
ADDING ON TO FORCED HOT AIR



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Heating systems are a mystery to most builders, even those who talk a good game. When the moment of truth comes and they're face to face with an old forced hot air furnace in a dank, dusty corner of a customer's basement, the best they can do is find the manufacturer's stamped label and read the capacity rating. But it takes more than Btu's to make a forced hot air system work efficiently, especially when adding on to an existing system to heat an addition.

One of your responsibilities as G.C. for an addition or renovation is to figure out if the existing heating system can handle the extra ductwork. The more you understand about the heating plant, the better you can avoid costly surprises and work with your clients and your hvac sub to design a safe and efficient system. In this article I'll review the issues and tradeoffs involved in adding on to an existing hot air system.

Planning the System

Planning a hot air system is like planning any other building component: You have to determine what your clients want, then decide how many of those wants you can satisfy given the budget and the house design.

THE EXISTING FURNACE CAN OFTEN HANDLE THE EXTRA HEATING LOAD OF A NEW ADDITION — IF YOU UPSIZE THE RETURN AIR DUCTS

Comfort. Since adding on to an existing heating system will affect how well it heats the existing building, it's important to discuss your client's overall heating needs. If there are two decision makers in the house, make sure they're both present, and take notes to document everyone's statements — you may need to “refresh” their memories six months later when the north winds are howling. If your clients claim to like the family room warm, probe a little deeper to find out what “warm” means to them. Are they Spartans who think that 62°F is comfortable, or are they used to wood stoves and think 76°F is normal? If a couple can't agree on what temperature a given room should be — if one likes the bedroom warm and the other likes it cold — then supply enough heat for the

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higher temperature and let them adjust it as needed.

Recovery time. Also find out what your clients consider an acceptable time for the house to recover from a setback temperature, such as when the heat is turned up from 65°F to 70°F in the morning. Make sure they understand that adding on to the existing system will slow recovery time, so it will take longer to bring the house up to temperature. To compensate, consider installing a setback thermostat, which will turn the heat on before they get up, turn it down again while they're at work, and turn it up again before they get home from work.

Aesthetics. Although comfort should be the focus of your discussion, don't forget aesthetics. Most people don't want to see any part of the heating system. Find out if it will be acceptable, for example, to build a chase in a corner of the room to hide the ductwork running to the second floor. If not, then try to find a stud bay in an interior partition or some other route for the ductwork.

Also ask about the location of the registers. If you're bringing hot air ducts to a room addition with a hardwood floor, the best place for the register may be exactly where the clients don't want to see a grille. In an addition, duct location isn't as critical if the new walls are better insulated than the original house. This means you don't necessarily need to place a register under every window, although for comfort it's a good idea to put registers beneath large areas of glazing, especially in lounging areas.

Balance. Study the amount of supply air entering each room through the heating ducts and try to match it with return air. If it's impractical or too expensive to place a return duct in every room, look for other ways to balance the air flow. If the room has a door, for example, create an air passage when the door is closed by using a louvered door or a loose-fitting door with a healthy undercut.

Noise control. Don't forget noise. Is this a room where the sound of air rushing from the registers will not be welcome? Construction of a room addition may provide an opportunity to correct existing air velocity or noise problems by installing insulated duct, for example, on the return side (Figure 1). Be aware, however, that insulated duct must be big enough to compensate for its higher resistance to air flow.

Sizing Up the Existing System

The first step in evaluating a heating system is to do a heat loss calculation. Any reputable hvac wholesaler should be able to calculate heat loss for the existing house and the addition. You will need to supply a scale drawing showing the layout of the exterior walls and the location and size of all windows. You'll also need to provide insulation values for walls and, on the second floor, ceilings. In northwestern Vermont, where I do most of my work, an existing structure may require 20 to 35 Btu's of furnace capacity per square foot of floor space, depending on insulation levels. A new addition in my area should come in at 10 to 15 Btu's per square foot.

Most older residential systems I encounter are undersized on the return air side (Figure 2). I often see two 8x16-inch



Figure 1. Using insulated duct on the return will dampen system noise, but you should oversize the duct to compensate for its higher resistance to air flow.

trunks coming off of the supply plenum but only one 8x16-inch trunk on the return side. In a well-balanced system, supply and return air should be equal. Because most furnaces of yesteryear were grossly oversized, however, they could heat the house in spite of the poor distribution system.

