURE

If during the initial CAS test-in failures occur in 50% or more of the sample set the sample size (both minimum and recommended) shall be doubled. If failures occur in 50% or more of the new *increased* sample size then it is deemed a "Systemic Failure". The BPI Professional may choose to make the Systemic Failure determination after the initial sample group has been tested if they have reason to believe that the failure conditions that they have identified are likely to be repetitive throughout the property.

When Systemic Failures are identified the BPI Professional shall:

1.5.1 Notify the property owner, manager, or their authorized agent.

1.5.1.1 It is advisable for the BPI Professional to obtain signed documentation from the authorized agent indicating acknowledgement of the combustion safety issues while on site.

1.5.2 Provide recommendations in the scope of work that the owner have all remaining units repaired prior to project completion and 100% test-out.

1.5.3 Include specific recommendations for how to address each issue.

1.5.4 Perform 100% CAS test-out of all units and spaces, regardless of whether they were affected by the scope of work upon project completion.

SYSTEMIC FAILURE EXAMPLE:	ACTIONS: BPI Professional shall:
• 55 unit multifamily building with the same type of combustion appliances in all units (1 Sample Group). • As per *Table 1 - Sample Rate*, sample size = min of 6 units • 1 unit has a gas leak • 1 unit fails spillage under natural conditions • 1 unit fails oven CO test at 350 ppm **50% of the sampled units failed CAS testing; therefore, the sample size is doubled from a total of 6 units (minimum) to a total of 12 units (minimum).** • Gas leaks are identified in 2 more of the units, and high CO (400 ppm) is found in the oven of the third unit. **3 or more <u>additional</u> units fail CAS tests (total of 6 out of the 12 units failed); therefore, a Systemic Failure has been identified.**	1. Communicate the spillage test and gas leak failures to the property owner, manager, or their authorized agent. 2. Request that the owner or authorized agent sign an acknowledgement form that indicates that they have been informed of the gas leaks and spillage failures and of their exact locations. 3. Include recommendations in the scope of work that the owner have all remaining units tested and repaired prior to project completion. 4. Include specific recommendation in the scope of work for how to address the spillage issue and the oven CO issues in the affected units. 5. Perform 100% CAS test-out of all units at project completion.

2 ACTIONS LEVELS

2.1 BPI COMBUSTION SAFETY TEST ACTION LEVELS

Refer to the BPI Gold sheet in **Appendix A** of this document for the Combustion Safety Test Procedure for Vented Appliances and for Combustion Safety Action Levels.

2.1.1 **Recommend Repairs:** When test results reveal conditions that are identified by the BPI Gold Sheet as "Recommend service call" or "Recommend that CO Problems be fixed" actions, the BPI Professional shall include specific recommendations for how to address the recommended repairs in their scope of work.

2.1.2 **Stop Work:** When test results reveal conditions that are identified by the BPI Gold Sheet as "Stop Work" actions, the BPI Professional shall immediately notify the building owner, manager, or their authorized agent of the condition, advise them to have the condition repaired immediately. It is advisable for the BPI Professional to obtain signed documentation from the authorized agent indicating acknowledgement of the combustion safety issues.

2.1.3 **Emergency:** When test results reveal conditions that are identified by the BPI Gold Sheet as "Emergency" actions, the BPI Professional shall have the building representative shut off fuel to the appliance and call for service immediately. It is advisable for the BPI Professional to obtain signed documentation from the authorized agent indicating acknowledgement of the combustion safety issues.

2.2 GAS LEAK ACTIONS (CENTRAL EQUIPMENT & DWELLING UNITS)

The BPI Professional shall test for gas leaks at all equipment located within the building enclosure on a sample basis based on *Table 1 - Sample Rate*. Gas line testing shall be performed within the combustion appliance zone in the dwelling unit, the mechanical room, or at the central appliance. Gas line testing is <u>not</u> required at the meter or from the meter to the appliance.

2.2.1 **Local Utility Rules:** Local rebate programs and/or utilities may have additional requirements or procedures for the testing for and reporting of gas leaks. The BPI professional should be familiar with local requirements and adhere to them accordingly. The BPI Professional shall refer to the local utility having jurisdiction for definitions of minor and significant gas leaks. In the absence of such a definition, the BPI Professional shall default to the actions for significant gas leaks outlined in 2.2.3 below.

2.2.2 **Minor Gas Leak:** When a **minor** gas leak (as defined by the local utility) is detected, the BPI Professional shall:

2.2.2.1 Report the gas leak to building owner, manager, or their authorized agent and document the requirement to fix the issue

2.2.2.2 Tag the leak, or include an image of the leak location in the report to the owner

2.2.3 **Significant Gas Leak:** When a **significant** gas leak (as defined by local utility) is detected, the BPI Professional shall:

2.2.3.1 Report the gas leak to building owner, manager, or their authorized agent

2.2.3.2 Have a building representative shut off fuel to the appliance, call for service immediately.

2.2.4 **Correction of Gas Leaks:** If a licensed contractor performs repairs, provides documentation photos, and certifies that leaks have been fixed (see Appendix C for example form), no further verification from the auditor is required.

2.3 RANGE AND OVEN ACTIONS

2.3.1 **100-300 ppm:** For ovens found to be generating 100-300 ppm CO after reaching steady state, the BPI Professional shall recommend cleaning. No test out is required.

2.3.2 **>300 ppm:** For ovens found to be generating over 300 ppm CO after reaching steady state, the BPI Professional shall require cleaning and tuning or appliance replacement. Test out is required unless the building replaces the appliance in question. If greater than 300 ppm after servicing, exhaust ventilation must be provided with a capacity of 25 CFM continuous or 100 CFM intermittent.

2.3.3 **Range & Oven Cleaning:** For all projects, regardless of test results, it is advised the BPI Professional recommend cleaning of ranges and ovens on an annual basis.

2.3.4 **CO Alarms:** CO alarms must be installed in all apartments where gas appliances are located in accordance with California Building Code. The alarms must comply with either UL 2034 or UL 2075 standards and meet the standards adopted by California State Fire Marshall, which requires Carbon Monoxide Alarms in all dwelling units.

2.4 LIMITATIONS AND EXCLUSIONS

2.4.1 **Accessible Areas:** Accessible areas are defined as those areas which are accessible via permanent access systems such roof hatches with permanent ladders or stairways, or via a standard A frame 6’ step ladder (such as most attics).

