

Green Building Practice Summary

3/10/2011

Sector: Residential

Category/Practice: IEQ / Safer Combustion Appliances: New Construction

Proposed GB Practice

Description

Most natural draft combustion appliances (furnaces, boilers, water heaters) must be located outside the pressure boundary of the building, in a mechanical room that is sealed from the rest of the building and connected to outdoors via code-required combustion air openings. A self-closing, gasketed door is required. No other exhaust appliances may be located in the mechanical room. Performance testing is required to document that:

- the mechanical room is decoupled from pressure changes within the building;
- natural draft combustion appliances pass the Building Performance Institute (BPI) combustion safety test under “worst-case” conditions.

Natural draft fireplaces, located anywhere in the building, must pass the Building Performance Institute (BPI) combustion safety test under “worst-case” conditions.

All testing will be performed by certified contractors.

When other types of combustion appliances are used that are less vulnerable to spillage of combustion products (power-vented, sealed-combustion or direct-vent appliances), there are no new restrictions on their location and no testing is required to document compliance with this amendment. All appliances designed to operate as sealed-combustion must be installed with hard-piped outdoor combustion air supply and sealed exhaust.

Applicability

New Construction: Applies

Existing Buildings/Additions: Applies to combustion appliances located in the addition.

Existing Buildings/Alterations: Does not apply (see companion proposed amendment: “Safer Combustion Appliances: Existing Buildings”)

Intent

Eliminate potential health and safety hazard of combustion products spilling into building.

Benefits and Costs

Triple Bottom Line Benefits

People: Health and safety for occupants is the primary benefit of this proposed change. Installing combustion equipment more safely or using equipment less vulnerable to spillage of combustion products addresses the root cause of potential health and life safety concerns.

If all combustion appliances are sealed-combustion or direct-vent, with 100% of combustion air directly drawn from outside through sealed ducts, open combustion air ducts can be eliminated; this, in-turn, eliminates a common source of cold drafts and improves occupant comfort.

Economic: By isolating or eliminating the need for open combustion air ducts, a sizable uncontrolled air leak is reduced or eliminated, providing a small reduction in heating and cooling energy use and costs (\$10 to \$15 per year).

When builders will choose to meet the requirement by selecting sealed-combustion furnaces, there will be savings associated with increased efficiency; virtually all sealed-combustion furnaces are rated at 90+ AFUE, whereas code-minimum furnaces are rated at 80 AFUE. Savings from this change are approximately \$50 to \$60 per year.

Environment: None

Costs Passed to Owner

The incremental cost estimate to meet the proposed requirement, using code-minimum-efficiency, natural draft space and water heating equipment, is “high” (\$1,200 to \$1,500). This represents the cost of building a sealed mechanical room and hiring a contractor to perform the testing to document compliance.

Alternatively, compliance can be achieved using combustion appliances that aren’t required to be isolated from the building. The aggregate cost increase is “high” (\$2000 max) to “very high” (greater than \$2000), based on the following appliances:

- Water heater incremental cost: The least expensive water heater option applicable in most new buildings will be power-vented storage units: \$500 to \$1500 cost increase compared with a conventional, natural draft storage water heater.
- Furnace incremental cost: The increased cost of a basic, single-stage, 90 AFUE sealed-combustion furnace compared with a basic, single-stage, 80 AFUE furnace (code-minimum) is approximately \$1000. (Note that 90+ AFUE sealed-combustion furnaces have been installed in most new Fort Collins homes in recent years, so it might be argued the incremental furnace cost is zero.)
- Fireplace incremental cost: No cost. Direct-vent units that meet this requirement are current practice in Fort Collins new construction.

Lost Opportunity

The City encourages installation of safer combustion appliances. Doing so at time of construction avoids lost opportunities associated with support details including gas piping, venting and electrical layout.

Implementation

Availability of Products and/or Services

Products and services are readily available to build mechanical rooms; however, see “Practicality” below regarding the challenge of effectively sealing a mechanical room from the building. Experience will be needed to be able to do so with a reasonable amount of labor.

Combustion appliances not required to be isolated from the building are readily available from all major equipment manufacturers. Local contractors have extensive experience installing sealed-combustion furnaces and direct-vent fireplaces, less so with compliant water heater options. It is anticipated that more widespread use of these products will, over time, decrease their incremental cost versus conventional combustion appliances.

Practicality

To comply with the proposed requirement by using atmospheric appliances will be a challenge. (see “Examples of Compliant Approaches” below). It is considerably more difficult to isolate the mechanical room from the building than one might expect, due to the many duct, plumbing and electrical penetrations between the mechanical room and building, and leakage in the furnace cabinet itself.

