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Photos: Glenn Mathewson

Planning Ahead for Combustion Air

Sometimes troubleshooting involves preventing trouble from arising in the first place, such as making sure that sufficient combustion air is provided for fuel-burning appliances. Without enough oxygen, combustion will be incomplete and as a result, not only will appliances run inefficiently, but dangerous carbon monoxide will be produced instead of carbon dioxide.

The furnace and water heater are often installed in the middle of an unfinished basement **(1)**, with access to the entire volume of air in the basement for combustion. Once a basement is finished, however, the furnace and water heater are usually isolated in a small mechanical or utility room, which limits the available combustion air and requires a different strategy.

The IRC and the IFGC (International Fuel-Gas Code) list four ways to provide combustion air: inside, outside, combination, and mechanically assisted. These methods offer a lot of flexibility for creating a code-compliant design, but they can be confusing. No matter which method you choose, each begins with the total input Btu per hour (Btu/h) rating of all the equipment in question. A common arrangement would be a 100,000-Btu/h furnace with a 40,000-Btu/h water heater, so I'll use a total figure of 140,000 Btu/h for the examples in this article.

INSIDE AIR

All homes leak air to some degree, and homes more than 10 years old are likely to leak a lot. These leaks occur at construction joints and penetrations of exterior walls and ceilings, as well as through doors and windows and along pathways such as dryer vents and kitchen exhaust systems. This air infiltration is looked at in relative proportion to the volume of the spaces within the house. Specifically, 50 cubic feet of interior

air (that communicates with the fuel/gas appliances) provides enough combustion air for 1,000 Btu/h. So for our 140,000-Btu/h example, we would need 7,000 cubic feet of volume, or an 875-square-foot unfinished basement with 8-foot ceilings. But the situation changes when a mechanical room is built to hide the furnace and water heater.

Transfer air grilles are one option for putting a furnace out of sight, but not out of compliance. These openings in the mechanical-room walls allow the air outside the mechanical room to communicate with the air inside. With this method, one opening must be placed within 12 inches of the ceiling and one within 12 inches of the floor, to promote thermocycling—the natural movement of air due to temperature differentials—in the room. Thermocycling is key for ventilation around the equipment.

Each opening must be sized individually and have at least 100 square inches of "free area"—the actual open area of the grille not including any mesh or other screen or louvers. (For a metal grille, the free area is typically 75% of the area of the grille, and for a wood grille, only 25%). If the opening is through a wall, it must provide 1 square inch of free area for every 1,000 Btu/h of all the appliances (140 square inches for our example). The upper opening can also communicate through the ceiling to the space above, but then it must have 2 square inches of free area for every 1,000 Btu/h.

Using fully louvered doors on the mechanical room is one solution. The bottom half of the door acts as the low opening and the upper half as the high. Even with a paltry 25% of actual free area, louvered doors are usually big enough to meet the overall size requirement.

Place transfer air openings so they won't be highly visible in the finished basement and make sure they won't be blocked by furniture. For design flexibility, the high and low transfer air openings don't have to be in the same part of the wall, as long as they both communicate with the same volume of space. Transfer air grilles cannot take combustion air from bedrooms or bathrooms.

OUTSIDE AIR

If fuel-burning appliances are in a dedicated room that's completely isolated from the rest of the home, outside air is a good option for providing combustion air. In this situation, the walls and ceiling should be insulated to thermally isolate the outside air in the mechanical room from the conditioned air in the rest of the home. There are a number of ways to use outside air for combustion.

When the mechanical room is adjacent to an outside wall, openings for combustion air can be direct to the outside **(2)**. When high and low openings are used (as with inside air), they need to have only 1 square inch of free area for every 4,000 Btu/h. So in our 140,000 Btu/h example, the high and low openings would each need to be just 35 square inches (or 7 inches in diameter). This same size would also work for vertical ducting to transmit outside air from above or from a ventilated attic or crawlspace. Inside the room, direct or vertical openings must terminate right where they enter the room.

If air travels through a horizontal duct to the appliances, a different sizing method must be used. In this case, the area of the ducts must be twice as large as with the direct and vertical methods—1 square inch for every 2,000 Btu/h, which would increase the diameter for our example to 10 inches. Air moving horizontally through a duct encounters more resistance than air moving vertically, but curiously, the code doesn't place limits on the duct's length.