2.4.2 **Inaccessible Areas:** Inaccessible areas are defined as those areas which require the use of a portable ladder greater than 6' in height, or are located on pitched roofs.

2.4.3 **Inaccessible Terminations:** CO testing of appliances which can only be tested at flues that terminate on or through a roof, or are not accessible without a 6' step ladder, is not required.

2.4.4 **Category III and Category IV Vented Appliances[2]:** Vent CO measurements and spillage testing of Category III and Category IV appliances (those that have positively pressurized vent systems), and any direct vent sealed combustion appliances is not required.

2.4.5 **Drilling of B-Vent:** Vent CO measurements of appliances with B-Vent type venting material shall be conducted to the best of the professional's ability without drilling a new hole into the B-vent. If the appliance does not have a draft hood or barometric draft that would allow for the insertion of a probe, a vent CO measurement is not required

2.4.6 **Access to Dwelling Units:** The BPI Professional must make every reasonable effort to have the building owner, manager, or their authorized agent provide access to all of the dwelling units and mechanical rooms that require testing.

2.4.6.1 The BPI Professional must access and test at least 90% of all dwelling units that require testing and repetitious mechanical rooms that require testing in order for the test-out to be deemed complete.

2.4.7 **Access to Equipment:** The BPI Professional must make every reasonable effort to have the building owner, manager, or their authorized agent provide access to all appliances requiring testing. However, the BPI Professional is not responsible for moving heavy furniture or other impediments to access appliances

2.4.8 **Outdoor Equipment:** Combustion equipment located completely outside of the building enclosure and are not affected by pressure dynamics within the building shall only be required to undergo gas line testing.

2.4.9 **New Ranges & Ovens:** Ranges and Ovens that have been newly installed as part of the scope of work do not need to be tested

[2] ANSI Z223.1 NFPA- National Fuel Gas Code, 2012 Edition

3 NEW CONSTRUCTION

The BPI standards, and this protocol, were developed to address Existing Building projects. However, portions of these protocols can and should also be applied when working on new construction projects.

3.1 TEST-IN

Test-in is not applicable for new construction projects.

3.2 TEST-OUT

Upon project completion, if natural draft Category I appliances equipped with a draft hood or barometric draft control and connected to a natural draft venting system have been installed within the building enclosure, a sample test out shall be performed in accordance with *Table 1 - Sample Rate*. This applies to both in-unit equipment and central equipment.

3.2.1 **Outdoor Equipment:** Appliances that are completely outside of the building enclosure and are not affected by pressure dynamics within the building are not required to be tested.

3.2.2 **Failures:** All failures must be repaired and resolved prior to occupancy. If the test-out process reveals a Systemic Failure (as defined in Section 1.4), the BPI Professional shall follow the Systemic Failure procedures outlined in Section 1.4.

3.2.3 **Range & Oven Testing:** Current California Building Code requires that all new buildings with gas ranges and ovens be equipped with ducted range hoods. Additionally, all ranges and ovens in new construction projects will presumably be new appliances, therefore range and oven testing is not required in new construction projects.

4 EXISTING BUILDINGS

4.1 TEST-IN

4.1.1 **Central Equipment**

4.1.1.1 **Sampling:** BPI Professional shall perform CAS testing on central mechanical equipment in accordance with *Table 1 - Sample Rate*.

4.1.1.2 **Visual Inspections:** BPI Professional shall perform visual inspection of at least 50% of <u>all</u> central equipment. This should include visual inspections for:

- Flue/chimney conditions
- signs of spillage
- appropriate CVA
- non-compliant gas lines

- presence of CO detectors in accordance with California Building Code
- other issues that can be determined visually

4.1.1.3 **Systemic Failure:** Systemic failure rules described in Section 1.4 apply to all inspected (both tested and visual) mechanical rooms.

4.1.1.4 **Combustion Ventilation Air (CVA) Requirements:** See CVA Calculation Rules in Appendix B.

4.1.2 **Dwelling Units**

4.1.2.1 **Sampling:** BPI Professional shall perform CAS testing in dwelling units according to Sampling *Table 1 - Sample Rate*.

4.1.2.2 **Systemic Failure:** Systemic failure rules described in Section 1.4 apply to all tested dwelling units.

4.1.2.3 **Combustion Ventilation Air (CVA) Requirements:** See CVA Calculation Rules in Appendix B.

4.1.3 **Central Equipment and Dwelling Units**

4.1.3.1 **Pressure Dynamics:** The BPI Professional shall review the scope of work and identify and document whether pressure dynamics within the building will be affected, and therefore whether or not combustion safety testing shall be required on the project at the completion of work.

4.1.3.2 **Reporting:** If it is determined that CAS testing is not required, the BPI Professional shall indicate in their report why the testing is not required.

4.2 TEST-OUT

4.2.1 **Central Equipment and Dwelling Units:**

4.2.1.1 All units or spaces undergoing work either on combustion appliances or on other aspects of the unit or space that may affect the pressure dynamics of that space shall undergo CAS test-out.

4.2.1.2 All units or spaces where the pressure dynamics may be affected by work in other parts of the building shall undergo CAS test-out.

4.2.1.3 For the purposes of this protocol, pressure dynamics are only relevant when dealing with natural draft or Category I appliances equipped with a draft hood or barometric draft control and connected to a natural draft venting system. Ovens and sealed combustion/direct vent

appliances are not impacted by pressure dynamics and are therefore only tested-out if issues were identified during the initial visual inspection of sealed combustion appliances and test-in of ovens.

4.2.1.4 Test-out of any failure that was identified during test-in.

4.2.1.5 100% test-out of all units and spaces is required regardless of whether they were affected by the scope of work if Systemic Failures were identified during test-in.

5 COMPLIANCE DEMONSTRATION

The BPI Professional shall provide documentation of compliance with these protocols in accordance with individual program requirements. Below is a list of data that should be collected to document compliance with this protocol.

