



Whole House Combustion Appliance Safety Test Procedure

for the Comfortable Home Rebates
Program 2020

Note: This procedure is subject to revision or modification by Franklin Energy at any time.

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1. Combustion Appliance Safety (CAS) Test

This test procedure is intended for use in the Comfortable Home Rebates Program.

These policies and procedures apply the most stringent testing components of the nationally recognized Building Performance Institute (BPI) Combustion Appliance Safety Testing Procedure as stated within the current *Standard Practice for Basic Analysis of Buildings* (version ANSI BPI-1200-S-2017) and the Statewide Low Income Program Natural Gas Appliance Testing (NGAT) PG&E *Low Income Program Weatherization Installation Standards*. These procedures are to be applied by Program participants (collectively consisting of participating Independent Building Analysts and participating contractors) prior to and after the installation of infiltration measures. These procedures are also to be applied by PG&E Central Inspection Program (CIP) personnel, Third Party Verifiers, and Program participants (collectively “inspectors or Program participants”) when combustion appliance safety testing must be performed. If more stringent BPI or NGAT testing protocols are released, this procedure will be updated to accordingly. BPI Certified Building Analysts should abide by all personal safety requirements, tool and equipment standards as specified by BPI. This testing procedure may include propane appliances, however all repairs associated with correcting safety related issues shall be referred to a properly licensed contractor. PG&E Gas Service Representatives are not to be called regarding propane issues or other non-PG&E fuels.

These test procedures recognize that during the initial assessment prior to work start, or test-in, the Program participant may be unable to make immediate repairs to correct conditions found in a home. The Program participant is expected to follow the *NGAT Action Guidelines* and if an issue persists, include any repairs in the scope of work for the upgrade. All appliance fails must be corrected prior to finishing the job and submitting for rebate approval.

1.1. Action Guidelines

In instances where an appliance fails the Combustion Appliance Safety (CAS), the Program participant should refer to the *Natural Gas Appliance Testing (NGAT) Action Guidelines* for next steps. Document results on the Action Guidelines and Test Measurement forms.

1.2. Participating Contractor Repairs

Participating Contractor may attempt to repair, or contract a qualified technician to repair, any conditions that caused a Combustion Appliance Safety (CAS) test to fail provided they are properly licensed to do so (refer to the *NGAT Action Guidelines*). If the participating Contractor is unable to repair any conditions that caused a CAS test to fail, the Program participant (Contractor or Rater; whoever performed the CAS testing) must call a PG&E Gas Service Representative (GSR), as required by the *NGAT Action Guidelines*.

If a GSR call is required, contact the GSR immediately (before leaving the customer's home). To contact the GSR and schedule a visit, the Program participant must call PG&E Central Inspection Program (CIP) Dispatch at 1-800-813-1975 during normal business hours or the PG&E Customer Service Line at 1-800-743-5000 after 5:30 PM or on weekends. The Program participant must also notify the customer of the need for a GSR visit.

In instances where an appliance fails during the initial assessment, or test-in, the Program participant is required to call a PG&E Gas Service Representative (GSR), as required by the *NGAT Action Guidelines*. If a condition persists the participating Contractor must include repairs in the scope of work of the upgrade in order to qualify for the Whole House Program.

If an appliance fail occurs during the course of work or the final assessment and a GSR call is not required, the participating Contractor (if properly licensed) will make the appropriate repairs or contract a properly licensed technician to repair the hazards.

1.3. Non-Feasible CAS Test

A CAS test-out will not be performed when the appliance(s) do not meet the criteria listed in **2.1 Gas Appliance(s) Within the Living Space (below)** or infiltration measures which may change pressure dynamics (air sealing measures, duct sealing, insulation) are not installed or scheduled to be installed.

1.4. CAS Test Components

The appliance or dwelling fails the CAS test if it does not pass the tests/inspections below:

1.4.1. Gas Leak and/or Soldered Flex Connector

The CAS test will fail when an inspector or Program participant detects a natural gas leak by sensory smell or electronic leak detector and it is verified by a soap test during the dwelling inspection (inside or outside). The CAS test fails if an inspector or Program participant finds a soldered flex connector or a flex connector clearly labeled prior to 1973 on any gas appliance. Uncoated brass connectors shall be recommended for replacement to the homeowner.¹

1.4.2. Drafting and Spillage

When an inspector or Program participant determines that drafting of the by-products of combustion is improper (e.g., 'spillage' is identified using a smoke test or mirror), the appliance will fail the CAS test.

1.4.3. Carbon Monoxide (CO)

Per BPI, a personal CO monitor is required during inspections. Both Appliance Ambient and Flue Gas readings must be taken on all natural gas combustion

¹ See ANSI/BPI-1200-S-2017, items 7.5.2.6 & 7.5.2.7

appliances per the attached Addendum #1 (“NGAT Ambient and Flue CO Levels for GSR Calls”). A Room Ambient CO reading must be taken in the center of each dwelling unit, six (6) feet above the floor level. When CO levels are found to be equal to or greater than those found in the attached Addendum # 1, the appliance fails the CAS test.