Remember that air just needs to be introduced to the basement or mechanical room, not brought directly to the equipment **(3)**. Don't duct outdoor air to a natural-draft combustion appliance. In colder regions, air brought directly to a natural-draft appliance can have an adverse effect on the flue, and the cold air can freeze nearby water pipes **(4)**.

In some basements, a plenum space in the ceiling framing or above a dropped ceiling can be used as a combustion air path, if the openings to the exterior are big enough. But this means subjecting those ceiling areas to cold outside air, which then translates to cold floors above—a situation likely to make the homeowners unhappy.

Yet another design option for drawing


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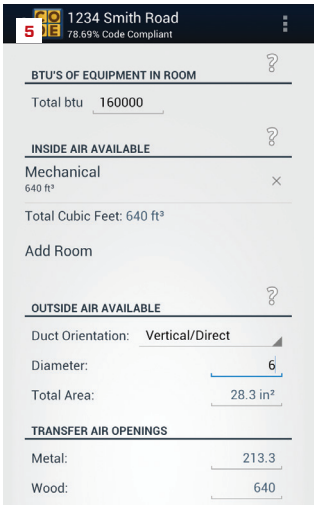

combustion air directly from the outside is the single-opening method, which allows you to use just one upper opening, either direct, vertically ducted, or horizontally ducted. This method reduces the thermocycling potential in the room, so a 1-inch minimum clearance space is required around all sides of the equipment to keep it ventilated, something that's usually not difficult to achieve. Also, 1 square inch of opening is required for every 3,000 Btu/h, and the single opening cannot be smaller than the combined area of all the vent connectors from each appliance.

This method originated in one of the three pre-IBC legacy codes and isn't always consistent with the other methods. For example, the minimum size for a single opening that's horizontally ducted is smaller than the minimum size for each opening in the method using two horizontal ducts. Because of this discrepancy, many local jurisdictions have amended this method out of their adopted code.

COMBINATION AIR

If the inside and outside air options are not sufficient on their own to provide combustion air for your appliances, the code allows you to use a combination of the two. While providing some design flexibility, the combination method is not necessarily an energy-efficient option. If the mechanical room communicates with both inside and outside air volumes, then the two volumes also communicate with each other via the mechanical room—not a wise choice in anything but moderate climates.

Calculating the weighted values for the two methods and summing them to comply with code can be tricky. I suggest buying the Combustion Air Calculator, a $0.99 app from codecalculators.com, which makes easy work of the calculations for all the methods, including sizing air openings and grille reductions for free area **(5)**.

MECHANICALLY ASSISTED AIR

The fourth option for providing combustion air is the mechanical method. Geared more toward large equipment with significantly greater Btu/h needs (such as commercial installations) or for situations where large openings are not possible, this method uses a fan to blow outside air into the room. The fan must provide .35 cfm for every 1,000 Btu/h (49 cfm in our example), and it must be interlocked with the appliance so the appliance burners operate only when the fan is operating.

CAREFULLY LOCATE OTHER APPLIANCES

Appliance location also makes a difference when you're planning for combustion air. If the air volume provided for combustion communicates with exhaust fans or dryer exhaust, make-up air must also be provided so that the negative pressure created by the exhaust does not steal air meant for combustion. Designs that put the laundry (including a dryer) in the mechanical room should be avoided **(6)**.

If it seems impossible to meet combustion air requirements, replacing an appliance with a high-efficiency model can often eliminate any issues. High-efficiency equipment reduces the amount of wasted heat carried out the vent and also provides a sealed combustion chamber with the option for a direct-vent installation. If equipment upgrades are planned for the near future, it might be wise to install the horizontal PVC pipe for direct venting before the ceiling is closed up. Until that time, combustion air must still be provided as described in this article, but those openings can easily be sealed up after the appliances are upgraded.

With direct venting, a dedicated combustion-air inlet pipe runs directly from the exterior to the sealed combustion chamber, completely separating the air inside the home from the air outside—a huge benefit that allows greater flexibility not only in combustion air, but also with appliance location. Direct-vent appliances can be installed in places where other appliances can't be, such as in a closet adjacent to a bedroom or bathroom. For some basement finish projects, that flexibility can often satisfy the owner's demands when the code otherwise gets in the way—something it does at times.

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