5.1 TEST-IN DATA

- Basic building data such as total units, unit type, fuel type in building
- Test in results
- Equipment data: for the building and units
- List of sampled units and equipment
- Weather conditions during testing
- Sample plan
- Proposed CAS Test out requirements based on the proposed scope of work

5.2 TEST-OUT DATA

- Units tested, equipment tested, and test-out results
- Reason for testing each unit based on scope of work
- Basic building data such as total units, unit type, fuel type in building
- Equipment data for the building and units
- List of sampled units and equipment
- Weather conditions during testing

6 PROFESSIONAL QUALIFICATIONS

All combustion safety testing shall be done by a BPI Certified Professional where that certification includes combustion safety testing, worst case depressurization, and diagnostic pressure testing as part of the knowledge task list for that certification. Qualified certifications include Building Analyst Professional, Envelope Professional, Heating Professional, Air Conditioning/Heat Pump Professional, or future BPI Certifications that may replace or supersede the listed certifications, but include these core knowledge task list competencies.

This document focuses on the protocols for combustion safety evaluation and not on whole-building evaluation. The professional qualifications for a whole-house assessment/evaluation are described in the Professional Qualification and Training section of the Multifamily HERCC report, *Improving California's Multifamily Buildings: Opportunities and Recommendations for Green Retrofit and Rehab Programs,* to which this document is an Appendix.

APPENDIX A – BPI GOLD SHEET

COMBUSTION SAFETY TEST PROCEDURE FOR VENTED APPLIANCES

1. **Measure the Base Pressure.** Start with all exterior doors and windows closed and the fireplace damper closed. Set all combustion appliances to the pilot setting or turn off the service disconnect. Combustion appliances include: boiler, furnace, space-heaters, and water heater. With the home in this configuration, measure and record the baseline pressure of the mechanical room WRT outside.

2. **Establish the Worst Case.** Turn on the dryer and all exhaust fans. Close all interior doors that make the CAZ pressure more negative. Turn on the air handler, if present, and leave on if the pressure in the CAZ becomes more negative, then recheck the door positions. Measure the net change in pressure from the CAZ to outside, correcting for the base pressure. Record the "worst case depressurization" and compare to the CAZ Depressurization Limit Table.

3. **Measure Worst Case Spillage, Draft, CO.** Fire the appliance with the smallest Btu capacity first, test for spillage at the draft diverter with a mirror or smoke test, and test for the CO at the flue at steady-state (if steady state is not achieved within 10 minutes, take the CO readings at the 10 minute mark). If the spillage test fails under worst case, go to Step 4. If spillage ends within 1 minute, test the draft in the connector 1' - 2' after the diverter or first elbow. Fire all other connected appliances simultaneously and test the draft diverter of each appliance for spillage. Test for CO in all appliances before the draft diverter.

4. **Measure Spillage, Draft, CO under Natural Conditions.** If spillage fails under worst case, turn off the appliance, the exhaust fans, open the interior doors and allow the vent to cool before re-testing. Test for CO, spillage, and draft under "natural conditions." Measure the net change in pressure from worst case to natural in the CAZ to confirm the "worst case depressurization" taken in Step 2 outside. Repeat the process for each appliance, allowing the vent to cool between tests.

5. **Ambient CO.** Monitor the ambient CO in the breathing zone during the test procedure and abort the test if ambient CO goes over 35 ppm. 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. The appliance must be repaired and the problem corrected prior to completing the combustion safety diagnostics. If the ambient levels exceed 35 ppm during testing under natural conditions, disable the appliance and instruct the homeowner to have the appliance repaired prior to operating it again.

6. **Action Levels.** Make recommendations or complete work order for repairs based on test results and the Combustion Safety Test Action Level Tables.

RANGES AND OVENS*

1. Remove any items/foil in or on oven/range top

2. Make sure self-cleaning features are not activated

3. Test oven in vent sleeve, before dilution air

4. **100 ppm to 300 ppm** as measured you must install a carbon monoxide detector and recommendation for service must be made to the consumer.

   Greater than 300 ppm as measured—the unit must be serviced prior to work. If greater than 300 ppm after servicing, exhaust ventilation must be provided with a capacity of 25 CFM continuous or 100 CFM intermittent.

Continually monitor ambient CO levels during test

COMBUSTION SAFETY TEST ACTION LEVELS

CO Test Result*	And/ Or	Spillage and Draft Test Results	Retrofit Action
0—25 ppm	And	Passes	Proceed with work
26—100 ppm	And	Passes	Recommend that the CO problem be fixed
26—100 ppm	And	Fails at worst case only	Recommend a service call for the appliance and/ or repairs to the home to correct the problem
100—400 ppm	Or	Fails under natural conditions	**Stop work:** Work may not proceed until the system is serviced and the problem is corrected
>400 ppm	And	Passes	**Stop work:** Work may not proceed until the system is serviced and the problem is corrected
>400 ppm	And	Fails under any condition	**Emergency:** Shut off fuel to the appliance and have the homeowner to call for service immediately

CO measurements for undiluted flue gases at steady state

CAZ DEPRESSURIZATION LIMITS

Venting Condition	Limit (Pascals)
Orphan natural draft water heater (including outside chimneys)	-2
Natural draft boiler or furnace commonly vented with water heater	-3
Natural draft boiler or furnace with damper commonly vented with water heater	-5
Individual natural draft boiler, furnace or domestic hot water heater	-5
Mechanically-assisted boiler or furnace commonly vented with water heater	-5
Mechanically-assisted boiler or furnace alone, or fan-assisted DHW alone	-15
Chimney-top draft inducer (Exhausto-type or equivalent); High static pressure flame retention head oil burner; Direct-vented appliances/Sealed combustion appliances	-50

ACCEPTABLE APPLIANCE SPILLAGE PERIODS

Appliance Type	Spillage Test Period (minutes)
Water Heater, Gravity Furnace, Boiler	1.0
Space Heater	1.0
Forced Air Furnace	1.0

ACCEPTABLE DRAFT TEST RANGES

Outside Temperature (degree F)	Draft Pressure Standard (Pa)
<10	-2.5
10-90	(T_out ÷ 40) - 2.75
>90	-0.5

APPENDIX B – COMBUSTION VENTILATION AIR

Addendum # 2: Combustion Ventilation Air (CVA)

CVA requirements only apply to open combustion furnaces and water heaters. Abandoned appliances (capped off or disconnected only) must be included in CVA or room volume calculations. Heating appliances with flex gas connector removed, the gas line shut off valve capped or valve removed and pipe capped are considered abandoned.

Confined Space - Is an area designed for the operation of combustion appliances which has a total volume **less than 50 cubic ft. per 1000 BTUs input** of all open combustion furnaces/heaters and water heaters within the space.

