Combustion Safety in the Codes

Larry Brand
Gas Technology Institute

Acknowledgement to Paul Cabot – American Gas Association
Combustion Safety in the Codes

Widely adopted fuel gas codes:

- International Fuel Gas Code – published by the International Code Council (IFGC)
- Uniform Plumbing Code published by IAPMO (UPC)

Safety codes become requirements when adopted by the Authority Having Jurisdiction (governments or fire safety authorities)
Formal Relationships Between these codes:

– The IFGC extracts many safety requirements from the NFGC
– The UPC adopts most safety requirements from the NFGC

Ensures all three codes have the same requirements
Combustion Safety in the Codes

Scope:
• All installations of gas piping, appliances, equipment, and related accessories.
• After the point of delivery defined as the gas utility meter or second stage regulator for LP.
• Systems/Installations up to gas pressure of 125 psig
What’s in the Code?

NFGC/IFGC/UPC - FUNDAMENTAL SAFETY RELATED COVERAGE:

1. Gas piping: allowed materials, sizing, installation, inspection and testing
2. Appliance Installation: clearances to combustible materials, combustion air, and testing
3. Appliance venting: allowed materials, vent type selection, sizing, installation, and testing
Three Key Provisions For Combustion Safety

1. Combustion air requirements
2. Language on placing an appliance in operation
3. Vent sizing tables for atmospheric combustion and fan-assisted (Category I) equipment
1. Combustion Air

General Combustion Air Supply:

Specified by appliance type:

- Natural draft and category I appliances:
  The code contains calculation methods for use of indoor air, outdoor air, or a combination.

- Other than natural draft and Category I appliances:
  In accordance with the manufacturers installation instructions.
Allowed Combustion Air Sources:

- 100% Indoor air
- 100% Outdoor air
- Combination of Indoor/Outdoor air
- Mechanically supplied
- Engineered Systems
Indoor Combustion Air:

Two calculation methods:

- Where the infiltration rate is **unknown**:  
  - 50 Cubic Feet (indoor building volume) per 1,000 Btu appliance input  
  - Historical basis is 0.5 Air Change per Hour (ACH)  
  - Assumes all appliances are natural draft (requires vent dilution air supply)

- Where the infiltration rate is **known** or is set by the local authority  
  - Indoor volume is calculated based on the ACH and appliance type  
  - Appliances are classified as either fan-assisted or other than fan assisted (Fan-assisted appliances do not require a vent dilution air supply)
1. Combustion Air

**Outdoor Combustion Air:**

Where indoor air is insufficient the code requires the use of outdoor air:

- Outdoor openings are sized based on:
  - Appliance Btu input
  - Number of openings to be installed (one or two)
  - The opening is directly to the outdoors or through ducts
Combination Indoor/Outdoor Combustion Air:
- The size of the outdoor openings can be reduced where some indoor volume can be used.

Mechanical Combustion Air:
- A central ventilation air system is allowed to be used to supply combustion air
- System must provide in addition to all ventilation air a minimum of 0.35 cubic foot per minute for each 1,000 Btu/hr of appliance input
- System must be interlocked to the appliances

Engineered Combustion Air:
- Must be approved by the Authority Having Jurisdiction
2. Placing an Appliance in Operation

2012 NFGC Section 11
Follow the manufacturers installation instructions.
1. Adjust input (on rate and derate for high altitude)
2. Adjust primary air
3. Check safety shutoff devices
4. Check automatic ignition devices
5. Check limit controls
6. Check the draft

2012 IFGC Section 305.1
Equipment and appliances shall be installed...according to the manufacturers installation instructions.