1.4.4. Flue and/or Venting System Defects

Disconnection, holes, missing sections, gaps, double diverters, inappropriate materials or installation, or other defects in the flue or venting system, a vent connection to a solid fuel chimney, a gas log fireplace that is the primary heat source and does NOT have a permanently held open damper with a clip or clamp, will cause the appliance to fail the CAS test for appliances located partially or entirely in the living space. When it is determined that improper terminations cause an appliance to fail the CAS test, Program participants must adhere to all California Mechanical Code requirements for vent terminations.

1.4.5. Inadequate Combustion/Ventilation Air (CVA)

The inspector or Program participant will verify that there is adequate combustion/ventilation air for all tested open burner or induced draft furnaces, room heaters, wall furnaces and water heaters located in a confined space (see Appendix #2 for a definition of confined space). Inadequate combustion/ventilation air will cause the appliance(s) to fail the CAS test. Inspectors and Program participants will refer to the California Mechanical Code and the attached Addendum #2 (“Combustion Ventilation Air Supplement”) for standards that define adequate combustion/ventilation air. All open combustion natural draft furnaces and water heaters must be included in the calculations regardless of age of the dwelling unit. For homes built on or after January 1, 2008, natural gas cooking appliances and dryers must also be included in the calculations.

1.4.6. Communication

The inspector or Program participant will conduct a visual inspection of the return duct system of a forced air system to determine if depressurization may cause by-products of combustion to be distributed throughout the living space of the house. Gaps discovered during visual inspection or missing sections of the return duct system will cause the appliance to fail the CAS test.

1.4.7. Unvented Combustion Space Heater in the Living Space

By observation and customer interviews, the inspector or Program

participant will determine if an unvented gas appliance is used to heat the living space. When an unvented appliance including a range, cook top, incinerator/heater as part of a range, or oven is used to heat the living space the dwelling will fail the CAS test.

1.4.8. Appliance Operating Characteristics

The inspector or Program participant will verify that the flame roll-out shield and doors to the appliance are in place, and that burner ignition is not delayed (indicated by an explosion, bang or boom at start up). Missing components, roll-out, delayed ignition, or other operating defects will cause the CAS test to fail.

1.4.9. Gas Clothes Dryer Located in the Living Space Not Exhausted to Outdoors

The inspector or Program participant will verify that a gas clothes dryer terminates outside of the building regardless of its location.

1.4.10. Whole House Fan(s) Located in a Ceiling with Open Combustion Gas Water Heater or Furnace with Standing Pilot Located within the Attic and Attic Net Free Vent Area is less than recommended by the Whole House Fan Manufacturer

If the inspector or Program participant finds that an open combustion furnace or water heater exists in an attic where a whole house fan is installed in the ceiling, the home will fail the CAS test. The inspector or Program participant *must not* operate an existing whole house fan to simulate a worst case depressurization condition.

1.4.11. Open Combustion Water Heater Located in a Sleeping Area

If the inspector or Program participant finds an open combustion water heater located within a sleeping area, the home fails the CAS test.

1.4.12. Open Combustion Water Heater Vent Termination within 10 feet of an Evaporative Cooler Inlet and does not extend 3 feet above.

If the inspector or Program participant finds an open combustion water heater vent termination located within 10 feet of an Evaporative Cooler Inlet and does not extend 3 feet above, the home fails the CAS test.

1.4.13. Open Combustion or Induced Draft Vent Termination within 10 feet of an Evaporative Cooler Inlet and does not extent 3 feet above AND cooler vent cover (s) cannot be installed

If the inspector or Program participant finds an open combustion or induced draft vent termination located within 10 feet of an Evaporative Cooler Inlet and does not extend 3 feet above AND cooler vent cover(s) cannot be installed, the home fails the CAS test.

2. Appliances

All gas appliances meeting the criteria specified in **2.1 Gas Appliance(s) Within the Living Space (below)**, will be subject to a CAS test performed in accordance with the procedures outlined within this document.

2.1. Gas Appliance(s) Within The Living Space

Combustion appliances in locations 1 through 3 below affecting the living space consist of (a) all combustion space heating appliances, and (b) other combustion appliances:

1. Partially or entirely within the living space (including closets located within the envelope but accessed from outdoors).
2. Attached garage, attic, basement or raised floor crawl space. An outdoor location when any part of an open combustion appliance including its vent system or the vent termination of a sealed combustion appliance is within four (4) feet of an operable door or window leading to the living space.
3. A location where combustion products from the appliance could infiltrate a forced air duct system (e.g., in a garage or room containing supply or return plenum/ductwork).

Appliances in all other locations are considered to be appliances NOT affecting the living space. These appliances must be checked for gas leaks, combustion ventilation air requirements, potential fire hazards due to charring of framing members, burner intakes clogged with dust and/or lint and other hazards.