Procedure for Determining if an *Open Combustion* Appliance is Located in a Confined Space

1. Measure enclosure or room: **L (length)** X **W (width)** X **H (height)** = Existing Area in Cubic Feet.
2. Total BTU's divided by 1000 X 50 cubic = Required Cubic Feet. Here is an easier method: Divide the total BTU input by 2, and then drop the last zero. Example: 44,000 total BTU input divided by 2 = 22,000. Drop the last zero = 2,200 cu. Ft.
3. If the result of 1 is less than 2, CVA **is** required.
4. If the result of 1 is equal to or greater than 2, CVA is **not** required.

CVA Calculation Rules

Determine the required Net Free Vent (NFV) area, **per opening(s)**, by taking the total BTU input and divide by 1000. Take the results and divide by the CVA Rule you have chosen to use. Example: The total BTU input is 80,000 BTUs. You have chosen rule 4. 80,000 divided by 1000 = 80. 80 divided by rule 4 = 20 sq. in required NFV area.

Rule 1: Requires two openings. CVA from **conditioned space** requires that each opening shall have a NFV area of at least **1 sq. in. for every 1000 BTUs** input. 1 upper vent within 12" of ceiling and 1 lower vent within 12" of floor venting to unconfined space. Each opening, **minimum 100 sq. in**.

Rule 2: Requires two openings. CVA supplied by **horizontal ducts** to the outside (**unconditioned space**). 1 upper duct and 1 lower duct. Each opening requires a NFV area of at least **1 sq. in. for every 2000 BTUs input**.

Rule 3: Requires one opening. CVA to outside (**unconditioned space**). 1 upper opening (or vertical or horizontal duct) may be used to provide the combustion air. The vent/duct must provide **1 sq. in. NFV area per 3,000 BTUs input**

Rule 4: Requires two openings. CVA to the outside (**unconditioned space**). 1 upper and 1 lower vent or vertical duct opening is required. Each opening shall have a NFV area of a least **1 sq. in. for every 4000 BTUs input.**

Note: With Rule 3, appliance must have clearances of 1 inch on sides and back and 6 inches in front from appliance to wall/door.

Note: In an unconditioned garage when it is considered a confined space, 1 vent either upper and/or lower, equal to 1 sq. in. per 4,000 BTU input for all applicable appliances is OK. The CVA opening can either be already installed, or installed by the participating Contractor. Must be designed CVA.

Note: If an water heater or furnace is in an enclosure that has non-standard doors (pocket, accordion, etc.) which cannot be weatherstripped, it is OK to not weatherstrip the doors, and in addition install or increase CVA to outside if necessary.

CALCULATIONS

Area of a Circle (sq. in.)

Area of a Circle = Radius X Radius X 3.14Radius = Half the diameter

3” diameter circle = 7.1 sq. in. 4” = 12.6 5” = 19.6 6” = 28.3 7”=38.5 8” = 50.3 9”=63.6 10” = 78.5 12” = 113

Vent Opening Multipliers

*Note: Use **only one** of the following multipliers to calculate NFV area. Use the multiplier that will reduce the overall NFV area to the lowest term.*

Mesh**,** ¼ in. or Larger = **90%** of the actual vent opening.
MESH, **LESS THAN** ¼ in. = **50%** of the actual vent opening.
METAL LOUVERS = **75%** of the actual vent opening.
WOODEN LOUVERS = **25%** of the actual vent opening.

Estimated BTUh Input Ratings of Unmarked Open Combustion Furnaces/Heaters and Water Heaters

Wall Furnaces
Single sided: 25,000 BTUh
Double sided: 50,000 BTUh

Floor Furnaces:
Standard (usually 22” wide): 30,000 BTUh
Large (usually larger than 1 floor-joist bay): 60,000 BTUh

Forced Air Furnace:
25,000 BTUh per burner

Free-Standing Heaters:
Small: 25,000 BTUh
Standard (24” + 12” deep): 50,000 BTUh

Water Heaters:
Standard: 1000 BTUh per gallon
Tankless / Instantaneous: 200,000 BTUh

APPENDIX C – BPI BUILDING ANALYST STANDARDS

BUILDING PERFORMANCE INSTITUTE

TECHNICAL STANDARDS

FOR THE BUILDING ANALYST PROFESSIONAL

Note: CAZ Depressurization Limits table on page 14 revised for clarification (1/4/12)

Health and Safety

All technicians performing diagnostic tests, inspections, or installations, must have access to all necessary personal safety equipment required by OSHA. Required safety equipment includes, but is not limited to:

- ✓ Fitted respirators with canister filters
- ✓ Dust masks
- ✓ Gloves
- ✓ Protective clothing
- ✓ Safety glasses
- ✓ Hard hats, as required

Technicians must be trained in proper use and applications for these devices and must adhere to OSHA regulations when on the job site.

All hand tools, power tools, ladders, and diagnostic equipment must be handled and used in a safe manner and kept in good working condition. Equipment and diagnostic tools must be maintained and calibrated according to manufacturer's specifications.

A copy of the Material Safety Data Sheets (MSDS) for all materials used on the job and installed in the home, must be kept on each crew vehicle and made available to all workers and clients upon request.

Where the presence of asbestos, lead, mold and/or other potentially hazardous material is known or suspected, all relevant state and federal (EPA) guidelines must be followed to ensure technician and occupant safety. Blower door depressurization tests may not be performed in homes where there is a risk of asbestos becoming airborne and being drawn into the dwelling.

Respirators with filter cartridges must be worn when working in areas where exposure to airborne mold, asbestos, lead, fiberglass, or formaldehyde is a risk.

Carbon monoxide levels in the ambient air around the technician must be monitored throughout all combustion safety tests. Diagnostic evaluations and inspections must be aborted if ambient CO concentrations greater than 35 ppm are recorded. CO producing appliances must be disabled and repaired before proceeding with additional diagnostics or inspections.

Refer to standards on combustion safety for complete requirements applicable to carbon monoxide exposure limits and action levels.

The following are the minimum required health and safety diagnostics and specifications for the Building Analyst Professional certification. Minimum health and safety requirements apply to all jobs with work related to energy efficiency and/or indoor air quality performed by BPI accredited firms.

