Combustion Appliance Safety Testing

California Building Performance Contractors Association

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Overview of Combustion Safety Test Procedure

- Measure the Base Pressure.
- Establish the Worst Case combustion appliance zone pressure.
- Monitor ambient CO during test procedure in the breathing zone.
- Measure Worst Case Spillage, Draft and CO.
- Measure Spillage, Draft and CO under natural conditions if necessary.
- Make recommendations or complete work per the Action Level Table.
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

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

*CO measurements for undiluted flue gases at steady state
<table>
<thead>
<tr>
<th>Venting Condition</th>
<th>Limit (Pascals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orphan natural draft water heater (including outside chimneys)</td>
<td>-2</td>
</tr>
<tr>
<td>Natural draft boiler or furnace commonly vented with water heater</td>
<td>-3</td>
</tr>
<tr>
<td>Natural draft boiler or furnace with damper commonly vented with water heater</td>
<td>-5</td>
</tr>
<tr>
<td>Individual natural draft boiler or furnace</td>
<td>-5</td>
</tr>
<tr>
<td>Induced draft boiler or furnace commonly vented with water heater</td>
<td>-5</td>
</tr>
<tr>
<td>Power vented or induced draft boiler or furnace alone, or fan assisted DHW alone</td>
<td>-15</td>
</tr>
<tr>
<td>Chimney-top draft inducer; exhausto type or equivalent; high static pressure flame</td>
<td>-50</td>
</tr>
<tr>
<td>retention head oil burner; Direct vented appliances; Sealed combustion appliances</td>
<td></td>
</tr>
<tr>
<td>Outside Temperature (degree F)</td>
<td>Draft Pressure Standard (Pa)</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>&lt;10</td>
<td>-2.5</td>
</tr>
<tr>
<td>10-90</td>
<td>( \frac{T_{out}}{40} - 2.75 )</td>
</tr>
<tr>
<td>&gt;90</td>
<td>-0.5</td>
</tr>
<tr>
<td>Appliance Type</td>
<td>Spillage Test Period (minutes)</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Water Heater, Gravity Furnace, Boiler</td>
<td>1.0</td>
</tr>
<tr>
<td>Space Heater</td>
<td>1.0</td>
</tr>
<tr>
<td>Forced Air Furnace</td>
<td>1.0</td>
</tr>
</tbody>
</table>
ATMOSPHERIC AIR INJECTION BURNER

SECONDARY AIR IS TAKEN FROM THE ATMOSPHERE IMMEDIATELY SURROUNDING THE FLAME

AIR SHUTTER IS TURNED TO REGULATE THE PRIMARY AIR

ADJUSTABLE ORIFICE HOOD

GAS WAY

PRIMARY AIR IS DRAWN IN HERE

BURNER PORTS

VENTURI OR MIXER TUBE - HAVING A 2° ANGLE OF INCREASE FROM THE THROAT TO BURNER HEAD

MIXER HEAD
Combustion with Sufficient Air

\[
\text{NATURAL GAS (CH}_4\text{)} + \text{AIR} \quad = \quad \text{(with flame)}
\]

\[
\text{H}_2\text{O} + \text{CO}_2 + \text{O}_2 + \text{N}_2 + \text{Heat}
\]
Combustion with Insufficient Air

NATURAL GAS (CH₄) + AIR
= (with flame)
H₂O + CO₂ + CO + O₂ + N₂
+ Less Heat
RECESSED WALL HEATER

VENT

SUPPLY (HEATED) AIR

GRILLE

HEAT EXCHANGER

COMBINATION DIAPHRAGM VALVE

MAIN BURNER

HYDRAULIC DIASTAT

RETURN (COOLER) AIR
PURPOSE OF A DRAFT DIVERTER

1.-PROVIDE RELIEF ON START UP.

2.-PROVIDE DILUTION AIR

3.-PROVIDE RELIEF FROM DOWNDRAFTS.

4.-PROVIDE RELIEF FROM UPDRAFTS.

5.-PREVENT EXCESSIVE STACK ACTION.
As seen in the cut-away view of the 7900 series furnace, combustion air is supplied to the burner through the roofjack, down the size of the furnace to an area around the burner inlet to the combustion chamber. Primary air for combustion is drawn into the venturi of the burner by the action of gas velocity (aspiration) in the venturi. This air and gas mixture is thoroughly mixed in the mixing chamber and discharged against the burner flame spreader where it is ignited by the pilot.

Combustion is completed with the addition of secondary air around the outside of the burner into the combustion chamber. The hot products of combustion then rise in the heat exchanger and pass to the outside through the inner flue pipe and top cover on the roofjack. All combustion air is taken in the lower roofjack cover from outside the home resulting in a system referred to as a sealed combustion furnace.

The 7900 Series (except the 7995-856) standing pilot furnaces operate with a natural draft which is started by the gas valve opening to first stage—low fire. The low fire stage starts the heated air finding its way upward and out through the flue. This starts the natural convection of air through the heat exchanger before the gas valve turns on full fire. The 7995-856 and the 7900 series auto ignition furnaces have a combustion air booster motor to start the cold air flowing up the flue before ignition of the burner. On the auto ignition furnace there is a delay before the igniter sparks. This is called the purge cycle.
The louvers on the top front of the furnace admit return air. Return air must be provided back to the circulating blower in order to provide air distribution. Do not enclose the furnace or otherwise obstruct these louvers. To do so will cause the burner to limit off.

A dirty filter will also block return air and limit the burner off.

The air is then blown down past the heat exchanger, where it picks up the heat, and into the furnace coil cavity. If an A/C coil has been installed in the furnace, the heated air must pass through the A/C coil before entering the warm air ducts.

If too many duct registers are closed or the duct has become restricted by some means, not enough heated air will be forced out of the furnace and cause the burner to limit off. A dirty A/C coil will also block heated air from leaving the furnace and limit the blower off. A moderate blockage of the heated air leaving the furnace could let the furnace heat the home fairly well but cause the furnace blower to cycle on after shut down of the burner system and cooling of the heat exchanger due to hot air flowing back into the furnace from the ducts and activating the fan switch.
Figure 7-I. Construction of Double-Wall Type B Gas Vent. (Drawing courtesy of Gas Vent Institute.)

Figure 7-J. Type B and Type B-W Double-Wall Gas Vent Fittings. (Photo courtesy of Selkirk Metalbestos.)
To make a gas dryer, manufacturers replace the electric heater in their electric dryers with a gas heater.
Primary serpentine heat exchanger → Secondary condensing heat exchanger
CONFINED SPACE
AIR FROM VENTILATED ATTIC/
CRAWL SPACE

ATTIC LOUVERS
TO OUTDOORS

CONFINED
SPACE

OUTLET
AIR

INLET
AIR DUCT

ALTERNATE
INLET AIR

ALTERNATE
INLET AIR