If the requirement is instead met by choosing types of equipment that don’t need to be isolated from the building, other considerations are relevant:

- Furnaces and water heaters that are not natural draft cannot be commonly vented, as has been common practice with conventional equipment. This means two separate vents and vent terminations rather than one, which could be a challenge with some building designs (the vent terminations must meet minimum separation requirements from air intakes and operable windows; and minimum clearance requirements above grade). In some buildings, though, separate vents that terminate at different sidewall locations are much easier to accommodate than running a common vent up through an open floor plan (this is especially true in multi-story buildings).
- Direct-vent combustion appliances (e.g. water heaters and fireplaces) typically must be located near exterior walls to meet venting requirements.
- Some power-vented and sealed-combustion water heaters require a dedicated electrical circuit, which can add cost. Tankless, sealed-combustion water heaters require a larger gas supply pipe than conventional water heaters, an added cost.

Certification Issues

BPI Building Analyst certification is likely to be the most appropriate credential for performing the testing associated with this proposed requirement. This credential requires both blower-door testing (required to document isolation of the mechanical room) and combustion safety testing skills. Testing may be performed by a certified individual working for the company installing the mechanical equipment or for the builder; third-party testing may also be utilized.

Enforcement Procedures

Permit application/plan review: Submitted plans must include information describing how this requirement will be met. If atmospheric appliances are to be used, details regarding mechanical room isolation from the building must be provided.

Field inspection: If this requirement is to be met using combustion appliances that don’t need to be isolated from the building, building inspectors check that the specified equipment has been installed to meet manufacturer installation requirements (current practice).

Certificate of Occupancy: If natural draft appliances are used, applicant will submit a signed performance testing form documenting compliance with requirements. The document will include the testing contractor’s certification numbers and expiration date.

Support Materials Needs

- Compliance form
- Information for building owners or occupants of buildings in which natural draft appliances are located in a mechanical room, instructing them how not to defeat the purpose of the requirement.

Training Needs – Industry

For builders planning to meet the proposed requirement with natural draft appliances in a sealed mechanical room, training will be needed regarding the details needed to meet the testing standards.

For builders choosing to meet the proposed requirement by using combustion appliances that don't need to be isolated from the building, training regarding installation of these appliances is provided by manufacturers and product suppliers.

Training Needs – Staff

Building Department staff should receive training to understand the performance testing and the compliance documentation submitted by contractors.

Background**Current Practice**

- In new Fort Collins construction, for more than 15 years, almost all fireplaces have been direct-vent units.
- In new Fort Collins construction, since 2005, almost all furnaces and boilers have been sealed-combustion units, with rated efficiencies of 90 AFUE and above. (In a survey of new homes built in 2007, about one-third of these were installed to draw house air for combustion rather than outside air.)
- In new Fort Collins homes surveyed in 2007, about two-thirds of the water heaters were conventional, natural draft; one-sixth were power-vented; one-sixth were sealed-combustion or direct-vent. Sealed-combustion, higher-efficiency tankless water heaters were provided as standard equipment by a small number of Fort Collins builders.
- Furnaces, boilers and water heaters are most often located in basements, the majority of which are unfinished when the building is sold. When basements are later finished, the equipment is typically walled off into a mechanical room.
- Code-required “combustion air ducts,” open ducts from outdoors or the attic that terminate near the equipment, are installed whenever appliances that draw indoor air for combustion are installed. One or two ducts, from four-inch to eight-inch diameter, are typical.
- In the 2007 new home survey, in a finished home that had just received its Certificate of Occupancy, two natural draft water heaters and a natural draft fireplace continuously spilled combustion products into the living space whenever the vented kitchen range hood was operated.

Context

Natural draft appliances draw indoor air for combustion; the buoyancy of hot combustion gases is intended to vent combustion products out of the building. This venting process relies on very small pressure differences to push the gases out the chimney. These pressures are easily disrupted by many factors: “stack effect” air leakage, exhaust fans (kitchen and bath fans, clothes dryers, radon vent systems, whole-house fans), other chimneys, leaks in the return ductwork, unbalanced supply and return air flows to different parts of the building, wind, varying outdoor temperatures.

These factors can act alone or in combination. When pressure imbalances exist, combustion products – potentially including carbon monoxide (CO) – can spill into the living space. The potential for this problem increases with tighter construction, which more readily supports pressure imbalances than leaky construction.