Minimum Health and Safety Requirements
(Building Analyst Professionals)

(refer to main text for detailed descriptions and applications of the standards below)

- When air sealing, enclosed cavity insulation representing 15% or more of the total building shell area, or sealing of the ducts outside the thermal envelope are recommended, the work scope must include pre and post-installation blower door tests.
- Whenever blower door tests are required, the results must be compared to the Building Airflow Standard to verify compliance with ASHRAE 62-89 requirements for ventilation. If natural ventilation is inadequate according to the ASHRAE standard, mechanical ventilation must be installed or recommended as part of the work scope to increase the ventilation to required levels (refer to page 6 for specific requirements).
- A preliminary and post-installation safety inspection of all combustion appliances must be completed whenever changes to the building envelope and/or heating system are part of the work scope.
- The combustion appliance safety inspection includes all of the following: carbon monoxide test, draft measurement, spillage evaluation, and worst-case depressurization of the combustion appliance zone.
- In homes with natural gas/propane service, the gas line must be inspected thoroughly and all leaks repaired.
- Combustion safety test results must be acted upon appropriately according to the Combustion Safety Action Level Table.
- Whenever an appliance fails any of the combustion safety test, appropriate repairs must be completed or specified in the work scope according to the requirements listed (refer to tables on page 13).
- Appropriate inspection and diagnostic tests must be included in the workscope when attic insulation and/or ventilation are specified.
- Whenever air sealing or other shell-tightening measures are recommended, leakage paths to the attic must be given highest priority on the work scope.

Building Airflow

Whenever changes to the building shell requiring a blower door test are part of the work scope, a Building Airflow Standard must be calculated for the home according to the air exchange requirements provided by ASHRAE standard 62-89. Actual occupancy of the building must be used when calculating the Building Airflow Standard. An example of the calculation is shown below:

Minimum Building Airflow Standard Example Calculation (ASHRAE 62-89)

BUILDING DATA

Living Space Area = 1500 sqft
Basement Area = 700 sqft
# of Occupants = 4
# of Stories Above Grade= 2
Location = Albany, NY

Step 1: Calculate the Ventilation Required for the Building

AIRFLOW(b) = 0.35 x volume / 60
volume = 8 x (1500 + 700) = 17600 cubic feet
AIRFLOW(b) = 0.35 x 17600 / 60
= 102 cfm

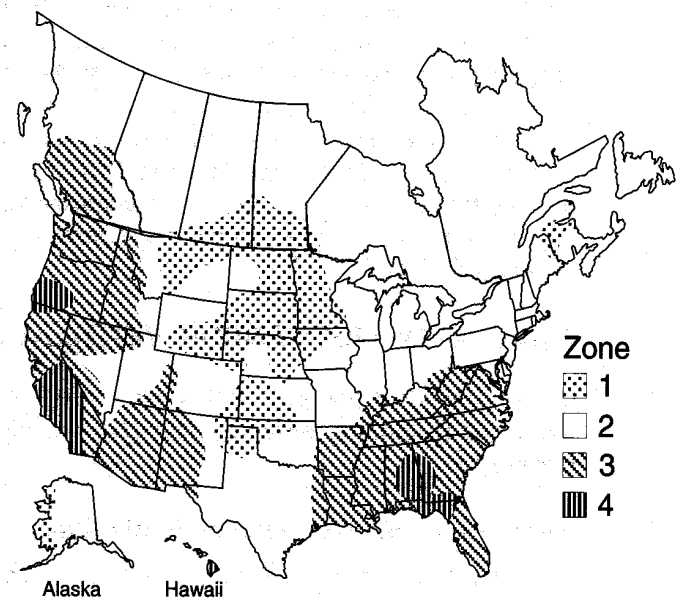
Step 2: Calculate the Ventilation Required for the People

AIRFLOW(p) = 15 x occupants
AIRFLOW(p) = 15 x 4
= 60 cfm

Step 3: Using the Higher Airflow Requirement, Convert to CFM50

MINIMUM_CFM50 = AIRFLOW x N
Where N is the LBL conversion factor (see chart)
MINIMUM_CFM50 = 102 x 15.4 = 1570 CFM50

Converting Between CFM 50 and Natural Airflow



LBL "N" Factors

Zone	N Factor
1	14-17
2	17-20
3	20-23
4	23-26

# of Stories	Height Correction Factor
1	1
1.5	0.89
2	0.81
2.5	0.76
3	0.72

To determine the correct multiplier, identify the N-factor for your region and multiply the result by the appropriate height correction factor
CFM50/N = Natural Airflow (cfm)

Height-Corrected N-Factors for New York

Number of Stories	N-Factor
1	19
1.5	16.8
2	15.4
2.5	14.4
3	13.7

A blower door test must be completed before and after installation of any of the following measures:

- Attic insulation, in order to quantify improvements to the air barrier between the attic and the living space.
- Enclosed cavity insulation representing an area greater than 15% of the total building shell area.
- Air sealing
- Sealing of ductwork located outside the building envelope or significant duct modifications within the building envelope.

Fires in woodstoves and/or fireplaces must be fully extinguished prior to performing a blower door test. Pressurization tests are not recommended under these conditions due to the fire safety risks.

If the measured CFM50 is less than the Building Airflow Standard (BAS), mechanical ventilation must be recommended or installed according to the following standards:

Condition	Action
BAS > final CFM50 > (0.7 x BAS)	Mechanical ventilation rated for continuous operation must be *recommended* to the customer as part of the work scope. System must be sized to make up the difference between the BAS and the final CFM50.
(0.7 x BAS) > final CFM50	Mechanical ventilation rated for continuous operation must be *installed* as part of the work scope. System must be sized to provide 100% of the ventilation requirement by mechanical means.

Recommended or installed mechanical ventilation must be designed appropriately to provide adequate air exchange to meet the occupancy ventilation requirements provided by ASHRAE 62-89.

Building Evaluation

Heat Loss and Savings Calculations

For heat loss and savings calculations, building components must be measured and area and volume calculations must be accurate +/- 10%. For use in heat loss and savings calculations use the following criteria for building component evaluations:

- R-values of installed insulation shall be determined based on an actual measurement of the insulation depth and the R-value per inch for that product.

- Voids in insulation must be accounted for by determining the net square footage of uninsulated area and recording it as a separate component of the building.
- Gaps between batt insulation and framing must be accounted for by determining the effective R-value for the insulation using the Effective R-value for Batt Insulation Chart provided below.
- Windows and doors must be measured and assigned appropriate R-values consistent with the material type and the ratings established by the National Fenestration Rating Council (NFRC). NFRC numbers are stamped on the metal spacer on most double-glazed (or better) units. This number may be looked up in the NFRC guide to determine the precise U-value and Solar Heat Gain Coefficient (SHGC).