2.1.1. Primary Gas Appliances

Primary gas appliances include the main source of heating, water heating and cooking. If present, primary gas appliances must be operational. Primary gas appliances *will not* be abandoned or disconnected to allow installation of infiltration reducing weatherization or energy efficiency measures.

2.1.2. Non-Primary Gas Appliances

Non-primary gas appliances may be abandoned at the customer's request. Clothes dryers and/or secondary or back-up gas appliances may be abandoned (e.g. a second gas range is no longer used). The customer must be advised to call a GSR or qualified technician to disconnect the appliance.

An abandoned gas-fired appliance which has been properly disconnected does not require CAS testing (and infiltration reduction measures may be installed). A disconnected appliance is an appliance found to be removed from service and (a) the flexible gas connector

has been removed, and (b) the gas line shutoff valve has been capped or the valve has been removed and the pipe capped. If an abandoned gas-fired appliance is found and not removed from the dwelling unit, a CVA assessment shall be performed for the abandoned appliance. The inspector or Program participant will note the status of the appliance.

3. General Procedures

1. Look for signs of soot on combustion appliance ventcaps terminating at the roof, or exterior walls of the house.
2. Note weather conditions (e.g. clear, mild winds, rain, strong wind, etc.)
3. Ask the customer how many gas appliances they have, where they are located, and if they are all operational. If appliances with standing pilots are present and pilots are not lit, continue the CAS test on all operable appliances and identify any additional problems. A Program participant or third party inspector who is properly licensed may choose to light the pilot(s) or schedule a GSR visit. If a PG&E inspector is conducting the CAS test and if the dwelling is served by PG&E- supplied natural gas, the PG&E inspector will light the pilot(s) and perform the CAS test. If the customer is not served by PG&E-supplied natural gas, the customer must be advised that the pilot must be lit by a qualified technician before the test can be completed. (Note: If the range top pilots are not lit, the test will still be performed by match- lighting the burners. Assuming the burner CO reads are within standards, the range will pass. The pilots do not have to be operational. Match-lit ovens will also be tested by lighting with a match).
4. Ask the customer where the thermostat for the heating system(s) is located.

3.1 Initial Walk Through

The inspector or Program participant will perform a walk through inspection of the dwelling and preliminary inspection of the appliances and if issues are identified, consult the *NGAT Action Guidelines* for next steps.

3.1.1. Water Heater

1. Make sure the unit is operational and the pilot is on.
2. Using a pencil (or other available marking device), mark on the control knob the temperature setting as found. Turn the temperature knob all the way down.
3. Perform combustion/ventilation air calculations. Inadequate combustion air will cause the CAS test to fail. Inspectors and Program participants will refer to the California Mechanical Code and the attached Addendum #2 ("Combustion Ventilation Air").
4. Does the water heater share a common vent with another appliance? If it does, the two appliances must be operating simultaneously when smoke or mirror tests are performed under worst case Combustion Appliance Zone (CAZ) depressurization.
5. Is there soot at the flue termination, draft hood, vent pipe or burner access door?

A "yes" answer to any of the questions #6-13 below will cause the CAS test to fail. Continue the walk through and visual appliance inspection in order to report all problems to the customer.

6. Is the water heater located within a sleeping area?
7. Is an open combustion water heater with a standing pilot located in an attic with a whole house fan and the attic Net Free Vent area is not adequate per the whole house fan manufacturer's requirement?
8. Is there a soldered flex connector present or is the flex connector clearly labeled prior to 1973? Is there an uncoated brass flex connector present?
9. Are both access doors to the appliance missing? At least one must be present.
10. Are components missing (e.g. draft diverter, vent, or other components)? Using leak detection ('bubble') solution or an electronic leak detector, is there a gas leak near any of the fittings, or an odor in general at the unit? Leaks identified by an electronic leak detector must be verified with a leak detection ('bubble') solution test.
11. Is the vent pipe damaged? Is the draft hood out of alignment with the water heater flue or is spillage occurring? Are the sections of pipe adequately fastened?
12. Are there rust and/or weak spots due to corrosion?
13. Are there double draft diverters?

3.1.2. Gas Heaters

1. Make sure the unit is operational and the pilot is on.
2. Note the thermostat setting as found.
3. Turn the thermostat all the way down or to the off position.
4. Perform combustion/ventilation air calculations. Inadequate air openings will cause the CAS test to fail. Inspectors and Program participants will refer to the California Mechanical Code and the attached Addendum #2 ("Combustion Ventilation Air").
5. Inspect the heat exchanger for cracks.
6. Does the furnace share a common vent with another appliance? If it does, the two appliances must be operating simultaneously when smoke or mirror spillage tests are performed under worst case CAZ depressurization.
7. Is there soot at the flue termination opening, draft hood or vent pipe?

A "yes" answer to any of the questions #8-13 below will cause the CAS test to fail. Continue the walk through and visual appliance inspection in order to report all problems to the customer.