CO poisoning, in relatively low concentration, can be fatal. Lower doses can cause chronic illnesses which mimic other conditions. Other combustion products include oxides of nitrogen (a respiratory irritant) and water (which can lead to excess humidity, mold, building damage).

The two most common natural draft combustion appliances installed in Fort Collins today are:

- Conventional gas water heater. This is the appliance most vulnerable to spillage at low pressure imbalances. This type of water heater was installed in about two-thirds of new Fort Collins homes in 2007.
- Induced-draft gas furnace. Though this type of furnace is natural draft, it does not incorporate a “draft hood.” A pressure sensor on the exhaust is designed to shut down the appliance when venting problems occur. These units have rated efficiency of approximately 80 AFUE, meeting code-minimum efficiency requirements. However, as noted above, the new construction market has largely moved beyond these to sealed-combustion, 90+ AFUE furnaces.

With few exceptions, building code requires that outside combustion air ducts are installed whenever combustion appliances that draw indoor air for combustion are specified. The minimum sizes for these ducts are based on the installed combustion capacity of the equipment. It is often assumed that one function of these ducts is to provide pressure relief to mitigate imbalances in the combustion appliance zone. In reality, these ducts can exacerbate pressure imbalances; air flow out through the combustion air duct can contribute to a spillage scenario.

Combustion air ducts also blur the line between “inside” and “outside,” providing a direct connection between the two environments. This contributes to uncontrolled air leakage. Cold drafts through combustion air ducts often trigger comfort complaints. Despite code-required warning labels, it is not unusual to find combustion air ducts plugged by occupants who don’t understand their intended function and want to stop the source of cold air.

Building scientists have long recognized the potential for combustion safety failures with atmospheric appliances. The City has provided training and education to builders, trades and consumers, addressing combustion safety concerns, since the early 1990s. Combustion safety was addressed in the City’s report on a [survey of Fort Collins homes built in the mid- to late-1990s](#). A [combustion safety fact sheet](#), developed by Fort Collins Utilities and E-Star Colorado, recommends safe combustion appliances in new buildings. The fact sheet has been widely distributed since 2005.

Green building rating systems, including LEED for Homes and the National Green Building Standard, award points for safer combustion appliances. NGBS does not allow points to be claimed for tight construction unless safer combustion appliances are installed.

ENERGY STAR New Homes Version 3 guidelines (which will be fully effective by January 2012), require safer combustion appliances in all homes that earn the ENERGY STAR label.

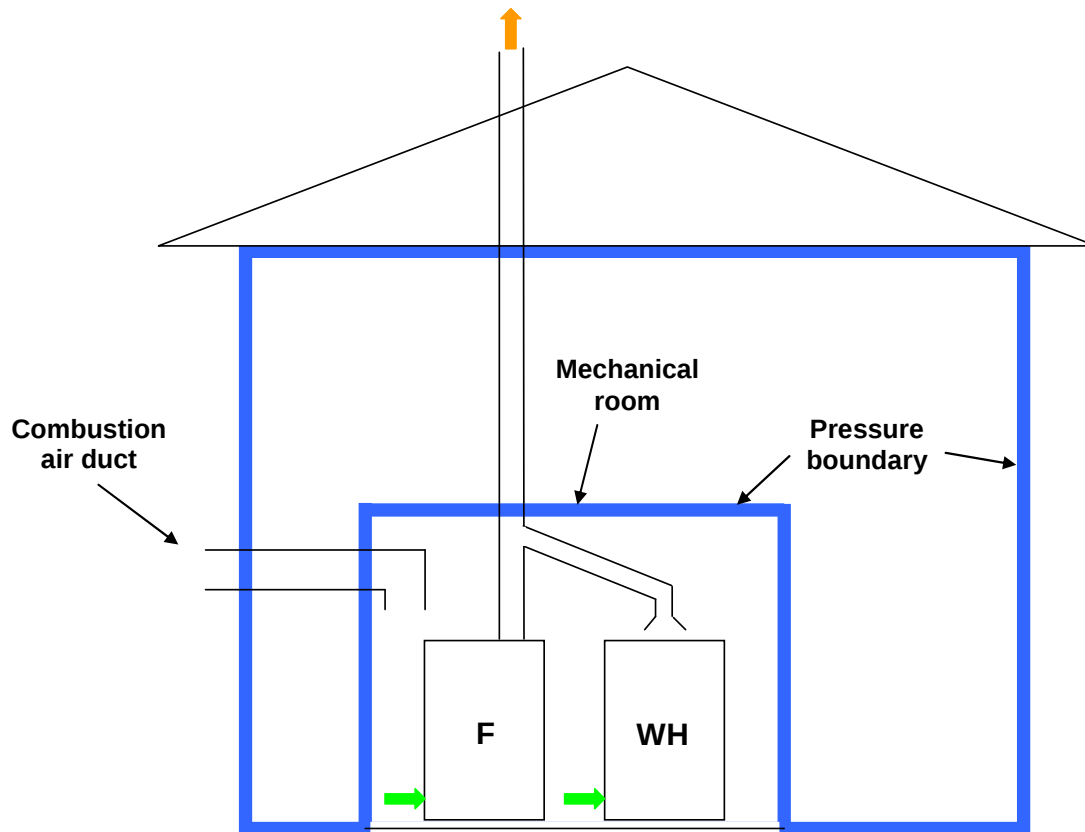
Gas ovens are unvented combustion appliances that often produce high levels of CO. In response, Fort Collins building code requires that vented range hoods are installed when gas ovens are installed. As noted above (“Current Practice”), vented range hood operation, drawing air out of the building, can cause other natural draft appliances to spill combustion products into the building.