Default Values for Insulation

When manufacturer's rated R-values for insulation are not available, use the chart below to estimate the R-value per inch for the installed product.

Typical Insulation R-values

Insulation Type	R-value per inch	Typical Applications
Cellulose, loose fill	3.7	Attic Floor
Cellulose, high density	3.2	Walls, Enclosed Cavities, Framing Transitions
Fiberglass, batts	3.0*	Basement Ceiling, Open Stud Walls, Attic Floor*
Fiberglass, loose fill	2.8	Attic Floor, Walls (existing)
Fiberglass, loose fill, fluffed below manufacturer's standards	uncertain	Do not install, or correct by blowing over with higher density
Rockwool	3.0	Attic Floor, Walls, Basement Ceiling (may be loose or batts)
Vermiculite	2.7	Attic Floor
Poly-isocyanurate, rigid board	7.0	Foundation Walls, Attic Access Doors
Polystyrene, expanded rigid board	4.0	Foundation Walls, Sill Plate
Polystyrene, extruded rigid board	5.0	Foundation Walls, Sub-Slab, Sill Plate
Low Density Urethane, sprayed foam	3.7	Attics, Walls (new construction); Sill Plate, Band Joist, Framing Transitions
Urethane, sprayed foam	6.0	Attics, Walls (new construction); Sill Plate, Band Joist, Framing Transitions
Urea Formaldehyde Foam	4.0	Attics, Walls (existing)

**see chart below for existing fiberglass batt evaluation*

Use the following chart to determine effective R-values for batt insulation installed in attics:

Effective R-values for Batt Insulation*

	"Good"	"Fair"	"Poor"
Measured Batt Thickness (inches)	Effective R-value (2.5 per inch)	Effective R-value (1.8 per inch)	Effective R-value (0.7 per inch)
0	0	0	0
1	3	2	1
2	5	4	1.5
3	8	5	2
4	10	7	3
5	13	9	3.5
6	15	11	4
7	18	13	5
8	20	14	5.5
9	23	16	6
10	25	18	7
11	28	20	8
12	30	22	8.5

1. *Measure the insulation thickness.*
2. *Determine the condition of the installation using the following criteria:*
   - ✓ *Good – No gaps or other imperfections*
   - ✓ *Fair – Gaps over 2.5% of the insulated area. (This equals 3/8 inch space along a 14.5 inch batt.)*
   - ✓ *Poor – Gaps over 5% of the insulated area. (This equals ¾ inch space along a 14.5 inch batt.)*
3. *Look up the effective R-value of the installed insulation using the condition and measured inches.*

**Derived from ASHRAE document "Heat Transmission Coefficients for Walls, Roofs, Ceilings, and Floors" 1996*

Default Values for Windows

Where NFRC numbers are not available, use the following chart to estimate the U-value and Solar Heat Gain Coefficient (SHGC) for windows and glazed areas of doors. If there is not a label etched on the glass identifying the presence of a low-e coating, this can be verified using a spectrally selective metering device. The values shown below are only estimates. They do not account for all possible window configurations and variations due to airspace thickness, insulated frames, mullions, etc. Since U-values can vary greatly depending on the window type (double-hung, casement, fixed) even within the same manufacturer's model line, it is strongly recommended that NFRC ratings are used whenever the windows are appropriately labeled.

Default Window Values

Frame Type	Glazing Type	U-Value	SHGC	U-Value with low e	SHGC with low e
Wood	Single	.90	.65	NA	NA
	Single w/ Storm	.49	.71	NA	NA
	Double	.49	.58	.39	.45
	Triple	.39	.53	.30	.45
Vinyl	Double	.46	.57	.36	.45
	Triple	.36	.52	.36	.45
Metal	Single	1.31	.80	NA	NA
	Double	.87	.73	NA	NA
Metal w/ Thermal Break	Double	.65	.66	.53	.52
	Triple	.53	.60	.43	.52

Combustion Safety and Carbon Monoxide Protection

A preliminary and post-installation safety inspection of all combustion appliances must be completed whenever changes to the building envelope and/or heating system are part of the work scope. This inspection includes all of the following tests: carbon monoxide (CO) measurement at each appliance, draft measurement and spillage evaluation for atmospherically vented appliances, and worst-case negative pressure measurement for each combustion appliance zone (CAZ). Combustion safety test results must be acted upon according to the Combustion Safety Action Level table.

Carbon Monoxide Tests
CO shall be measured of undiluted flue gases, in the throat or flue of the appliance using a digital gauge and measured in parts per million (ppm).

Do not drill holes in flues for power vented or sealed combustion units. Instead, measure CO at the exterior outlet of the flue and proceed with appropriate actions according to the CO limits identified in the Combustion Safety Action Level table.

For all combustion appliances, CO shall be measured at steady-state operating conditions. Measurements shall be taken of undiluted flue gases.

With the exception of unvented gas or propane cooking appliances, CO must be tested in all combustion appliances under worst-case conditions and normal draft conditions (when the appliance fails under worst-case). In addition, it is recommended that CO be tested under a mild down-draft if conditions are safe.

For gas ovens, CO shall be measured at steady state (usually after 5-10 minutes of operation) at the highest setting. When measuring CO on gas ovens, it is recommended to turn on the exhaust hood and open a window to reduce risk of exposure to elevated ambient CO levels.

Ambient CO levels shall be monitored upon entering the combustion appliance zone and during the test period for all appliances. If ambient levels exceed 35 ppm at any time, turn off the appliance immediately and make appropriate repair recommendations according to the charts provided.

Spillage and Draft Tests

Spillage and draft tests must be completed for all natural and induced draft space heating systems and water heaters. Spillage and draft must first be tested under worst-case conditions (see procedure below) and then repeated for natural conditions if the appliance fails under worst-case.

When a chimney is shared by multiple appliances the appliance with the smallest Btu input rating shall be tested first and remaining appliances tested in order of increasing input rate.

Induced draft heating systems shall be checked for spillage at the base of the chimney liner or flue. If a chimney is shared between and induced draft heating system and a natural draft water heater, spillage shall be checked at the water heater draft diverter.