8. Is there a soldered flex connector present or is the flex connector clearly labeled prior to 1973? Is there an uncoated brass flex connector present?
9. Is an open combustion gas heater with a standing pilot located in an attic with a whole house fan?
10. Is the flame roll out shield or access door(s) to the appliance missing?
11. Are there components missing (e.g. access doors, draftdiverter, vent,

- or other components)?
12. Using a soap test solution or an electronic gas detector, is there a gas leak near any of the fittings, or an odor in general at the unit? Leaks identified by an electronic leak detector must be verified with a soap test.
 13. Is the vent pipe damaged? Are there rust and/or weak spots due to corrosion? Are the connections adequately fastened?

3.1.3. Central Forced Air

In addition to 3.1.2 Gas Heaters questions #1-13 above, a “yes” answer to question 1 below will cause the CAS test to fail. Continue the walk through and visual appliance inspection in order to report all problems to the customer.

1. Are the return air ducts damaged?
Look for communication. Check for openings that allow the return system of the furnace to draw by-products of combustion into the return duct systems and distribute them throughout the living space. (e.g. Furnace cabinet is misaligned with return plenum, blower compartment door is severely damaged and cannot be reinstalled or is not present, platform return has large holes and/or missing sections of sheetrock.) Make sure the return duct is sealed to the forced air unit. Make sure the filter compartment door is in place prior to operating the unit.

3.1.4. Gas Cook Tops, Ovens and Broilers

1. Make sure the unit is operational and the pilot(s) is lit. (Note: if the range top pilots are not lit, the test can still be performed by match-lighting the burners. Individual burners that are found non-operational and cannot be lit with a match must not be tested and must be noted. Cook stoves are never reported to CIP Dispatch or the PG&E Customer Service Line unless none of the burners operate *and* the customer has no means of cooking food (e.g. electric hot plate, microwave not present).
2. Remember that all exhaust fans and devices are off when testing cooking appliances.
3. Is there burned food (carbon deposits) inside the oven? If so, operate the oven for up to 15 minutes and note where reading stabilizes. Consult Addendum #1 to determine action.

A “yes” answer to questions #4-5 below will cause the CAS test to fail. Continue the walk through and visual appliance inspection in order to report all problems to the customer.

4. Using a soap test solution, is there a gas leak near any of the fittings, or a strong odor in general at the unit? Leaks identified by an electronic leak detector must be verified with a soap test.
5. Is there a soldered flex connector present or is the flex connector clearly

labeled prior to 1973? Is there an uncoated brass flex connector present?

3.1.5. Gas Clothes Dryer

1. Make sure the unit is operational and if it is standard ignition, that the pilot is on.

A “yes” answer to any of the questions #2-6 below will cause the CAS test to fail. Continue the walk through and visual appliance inspection in order to report all problems to the customer.

2. Using soap test solution or an electronic leak detector, is there a gas leak near any of the fittings, or an odor in general at the unit? Leaks identified by an electronic leak detector must be verified with a soap test.
3. Is dryer not being properly exhausted outside the building regardless of its location?
4. Does the dryer exhaust into another gas appliance’s vent system?
5. Does the dwelling have a floor furnace *and* is the dryer exhausted under the house?
6. Is there a soldered flex connector present or is the flex connector clearly labeled prior to 1973? Is there an uncoated brass flex connector present?

4. Room Ambient CO Reading

Alert the customer that testing is in progress and will require their cooperation. Close all doors and windows to the exterior and open all interior doors. Advise the customer not to open or close any doors or windows, or operate any gas appliances, exhaust fans, run hot water, or other interfering activity. The following procedure will produce the Room Ambient CO reading.

1. Turn on and zero the CO meter outside, away from car exhaust, smokers, fireplace or woodstove exhaust, or any other potential source of CO.
2. Turn off all gas appliances at the thermostat so as to allow only pilot burner operation.
3. Ask the customer if they have used an unvented appliance within the last ½ hour. If they have and the initial test fails, ventilate the dwelling for 15 minutes, then retest.
4. Close all egress doors and windows.
5. Close all doors and windows to gas appliance rooms.
6. Go to a central location within the house, at least ten (10) feet away from any combustion appliance. With all gas appliances in the home turned off at the thermostat, measure the Room Ambient CO at six (6) feet above the floor. If the Room Ambient CO level is 10 parts per million (ppm) or higher, follow the procedure outlined in #3 above. If this reading is still 10 ppm or more, the dwelling fails the CAS test.
7. The Room Ambient CO must be used to determine whether the CO Appliance Ambient readings for space heaters cause the CAS Test to Fail in Addendum #1 (“NGAT Ambient and Flue CO Action Levels for GSR Calls”) below.

5. Combustion Appliance Zone (CAZ) Worst Case Condition

The worst case condition must be established in each CAZ before performing 'appliance-on' testing. See Addendum #3 "Worst Case Depressurization Protocol" to establish the worst case condition in each CAZ.