State law prohibits the installation of other unvented combustion appliances.

By state law, CO detectors are required in new construction. These detect one symptom of combustion problems.

Examples of Compliant Approaches

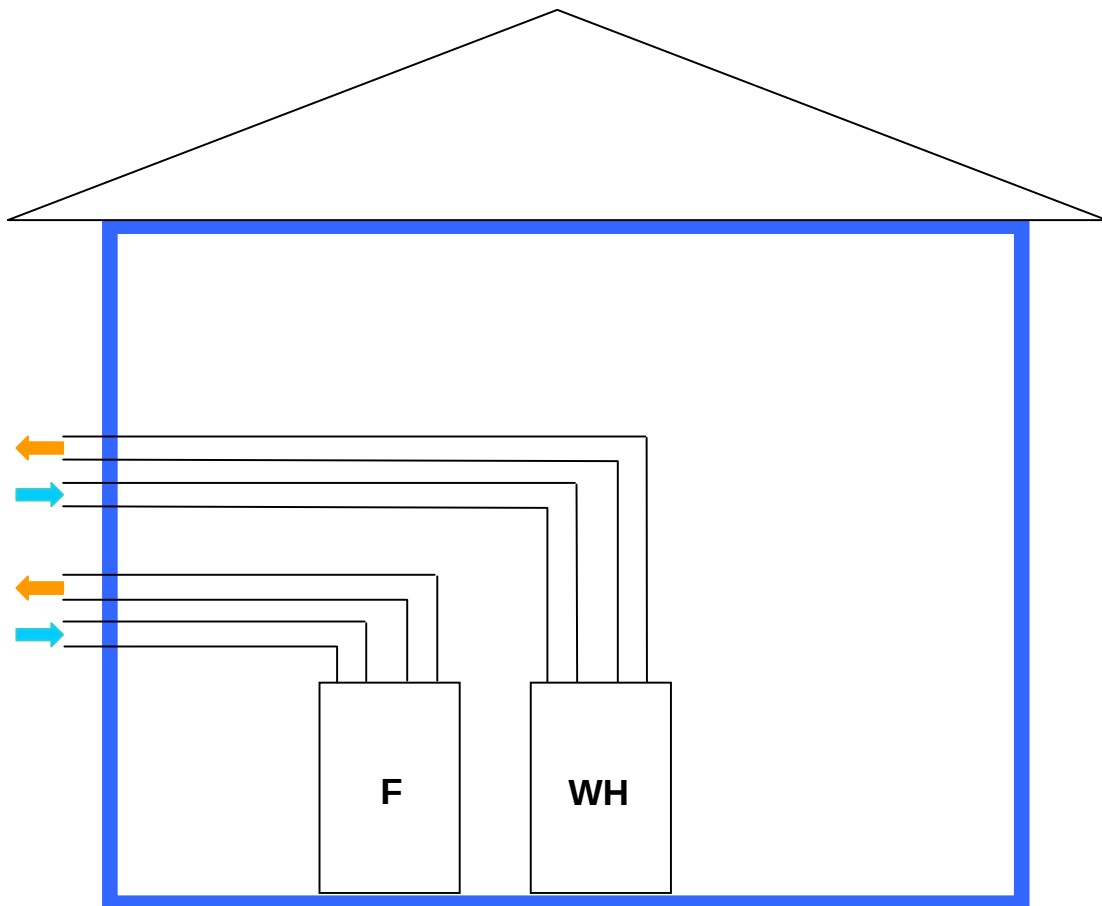
The following drawings illustrate three examples of approaches that would comply with the proposed requirement