Vent draft pressure shall be measured at steady-state operating conditions for all natural draft heating and hot water appliances. Draft test location should be approximately 1-2' downstream of the appliance draft diverter. The test hole must be sealed with an appropriate plug after the test. Acceptable draft test results are shown below:

Acceptable Draft Test Ranges

Outside Temperature (degree F)	Minimum Draft Pressure Standard (Pa)
<10	-2.5
10-90	(T_out ÷ 40) – 2.75
>90	-0.5

Most appliances will spill upon startup with a cold chimney. Document the amount of time it takes for spillage to stop and a positive draft to be established. Any appliance that continues to spill flue gases beyond the time limits established in the statement below has failed the spillage test.

Acceptable Appliance Spillage Periods

Vented appliances, regardless of type, that spill flue gases for more than 60 seconds after startup, fail the spillage test.

Worst-Case CAZ Depressurization

The worst-case depressurization test is configured by determining the largest combustion appliance zone depressurization due to the combined effects of door position, exhaust appliance operation, and air handler fan operation. A base pressure must be measured with all fans off and doors open. The worst-case depressurization is the pressure difference between worst-case and the base pressure.

A recommended protocol for completing all of the combustion safety tests for vented appliances follows. This step-by-step procedure is recommended to guide technicians through a complete combustion safety analysis safely and efficiently: (see chart on following page)

Gas Supply Safety

The entire gas/propane line must be examined and all leaks repaired. Particular care should be made in the immediate vicinity of the appliances and at the joints, shutoff valves, and pilot lines. Identify leaks using a gas leak detector and accurately locate the source of the leak using a soap bubble solution.

Flexible gas lines must be replaced if they are: kinked, corroded or show signs of visible wear, the line was manufactured before 1973 (date is stamped on the date ring attached to the line), or the line has any soldered connections.

COMBUSTION SAFETY TEST PROCEDURE FOR VENTED APPLIANCES

1. **Measure the Base Pressure.** Start with all exterior doors, windows, and fireplace damper(s) closed. Set all combustion appliances to the pilot setting or turn off the service disconnect, including: boiler, furnace, space-heaters, and water heater. With the home in this configuration, measure and record the base pressure of the combustion appliance zone (CAZ) WRT outside.
2. **Establish the Worst Case.** Turn on the dryer and all exhaust fans. Close interior doors that make the CAZ pressure more negative. Turn on the air handler, if present, and leave on if the pressure in the CAZ becomes more negative, then recheck the door positions. Measure the net change in pressure from the CAZ to outside, correcting for the base pressure. Record the "worst case depressurization" and compare to the CAZ Depressurization Limit Table.
3. **Measure Worst Case Spillage, Draft, CO.** Fire the appliance with the smallest Btu capacity first, test for spillage at the draft diverter with a mirror or smoke test, and test for CO at the flue at steady-state (if steady-state is not achieved within 10 minutes, take CO readings at the 10 minute mark). If the spillage test fails under worst-case go to step 4. If spillage ends within 1 minute, test the draft in the connector 1-2' after the diverter or first elbow. Fire all other connected appliances simultaneously and test the draft diverter of each appliance for spillage. Test for CO in all appliances in the flue, before the draft diverter.
4. **Measure Spillage, Draft, CO under Natural Conditions.** If spillage fails under worst case, turn off the appliance, the exhaust fans, open the interior doors, and allow the vent to cool before re-testing. Test for CO, spillage, and draft under "natural conditions". Measure the net change in pressure from worst case to natural in the CAZ to confirm the "worst case depressurization" taken in step 2. Repeat for each appliance, allowing the vent to cool between tests.
5. **Ambient CO.** Monitor the ambient CO in the breathing zone during the test procedure and abort the test if ambient CO goes over 35 ppm. 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. The appliance must be repaired and the problem corrected prior to completing the combustion safety diagnostics. If the ambient levels exceed 35 ppm during testing under natural conditions, disable the appliance and instruct the homeowner to have the appliance repaired prior to operating it again.
6. **Action Levels.** Make recommendations or complete work order for repairs based on test results and the Combustion Safety Test Action Level Tables.

Combustion Safety Test Action Levels

CO Test Result*	And/ Or	Spillage and Draft Test Results	Retrofit Action
0 – 25 ppm	*And*	**Passes**	Proceed with work
26 – 100 ppm	*And*	**Passes**	Recommend that the CO problem be fixed
26 – 100 ppm	*And*	**Fails at worst case only**	Recommend a service call for the appliance and/or repairs to the home to correct the problem
100 - 400 ppm	*Or*	**Fails under natural conditions**	Stop Work: Work may not proceed until the system is serviced and the problem is corrected
> 400 ppm	*And*	**Passes**	Stop Work: Work may not proceed until the system is serviced and the problem is corrected
> 400 ppm	*And*	**Fails under any condition**	Emergency: Shut off fuel to the appliance and have the homeowner to call for service immediately

**CO measurements for undiluted flue gases at steady state*

When CAZ depressurization limits are exceeded under worst-case conditions according to the CAZ Depressurization Limit table, make up air must be provided or other modifications to the building shell or exhaust appliances must be included in the work scope to bring the depressurization within acceptable limits. Worst-case CAZ depressurization limits are shown below:

CAZ Depressurization Limits

Venting Condition	Limit (Pascals)
Orphan natural draft water heater (including outside chimneys)	-2
Natural draft boiler or furnace commonly vented with water heater	-3
Natural draft boiler or furnace with vent damper commonly vented with water heater	-5
Individual natural draft boiler, furnace or domestic hot water heater	-5
Mechanically-assisted draft boiler or furnace commonly vented with water heater	-5
Mechanically-assisted draft boiler or furnace alone, or fan-assisted DHW alone	-15
Chimney-top draft inducer (Exhausto-type or equivalent); High static pressure flame retention head oil burner; Direct-vented appliances/Sealed combustion appliances	-50

If the CO in any appliance is measured greater than 100 ppm during diagnostic testing, or the ambient CO in the home exceeds 35 ppm during appliance operation, an appliance clean and tune must be completed as part of the work scope.

The homeowner shall be notified of the results of all combustion safety tests.

Unvented Appliances
No unvented combustion appliances may operate in the living space with the exception of gas ranges/ovens. Exhaust ventilation must always be recommended whenever a gas or propane cooking appliance exists. See table below for testing instructions and action levels.