6. Individual Appliance-On Testing

CO reading(s) in excess of standards per attached Addendum #1 ("NGAT Ambient and Flue CO Action Levels for GSR Calls"), or gas leaks identified by a gas odor, soap test or electronic leak detector will cause the CAS test to fail. Leaks identified by an electronic leak detector must be verified with a soap test. Per Section 1.1, a GSR or a properly licensed qualified technician must be called immediately (before leaving the customer's home) to schedule a visit. If the appliance fails and cannot be put into a safe operating condition, the appliance must be capped by a GSR, or capped or replaced by a properly licensed participating Contractor or properly licensed qualified technician contracted by the participating Contractor.

Always test the appliance with the smallest BTU_h input rate first after establishing the worst case depressurization per Part 5, Combustion Appliance Zone Test. When the smallest input appliance is a water heater that shares a common vent, test the water heater by itself under worst case condition first. Second, test the other appliance which is commonly vented with the water heater by itself under worst case condition. Third, perform spillage tests with both appliances operating simultaneously under worst case condition.

6.1. Water Heater (Separately Vented)

1. Turn the water heater thermostat to high, running water if necessary to cause continuous main burner operation, and note the time.
2. Verify that burner ignition is not delayed and check for flames more than 50% yellow. Roll-out, delayed (explosion, bang or boom at start up) ignition, or other operating defects will cause the CAS test to fail.
3. Check for spillage with smoke or mirror at 2 minutes for warm vent water heaters. If the spillage test fails at 2 minutes, advise the customer but DO NOT call for a GSR.²
4. After 5 minutes of burner operation, check the CO appliance ambient in the atmosphere above the tank near the draft diverter. Go all the way around the draft diverter and record after 1 minute or per combustion analyzer manufacturer's instructions.

² Water heaters are considered "warm vent" appliances per ANSI/BPI-1200-S-2017. Note: Appliances other than water heaters are considered "cold vent" unless they have been in operation immediately before the testing procedure or a commonly vented furnace with a water heater.

5. Check for spillage with smoke or mirror.
6. Test for CO at the flue at steady-state. Place the CO meter probe inside the draft hood into the flue of the appliance. The CO sampling must be taken before dilution air in the flue. Take a reading on both sides of the baffle and record the highest of the two readings. Record the CO Appliance Ambient level, Air Free Flue Gas CO level, and draft reading under the worst case CAZ depressurization. CO Appliance Ambient and Flue measurements in excess of attached Addendum # 1 (“NGAT Ambient and Flue CO Action Levels for GSR Calls”) will cause the CAS test to fail.

If CO flue gas testing is not safe and accessible, then the CO test will be limited to checking for CO in the ambient air above the unit. This is the CO Appliance Ambient reading. A CO Appliance Ambient reading of 10 ppm or more will cause the appliance to fail the CAS test. See attached Addendum # 1 (“NGAT Ambient and Flue CO Action Levels for GSR Calls”).

7. At the conclusion of ‘appliance-on’ testing, the contractor shall return the temperature to the ‘as found’ setting and advise the customer that the water temperature may be warmer than expected until the customer draws enough water to reduce the tank temperature to the as found setting.

6.1.1. Sealed Combustion Water Heaters

It is not possible to perform smoke or mirror spillage tests on these types of water heaters because they do not have natural draft (e.g. draft diverters, vent pipes). The CO test point is typically located at the rain cap on the roof or side wall of the structure. CO testing at these terminations should only be performed if it is safe to do so and only with proper ladders and other safety gear.

6.2. Heating Appliances (Separately Vented)

1. Turn the heater thermostat to high.
2. Verify that burner ignition is not delayed and check for flames more than 50% yellow. Roll-out, delayed (explosion, bang or boom at start up) ignition, or other operating defects will cause the CAS test to fail.
3. If warm vent heater, check for spillage after 2 minutes. If the spillage test fails at 2 minutes, advise customer but DO NOT call for a GSR.
4. At 5 minutes, check the CO Appliance Ambient in the first register nearest the furnace.
5. Check for spillage with smoke or mirror for cold vent heaters.
6. After 5 minutes, test for CO at the flue. Place the CO meter probe inside the draft hood into the flue of the appliance. The CO sampling must be taken before dilution air in the flue. CO Appliance Ambient and Flue

measurements in excess of attached Addendum # 1 (“NGAT Ambient and Flue CO Action Levels for GSR Calls”) will cause the CAS test to fail.

7. At the conclusion of ‘appliance-on’ testing, the contractor shall return the temperature to the ‘as found’ setting and advise the customer that the water temperature may be warmer than expected until the customer draws enough water to reduce the tank temperature to the as found setting.
8. Non ducted heating systems are checked for the Appliance Ambient CO in the Atmosphere above the unit.

6.2.1. Sealed Combustion Heaters

It is not possible to perform smoke tests on these types of heaters because they do not have natural draft (e.g. draft diverters, vent pipes). The CO test point is typically located at the rain cap on the roof or wall. If CO Flue Gas testing is not feasible, the CO test will be limited to checking for CO in the ambient air above the unit. This is the CO Appliance Ambient reading. For central forced air sealed combustion heaters, the CO Appliance Ambient reading must be taken inside the first supply register closest to the furnace. CO Appliance Ambient read of 2 ppm or greater than the CO Room Ambient reading will cause the appliance to fail the CAS test. See attached Addendum # 1 (“NGAT Ambient and Flue CO Action Levels for GSR Calls”).