OPTION 1

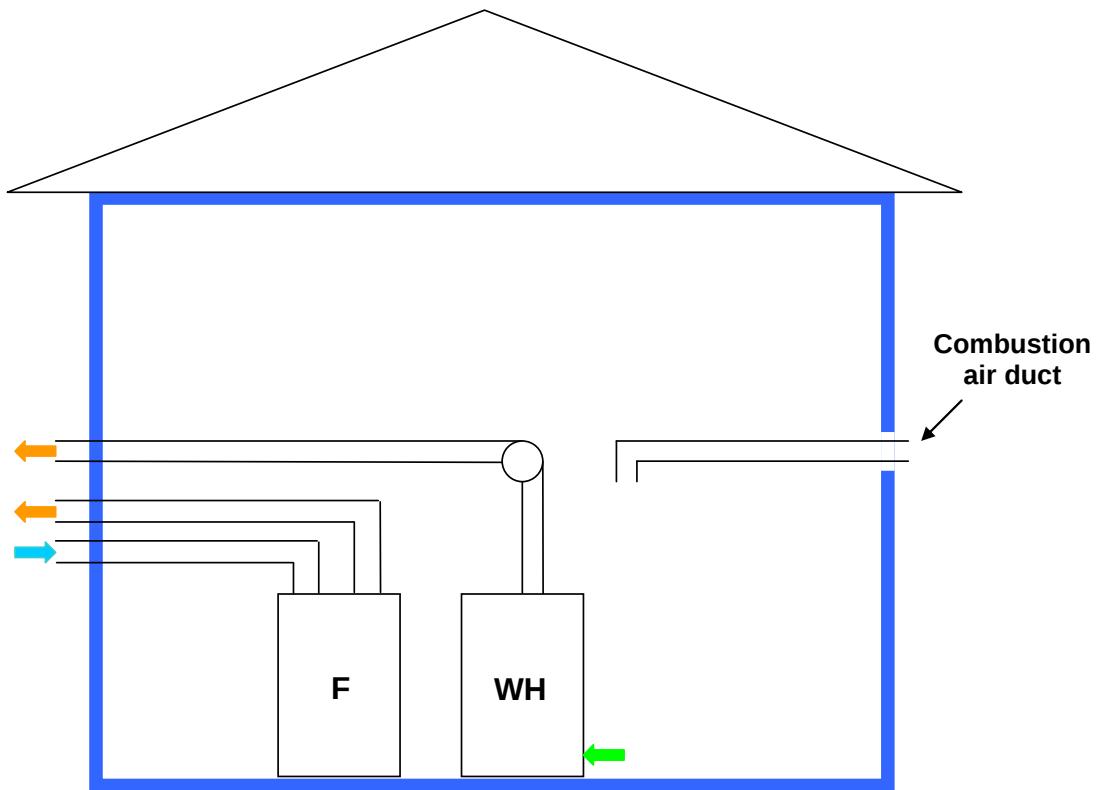
Natural draft appliances. These are located in a mechanical room that is sealed from the rest of the building, connected to the outside by an open combustion air duct. This effectively places the combustion appliances outside the pressure boundary, as shown. The combustion air duct is sized based on the total input combustion capacities of the furnace and water heater.

The isolation of the mechanical room from the building must be demonstrated with a differential pressure test. The appliances must pass a worst-case combustion safety test.



OPTION 2

Sealed-combustion appliances. Because they have hard-piped combustion air intakes and combustion product exhausts, these appliances are not vulnerable to pressure imbalances in the building. Mechanical room, open combustion air ducts, performance testing are not required.



OPTION 3

Sealed-combustion furnace and power-vented water heater. The furnace has hard-piped combustion air intake and combustion product exhaust, so is fully isolated from pressure changes in the building. The water heater uses indoor air for combustion air; combustion products are fan-forced out of the building. A (small) open combustion air duct typically is required, sized based on the input combustion capacity of the water heater. The small combustion air duct represents a breach in the pressure boundary.

Neither a mechanical room nor a performance test is required.

Related Green Building Practices

Safer combustion appliances are a key part of a systems approach to healthier indoor air and other aspects of improved performance. These practices go hand-in-hand:

- Tight construction
- Healthy indoor air
- Exhaust-only ventilation approaches can only safely be used with safer combustion approaches.
- Eliminate uncontrolled leakage through open combustion air duct

Known Objections

- Higher first cost versus current approach.
- There aren't many deaths from CO poisoning.
- State law requires CO detectors in new homes.
- Builders may locate combustion appliances in garages; this approach introduces other problems.