Interim Gas/Propane Oven Testing Procedure

Range tops and ovens produce moisture and oxides of nitrogen. Excess moisture is not good for the durability of the home (possibly contributing to mold problems) and NOX is not healthy. These combustion appliances are capable of producing CO, which is a health hazard. In all cases a carbon monoxide detector is recommended and homeowners should use exhaust ventilation when using these appliances. New appliances may require an extended warm up period to reach steady state.

1. Remove any items/foil in or on oven.
2. Make sure self cleaning features are not activated, set oven to highest setting.
3. Test oven for CO in the flue, before dilution air.
4. After 5 minutes of operation, check for steady state:

Level I Action - 100 ppm to 300 ppm as measured you must install a carbon monoxide detector and recommendation for service must be made to the consumer.

Level II Action - Greater than 300 ppm as measured - the unit must be serviced prior to work. If greater than 300 ppm after servicing, exhaust ventilation must be provided with a capacity of 25 CFM continuous or 100 CFM intermittent.

***Continually monitor ambient CO levels during test.**

Since all gas cooktops generate CO and it is difficult to simulate an actual operating condition for these appliances during the course of a typical house inspection, specific action levels for these burners are not specified by BPI. However, technicians must specify appropriate measures to mitigate potentially dangerous CO production of these units. ASHRAE exposure limits for CO shall be referenced when making recommendations for CO control in these areas. The recommended ASHRAE limit for 24-hour exposure of 9 ppm shall be applied to building occupants. In most cases, it will not be possible to effectively test for this condition, however the following measures shall be recommended whenever gas cooktops exist in the home:

- ✓ If burners do not ignite properly or do not burn cleanly, a clean and tune of the appliance shall be recommended.
- ✓ If the appliance is located in a confined space and mechanical ventilation is not readily available, mechanical ventilation shall be recommended.

Ventilation provided for unvented gas ovens must provide a minimum capacity of 25 cfm continuous airflow or 100 cfm intermittant.

CO Detectors

At least one CO detector meeting UL-2034 requirements shall be installed according to manufacturer's instructions in every home with an attached garage and/or combustion appliances. It is recommended that additional CO detectors are installed, as needed, to provide a separate detector for each floor of the building.

Furnace Inspection

Forced warm air furnaces must be inspected for flame interference. Visually inspect the burner as the blower fan comes on. If the flames burn differently when the blower comes on, a complete analysis needs to be done to find the source of the flame interference. This problem must be referred to a heating contractor. A cracked heat exchanger cannot effectively be repaired and must be replaced.

Attached Garages

Garage to living space connections must be tested for air tightness using a smoke stick in conjunction with the blower door. Air leaks between the garage and living space must be sealed as part of the work scope.

Work Scope Requirements

Insulation and Air Sealing
Attic ventilation shall not be recommended or installed without first verifying the presence of an effective air barrier and thermal barrier between the attic and the living space or specifying appropriate attic air sealing as part of the work scope.

Attic insulation shall not be recommended or installed without first verifying the presence of an effective air barrier between the attic and living space or specifying appropriate attic air sealing as part of the work scope.

Appropriate inspection and diagnostic tests (listed below) must be recommended as part of the work scope for an Envelope Professional when attic insulation and/or ventilation are recommended.

The effectiveness of the air barrier shall be determined using the following techniques:

- ✓ Pressure differential diagnosis, including: series leakage tests and/or "add a hole" method where applicable. (Refer to the blower door instruction manual for details on how to perform these tests.)
- ✓ Visual inspection of the attic. Visual indicators include all of the following:
  - o Inspect the attic floor underneath the insulation to locate thermal by-passes and cavities requiring air sealing.
  - o Inspect for areas where moisture migration into the attic is apparent and determine the source of the moisture.
  - o Insulation that has turned black is an indicator of air movement through the insulation. Identify the source.
- ✓ With the blower door running under depressurization, use a smoke stick in the attic to verify the integrity of installed air sealing measures.

If communication between the attic and living space is identified using any of the tests listed above, the area must be sealed prior to installation of insulation and/or ventilation in the attic. Whenever air sealing or other shell-tightening measures are recommended, leakage paths to the attic must be given the highest priority on the work scope.

Refer to local codes for minimum required insulation levels.

Where air sealing, enclosed cavity insulation representing 15% or more of the total building shell area, or sealing of ducts outside the thermal envelope are recommended, the work scope must include pre and post-installation blower door testing.

Ductwork
When duct sealing is recommended, the work scope must include pre and post-installation duct leakage and system airflow testing.

When heating ducts are located outside the building envelope or cooling ducts are located in attic spaces, they must always be sealed underneath the duct wrap, at all accessible connections with duct mastic and insulated to a minimum R-5 as part of the work scope.

APPENDIX D – CONTRACTOR VERIFICATION OF GAS LEAK REPAIRS FORM

CONTRACTOR VERIFICATION OF GAS LEAK REPAIRS

Property Name: _____ Program Auditor: _____

Property Address:_____ Date: _____

(THIS FORM IS NOT TO BE USED FOR EMERGENCY LEAKS WHICH NEED TO BE DEALT WITH THE SAME DAY AS THEY ARE FOUND – SEE "COMBUSTION SAFETY EMERGENCY SIGN OFF FORM" FOR THIS)

The following form indicates where gas leaks were found during the test out inspection performed by a program auditor. All of these leaks must be repaired prior to claiming project rebate. After licensed contractor or certified technician have repaired the leaks they must sign the form

Gas Leak (s) Found:

Describe each gas leak location sufficiently for contractor to know where leak is located: Unit #, appliance location, location on gas line/appliance, and include a labeled reference photo.

As owner or authorized party responsible for this property I acknowledge that I have been informed of the above situation, understand the issue(s) described, and are fully responsible for having repairs made to remedy the issue(s).

Authorized Party Signature:

Authorized Party Name (PRINT):

Authorized Party Title:

Date:

As a licensed plumbing contractor, mechanical contractor, or appliance repair technician, I certify that I have repaired all of the gas leaks indicated in this report and verified that the leaks were fixed using an approved bubble leak solution. *(If gas leaks are repaired by a PG&E Gas Service Representative (GSR) the project Authorized Party is responsible for attaching documentation from GSR that indicates all of the above leaks have been repaired).*

Contractor Signature:

Contractor Company:

Contractor License or Certification #:

Contractor Name (PRINT):

Date:

Supplemental Photos

Describe each gas leak location sufficiently for contractor to know where leak is located: Unit #, appliance location, location on gas line/appliance, and include a labeled reference photo.