6.2.2. Commonly Vented Water Heater and Furnace

1. Turn the water heater thermostat to high, running water if necessary to cause continuous main burner operation, and note the time.
2. Verify that burner ignition is not delayed and check for flames more than 50% yellow. Roll-out, delayed (explosion, bang or boom at start up) ignition, or other operating defects will cause the CAS test to fail.
3. Check for spillage with smoke or mirror at 2 minutes for warm vent water heaters.³
4. After 5 minutes of burner operation, check the appliance ambient in the atmosphere above the tank near the draft diverter. Go all the way around the draft diverter and record after 1 minute or per combustion analyzer manufacturer’s instructions.
5. Check for spillage with smoke or mirror.
6. After 5 minutes, test for CO at the flue. Place the CO meter probe inside the draft hood into the flue of the appliance. The CO sampling must be taken before dilution air in the flue. Take a reading on both sides of the baffle and record the highest of the two readings.

³ Water heaters are considered “warm vent” appliances per ANSI/BPI-1200-S-2017. Note: Appliances other than water heaters are considered “cold vent” unless they have been in operation immediately before the testing procedure or a commonly vented furnace with a water heater.

7. Turn on the larger appliance, typically the furnace. Wait 2 minutes and test for spillage on the smaller appliance, typically the water heater.
8. Check for spillage on the larger appliance, typically the furnace.
9. At 5 minutes after turning on the larger appliance, check for the Appliance Ambient CO in the register nearest the furnace. If the reading is 2 ppm or greater than the Room Ambient, the furnace fails the CAS test.
10. Test spillage at the larger appliance, typically the furnace.
At 5 minutes, test for CO at the flue. Place the CO meter probe inside the draft hood into the flue of the appliance. The CO sampling must be taken before dilution air in the flue. CO Appliance Ambient and Flue measurements in excess of attached Addendum # 1 (“NGAT Ambient and Flue CO Action Levels for GSR Calls”) will cause the CAS test to fail.

6.3. Gas Dryer

Gas Dryers must be checked for gas leaks (by sensory smell or electronic leak detector and verified by a leak detection [‘bubble’] solution test) and must exhaust to the outside of the building as stated in 3.1.5 above. Measure the CO in the dryer exhaust. Measurements of 101 ppm air free or greater fail (please note the significant difference with BPI⁴⁴).

6.4. Gas Cook Tops, Ranges, Ovens, Broilers

1. Locate the flue gas termination for all existing oven and broiler burners.
2. With exhaust fans and devices off, turn on all the cook top burners including any griddle burner present. Measure and record Appliance Ambient CO read in the middle of the kitchen and 6 feet above the floor after 1 minute of burner operation. If this reading is 10 ppm or more, the cook tops fail the Appliance Ambient CO test.
3. Turn off all cook top and griddle burners except the one in the upper left hand corner facing the appliance (left rear burner). Measure and record CO Flue as measured readings for each cook top burner separately 12 inches above the visible part of the flame. If any burner measures 26 ppm or greater, the burner fails the CO as measured flue test.
4. Test each oven or broiler burner separately, recording an Appliance Ambient CO read and an as measured Flue CO read for each burner.
5. Run each oven or broiler burner at its highest setting for a minimum of 5 minutes before taking Appliance Ambient CO and as measured Flue CO readings.
6. Measure the Appliance Ambient CO read for each oven or broiler burner separately (after each has been operating for 5 minutes) in the middle of the kitchen and 6 feet above the floor. If the Appliance Ambient reading is 10 ppm or greater, the oven or broiler burner fails the test.
7. After each Appliance Ambient CO read is taken for an oven burner or a broiler burner, immediately take the Flue CO as measured reading for

⁴ See Table page 13, Table 1, item 7.9.5 of ANSI/BPI-1200-S-2017.

that same burner inside the flue. Each burner should be operating separately for 5 minutes. If the Flue CO as measured reading for any oven or broiler burner is 226 ppm or more, that burner fails the test. See Addendum #1 ("NGAT Ambient and Flue CO Action Levels for GSR Calls").

8. If one burner provides both broiling and baking, read a record the one burner as an OVEN burner.

6.5. Gas Log Fireplaces

Natural gas log fireplace heaters will be inspected and a CO test performed to determine CO levels during normal operation. The CO meter probe will be placed at least 12" above the flame. A CO reading of 26 ppm or higher will cause the CAS test to fail. Ceramic logs must be allowed to heat for at least ten (10) minutes before the test is taken. A smoke test will be performed to ensure that the appliance is operating correctly. Continuous spilling will cause the CAS test to fail. Dampers must be open during this test.

6.6. Gas Log Lighters

Gas log lighters will be inspected for gas leaks only, and do not require appliance-on CO and draft/spillage testing.