Appendix D (IFGC), Annex G (NFGC) - “Recommended Procedure for Safety Inspection of an Existing Appliance Installation”
Not a part of the code.
(Continued)
“Draft hood-equipped appliances shall be checked to verify that there is no draft hood spillage after 5 minutes of main burner operation.”
Failing the test fails the inspection and remediation is required.
2. Atmospheric Water Heater Manufacturers Installation Instructions (example)

**COMBUSTION AIR AND VENTILATION FOR APPLIANCES LOCATED IN UNCONFINED SPACES**

**UNCONFINED SPACE** is a space whose volume is not less than 50 cubic feet per 1,000 Btu per hour (4.8 cm per kW) of the aggregate input rating of all appliances installed in that space. Rooms communicating directly with the space in which the appliances are installed, through openings not furnished with doors, are considered a part of the unconfined space.

In unconfined spaces in buildings, infiltration may be adequate to provide air for combustion, ventilation, and dilution of flue gases. However, in buildings of tight construction (for example, weather stripping, heavily insulated, caulked, vapor barrier, etc.), additional air may need to be provided using the methods described in "Combustion Air and Ventilation for Appliances Located in Confined Spaces."

**COMBUSTION AIR AND VENTILATION FOR APPLIANCES LOCATED IN CONFINED SPACES**

**CONFined SPACE** is a space whose volume is less than 50 cubic feet per 1,000 Btu per hour (4.8 cm per kW) of the aggregate input rating of all appliances installed in that space.

A. ALL AIR FROM INSIDE BUILDINGS: (See Figure 4 and 5)

The confined space shall be provided with two permanent openings communicating directly with an additional room(s) of sufficient volume so that the combined volume of all spaces meets the criteria for an

**START UP CONDITIONS**

DRAFTHOOD OPERATION

Check draft hood operation by performing a worst case depressurization of the building. With all doors and windows closed, and with all air handling equipment and exhaust fans operating such as furnaces, clothes dryers, range hoods and bathroom fans, a match flame should still be drawn into the draft hood of the water heater with its burner firing. If the flame is not drawn toward the draft hood, shut off water heater and make necessary air supply changes to correct.

**VENTING SYSTEM INSPECTION**

**WARNING**

Breathing Hazard - Carbon Monoxide Gas

- Flue gases may escape if vent pipe is not connected.
- Be aware of obstructed, sooted or deteriorated vent system to avoid serious injury or death.
- Do not store corrosive chemicals in vicinity of water heater.
- Chemical corrosion of flue and vent system can cause serious injury or death.

Breathing carbon monoxide can cause brain damage or death. Always read and understand instruction manual.

At least once a year a visual inspection should be made of the venting system. You should look for:

1. Obstructions which could cause improper venting. The combustion and ventilation air flow must not be obstructed.
2. Damage or deterioration which could cause improper venting or leakage of combustion products.
3. Rusted flues around top of water heater.

Be sure the vent piping is properly connected to prevent escape of dangerous flue gases which could cause deadly asphyxiation.

Obstructions and deteriorated vent systems may present serious health risk or asphyxiation.
2. Procedures for Safety Inspection

“This appendix is informative and not a part of the code.”

Procedure is intended as a guide that an appliance is properly installed and in safe condition for continuing use. Intended for central furnaces and boilers.

1. Check for gas leaks
2. Inspect the vent for compliance to codes and deterioration
3. Shut off gas
4. Inspect burners and crossover tubing
5. Furnace – inspect heat exchanger
6. Boiler – inspect for leaks
7. Set up the house for test
   a. Close all doors and windows
   b. Turn on clothes dryers
   c. Turn on exhaust fans at max speed – range hoods and bathroom vents (not whole house fan)
   d. Close fireplace damper
2. Procedures for Safety Inspection

7. Place appliance in operation – set to operate continuously
8. Check pilot, main burner ignition, pilot sense device
9. Check main burner - no floating, lifting, flashback

10. Test for spillage at the draft hood relief opening after 5 minutes of operation with match, candle, or smoke

11. Turn on other appliances in the same room
12. Repeat steps 10-11 on appliance being inspected
13. Return building to previous condition
14. Furnace – check limit and fan control
15. Boiler – check safety devices
SELF-SELECTION OF VENTS:

- Based on appliance operating parameters:
  - Natural draft or mechanically vented
  - The listed vent category for furnaces and boilers
    - I, II, III, or IV

Types of Vents

- Masonry, metal, and factory-built chimneys
- Gas Vents
  - Listed Type B & Type L
  - Vents specified by the manufacturer

VENTING TABLES

• 15 Tables
• Applicable to natural draft appliances
  – Includes Category I and fan assisted Category I appliances
  – Typical storage-type water heaters, 78%-82% AFUE furnaces & boilers

Table 13.2(a) Type B Double-Wall Vent

Vent CONNECTOR Capacity

<table>
<thead>
<tr>
<th>Appliance Vent Connection</th>
<th>Type B Double-Wall Connector Diameter — D in.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Number of Appliances:</td>
<td>Two or More</td>
</tr>
<tr>
<td>Appliance Type:</td>
<td>Category I</td>
</tr>
<tr>
<td>Appliance Vent Connection:</td>
<td>Type B Double Wall Connector</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Height (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

Appliance Input Rating Limits in Thousands of Btu per Hour

<table>
<thead>
<tr>
<th>Height (d)</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vent systems other than Category I – refer to manufacturers installation instructions
What combustion safety-related assumptions are behind the venting tables – FAN and NAT?

- **Minimum capacity** – FAN only; governed by the wet-time rule to avoid corrosion failures.
- **Maximum capacity** – Governed by buoyancy requirements.
  - For FAN - Calculated based on zero static vent pressure 1 ft. from appliance outlet 1 minute from the start of the third appliance cycle. These systems also have vent safety switches.
  - For NAT, maximum capacity is based on venting tables originally published in the 1950’s and supported by 60 years of field performance.
All Codes

1. Required volume of combustion air as calculated
2. For draft hood equipped appliances: no spillage after 5 minutes of main burner operation. Recommended safety inspection. For fan-assisted appliances, tables are based on: zero static pressure one ft. from appliance outlet 1 minute into the third appliance cycle.
3. Vent installation consistent with the tables
Summary – Open Questions

- What is the basis for the combustion air calculations?
- What is the basis for checking performance of the draft hood after 5 minutes?
- Has anything changed to cause us to re-visit the assumptions behind the recommendations in the codes?
Overall residential gaps/barriers addressed in this presentation:
Common Basis for Combustion Safety Recommendations

- Specifically, recommendations for tight houses

What have we achieved so far?

- This presentation sets the basis for combustion safety procedures in the National and International Fuel Gas Code.

What is left to achieve?

- The highest priority issue remaining to be solved is disconnect between code language, manufacturer installation instructions, and recommendations by field inspectors.
- We plan to continue to close this gap by identifying the differences between recommendations and seeking common ground.
- Possible risks going forward include differing recommendations not based on building science research.
Combustion Safety Expert Meeting

U.S. Department of Energy, Energy Efficiency and
Renewables, Building America Program

Partnership for Advanced Residential Retrofit (PARR)

**Topic:** “Combustion Safety in Tight Houses”

**When:** Thursday June 28, 2012; 9 a.m. to 3 p.m. Central, (post-ASHRAE)

**Where:** CPS Energy Board Room *(Address)*, San Antonio Texas

**Dial-in Number:** NREL Live Webinar

**Description:** The Department of Energy Building America program focuses on reducing energy consumption in the nation’s housing stock through smart application of energy efficient design and whole-house upgrades. The target is a 30% energy savings captured through application of many measures including reduction in air infiltration, equipment upgrades, and thermal envelope losses. Combustion safety testing is an important part of the test-in and test-out process in new construction and retrofit (upgrade) projects when houses are being tightened to reduce energy losses through air infiltration. Where combustion safety testing identifies excessive spillage or continuous back-drafting, remedial measures are required.