List of Addenda

Addendum #1: NGAT Ambient and Flue CO Action Levels for GSR Calls -- Revised for Make Safe CO Levels 09/01/2018

Addendum #2: Combustion Ventilation Air Supplement
Addendum # 3: Worst Case Depressurization Protocol

Addendum #1: NGAT Ambient and Flue CO Action Levels for GSR Calls

(Revised for Make Safe CO Levels 09/01/2018)

Appliance/Room	Ambient CO ppm	Ambient Measurement Location	Flue CO ppm As Measured	Flue CO ppm * Air Free	Flue Measurement Location *	Make Safe CO Thresholds (IR)
Room Ambient	10 ppm or greater	Center of home 6 ft above floor	-----	-----	-----	Equal to or greater than 26 ppm
Floor Furnace	2 ppm or greater above room ambient	Above top of unit	-----	101 ppm or greater	Inside each exhaust port separately. Record left to right if more than one.	-Flue CO equal to or greater than 401 PPM Air Free OR -“Ambient 2” Ambient CO Read is 2 PPM greater than “Ambient 1” Room Ambient CO Read
Forced Air Furnace (Includes Dual Pack)	2 ppm or greater above room ambient	Inside supply register nearest to furnace	-----	101 ppm or greater	Inside each exhaust port separately. Record left to right if more than one. No flue read required for RTFAF*	-Flue CO equal to or greater than 401 PPM Air Free OR -“Ambient 2” Ambient CO Read is 2 PPM greater than “Ambient 1” Room Ambient CO Read
Gas Log Heater-Freestanding/Insert/Direct Vent	2 ppm or greater above room ambient	Above unit	-----	101 ppm or greater	Inside the flue	-Flue CO equal to or greater than 401 PPM Air Free OR -“Ambient 2” Ambient CO Read is 2 PPM greater than “Ambient 1” Room Ambient CO Read
Gravity Furnace	2 ppm or greater above room ambient	Inside supply register nearest to furnace	-----	101 ppm or greater	Inside each exhaust port separately. Record left to right if more than one.	-Flue CO equal to or greater than 401 PPM Air Free OR -“Ambient 2” Ambient CO Read is 2 PPM greater than “Ambient 1” Room Ambient CO Read
Vented Room Heater	2 ppm or greater above room ambient	Above top of unit and draft diverter	-----	101 ppm or greater	Inside each exhaust port separately Record left to right if more than one	-Flue CO equal to or greater than 201 PPM Air Free OR -“Ambient 2” Ambient CO Read is 2 PPM greater than “Ambient 1” Room Ambient CO Read
Wall furnace	2 ppm or greater above room ambient	Above top of unit and draft diverter	-----	101 ppm or greater	Inside of flue on each side of baffle Record the highest read	-Flue CO equal to or greater than 201 PPM Air Free OR -“Ambient 2” Ambient CO Read is 2 PPM greater than “Ambient 1” Room Ambient CO Read

Appliance/Room	Ambient CO ppm	Ambient Measurement Location	Flue CO ppm As Measured	Flue CO ppm * Air Free	Flue Measurement Location *	Make Safe CO Thresholds (IR)
Wall Furnace Direct Vent	2 ppm or greater above room ambient	Above top of unit	-----	101 ppm or greater	Flue gas CO is measured at the flue termination when it is accessible from the ground	-Flue CO equal to or greater than 401 PPM Air Free OR -"Ambient 2" Ambient CO Read is 2 PPM greater than "Ambient 1" Room Ambient CO Read
Water Heater	10 ppm or greater	Above and around top of tank and draft diverter	-----	101 ppm or greater	Inside flue on each side of baffle Record the highest read	-Flue CO equal to or greater than 201 PPM OR -Appliance Ambient CO PPM is equal to or greater than 26 PPM
Range Top Burners and Griddle	10 ppm or greater	Center of kitchen	26 ppm or greater (per Burner)	-----	Burner: 12 inches above flame Griddle: Inside port opening U or W pattern left to right	-Equal to or greater than 26 PPM As-Measured (per burner) OR -Appliance Ambient CO PPM is equal to or greater than 26 PPM
Oven/Broiler	10 ppm or greater	Center of kitchen	226 ppm or greater	-----	Inside exhaust port	-Equal to or greater than 226 PPM As-Measured OR -Appliance Ambient CO PPM is equal to or greater than 26 PPM
Gas Log Fireplace	-----	-----	26 ppm or greater	-----	Inside top edge of fireplace opening	-Equal to or greater than 26 PPM As-Measured (per burner)
Gas Dryer	-----	-----	-----	101 ppm or greater	Inside the dryer exhaust or lint filter access	Not Applicable (NO Make Safe Level within PG&E Policy)

* If flue is not accessible and no flue read is possible, appliance ambient determines action. Include valid reason for no flue read in Comments on NGAT Results.

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 CubicFeet.
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 (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 1, conditioned space in different stories is considered communicating when 2 in² NFVA per 1K BTU/hr.

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: Minimum dimension of air openings shall not be less than 3 in.

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 a water heater or furnace is in an enclosure that has non-standard doors (pocket, accordion, etc.) which cannot be weather-stripped, it is OK to not weather-strip 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 3.14 Radius = 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 = 75% of the actual vent opening.

MESH, LESS THAN ¼ in. = Non-compliant.

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

Addendum # 3 Worst Case Depressurization and Combustion Procedure

Name: _____
Address: _____
City: _____

Date: _____ Time: _____ AM/PM
Wind: _____
Temp Out: _____ Ambient CO _____

WORST CASE DEPRESSURIZATION & COMBUSTION PROTOCOL

MEASURE AMBIENT CO DURING TEST (If 26 ppm or greater stop test and Make Safe. If 70 ppm or greater, evacuate the building.)

Measure and Record Baseline Pressure in each CAZ

- Close and latch all exterior doors and windows
- All interior doors closed except rooms with an exhaust fan or rooms with a central return. This includes a room with only an exhaust fan and a supply register.
- All appliances set to stand-by mode, all fireplace dampers closed with flames extinguished.
- Close all CAZ doors.
- All exhaust fans and devices off.
- All ventilation fans, either supply and/or exhaust, that run 24 hours a day 7 days a week should be left on.
- Measure and record pressure in each CAZ WRT outside. It is possible that after comparing all of the pressures below, the baseline pressure itself in each CAZ may be the worst case (most negative pressure.)

CAZ # 1 ____ CAZ #2 ____ CAZ #3 ____ CAZ #4 ____

Steps for Measuring and Recording Worst Case Pressure in each CAZ

1. Turn on exhaust equipment: clothes dryers, range hoods, and any other exhaust fans. Run at high speed, do not turn on whole house fans.
-Measure and record pressure in each CAZ WRT outside.
Measured: CAZ # 1 ____ CAZ #2 ____ CAZ #3 ____ CAZ #4 ____
2. Turn on any (all) air handlers with all exhaust devices in Step 1 on. Measure and record pressure in each CAZ WRT outside. _
Measured: CAZ # 1 ____ CAZ #2 ____ CAZ #3 ____ CAZ #4 ____
3. Open interior door (s) directly leading to the CAZ one at a time. Measure each CAZ WRT outside. Leave the air handler on if any of the CAZ (s) become more negative than Step 1 above.
Measured: CAZ # 1 ____ CAZ #2 ____ CAZ #3 ____ CAZ #4 ____
4. Determine worst case for each CAZ considering all Steps above.

Record Worst Case for each CAZ WRT outside

Worst Case CAZ #1 _____ Worst Case CAZ #2 _____ Worst Case CAZ #3 _____ Worst Case CAZ #4 _____

Operate appliances to be tested individually under Worst Case Depressurization condition found for each CAZ above. When two appliances share a common vent, follow these steps: 1) test smallest unit for Spillage and CO, turn off. 2) Test larger unit for Spillage and CO. 3) Restart smaller unit so both are running and test with Spillage for both units. Measure and record results for each appliance. See Whole House CAS Protocol for all visual inspection and appliance on testing details. For required actions to be taken, see Natural Gas Appliance Testing Action Guidelines (Non ESA/Non Low Income 2019).

Special Exception for Worst Case CAZ Pressures found: When testing a combustion appliance in a room with a door that can be closed (not in the main body of the house) with an exhaust device (s) and a supply register from the forced air system, close both the supply register and the door to this room and leave the exhaust device (s) on while testing. Test the cooking appliances last. Before testing the cooking appliances, turn off all exhaust fans and devices including the air handler and leave the doors in their current position.

Water Heater #1

Smoke Test P or F
Ambient CO _____ P or F
Flue CO _____ P or F

Water Heater #2:

Smoke Test P or F
Ambient CO _____ P or F
Flue CO _____ P or F

Space Heater #1

Smoke Test P or F
Appliance Ambient CO _____ P or F
Flue CO Reads: ___ P or F ___ P or F ___ P or F ___ P or F ___ P or F

Space Heater #2

Smoke Test P or F
Appliance Ambient CO _____
Flue CO Reads: ___ P or F ___ P or F ___ P or F ___ P or F ___ P or F

Gas Log Fireplace: Smoke Test _____ (P or F) Flue Read _____ (P or F)

Tankless Water Heater: Appliance Ambient _____ (P or F) Flue CO _____ (P or F)

Gas Cook Tops : Appliance Ambient _____ (P or F) Individual Reads: 1. _____ (P or F) 2. _____ (P or F) 3. _____ (P or F) 4. _____ (P or F) 5. _____ (P or F) 6. _____ (P or F)

Oven: Appliance Ambient _____ (P or F) Flue Read _____ (P or F)

Broiler: Appliance Ambient _____ (P or F) Flue Read _____ (P or F)

Additional 1 : Type _____ Smoke Test P or F Appliance Ambient CO _____ Flue CO _____

Additional 1 : Type _____ Smoke Test P or F Appliance Ambient CO _____ Flue CO _____