Testing furnace capacity. Although many older furnaces have plenty of excess capacity for an addition, you may need to beef up the return ductwork to make use of that excess capacity. One way to quickly find out if the returns are undersized is to open the blower filter compartment cover when the system is running. Be

extremely careful not to put your hands inside the compartment because it includes a motor, fan, and fan belt moving at high speed. Have the homeowner go upstairs and put a hand over a supply-side register. When you remove the blower cover, the result can be dramatic — the air flow at the register can double. (Make sure you put the blower cover back on the furnace before the family pets investigate.)

Another simple test is to put your hand on the supply plenum. If it's too hot to touch, then the burner has Btu's to spare. In a properly designed system, the air moves through the ducts at a rate that doesn't allow the ducts to overheat.

Once you've established that the furnace has excess capacity, determine its heat output in Btu's and its blower capacity in cubic feet per minute (cfm). You can read the Btu capacity right off the name plate. Blower fans are sized according to the furnace's rated heat output. Unfortunately, on an older blower, it may be impossible to determine the blower rating without the original paperwork. If the furnace is relatively new, call the dealer or manufacturer to get the rating. With enough experience, you can make a good guess from the type and age of the furnace. Blowers are usually designed to operate at between 800 and 2,000 cfm. For example, a typical 1,500-square-foot house requires 40,000 Btu's at 800 to 1,000 cfm, while a 4,000- to 5,000-square-foot building would generally need 100,000 Btu's at nearly 2,000 cfm.

Increasing efficiency. Most older furnaces have belt-driven blower motors with pulleys (like the fan and fan belt on a car) that can be adjusted to increase the blower speed. To increase the speed of the fan, tighten the belt on the pulley. This will force more air to pass across the heat exchanger and increase efficiency.

Most older furnaces also have an adjustable fan limit switch. You can adjust the fan cycle so that the fan stays on longer, capturing warmed air that would otherwise go up the chimney. Normal settings turn the fan on at about 140°F and off at about 110°F. To increase efficiency, adjust the fan to different on and off settings until, through trial and error, you find the optimum setting. I find that if the fan comes on at 110°F and turns off at about 95°F, a well-balanced system will capture all of the heated air, but the fan won't push cold air into the room

by running too long after the burner has shut down.

Newer gas furnaces are set at the factory and shouldn't be adjusted — in fact, most can't be adjusted. In this case, you are limited to modifying the distribution system to improve efficiency.

Mapping the System

Now you have to get dirty. Your goal is to map the system to determine its actual air-handling ability. Use pencil and paper to sketch out a graphic representation of all supply and return ducts, as well as the grilles, registers, and main trunk. Make note of the shape and size of the ducts, the number of wye's and elbows, and the lengths of the runs.

How air will move through a given duct size depends to a large degree on the shape of the duct. Irregularly shaped fittings are assigned a straight-duct equivalent design value (Figure 3, next page). For example, a 6-inch-diameter, 90-degree elbow might be assigned a value of 10 feet, indicating that it has the same friction loss as 10 feet of

straight 6-inch-diameter round pipe. This information is used to determine the necessary tradeoffs between cost, aesthetics, and performance. For example, providing more headroom in the basement may be a priority, but the extra fittings needed may destroy the air flow.

Also, be sure to remove each register and look behind it. It's not uncommon to find a large duct in the basement leading to an equally large wall grille in the living space. But when you remove the grille, you discover that the air flow is blocked by a sole plate, and the half-dozen 1-inch-diameter holes drilled through it aren't enough to allow the air to pass freely.

When adding new ductwork, it's important to size it properly. Heating system designers use charts called "duct calculators" (Figure 4, next page) to quantify how much air can quietly move through a given duct size. The same chart can be used to determine if the existing ductwork is adequate. These calculations depend on friction ratings and air volume requirements that are best left in the hands of profes-

sionals. The duct calculator can be useful, however, to convert between round and rectangular duct sizes.

Cleaning and Tuning

Next, have a reliable, certified hvac contractor clean and tune the furnace and examine the heat exchanger for cracks. To ensure that the system is safe, the hvac contractor should perform either a smoke test (which involves putting a smoke bomb into the heat exchanger and turning on the blowers to see if smoke leaks into the house), or a carbon monoxide test (to check for traces in the house air). If the furnace fails either test, replace it. Some hvac contractors may claim they can patch up the old furnace, but this is risky since the patch can fail at any time.

Also ask the hvac contractor to strongly recommend in writing that your client update the system's safety features. Many gas utilities and heating contractors recommend or mandate "spill switches" on chimney-vented appliances. These devices shut off the furnace if the chimney

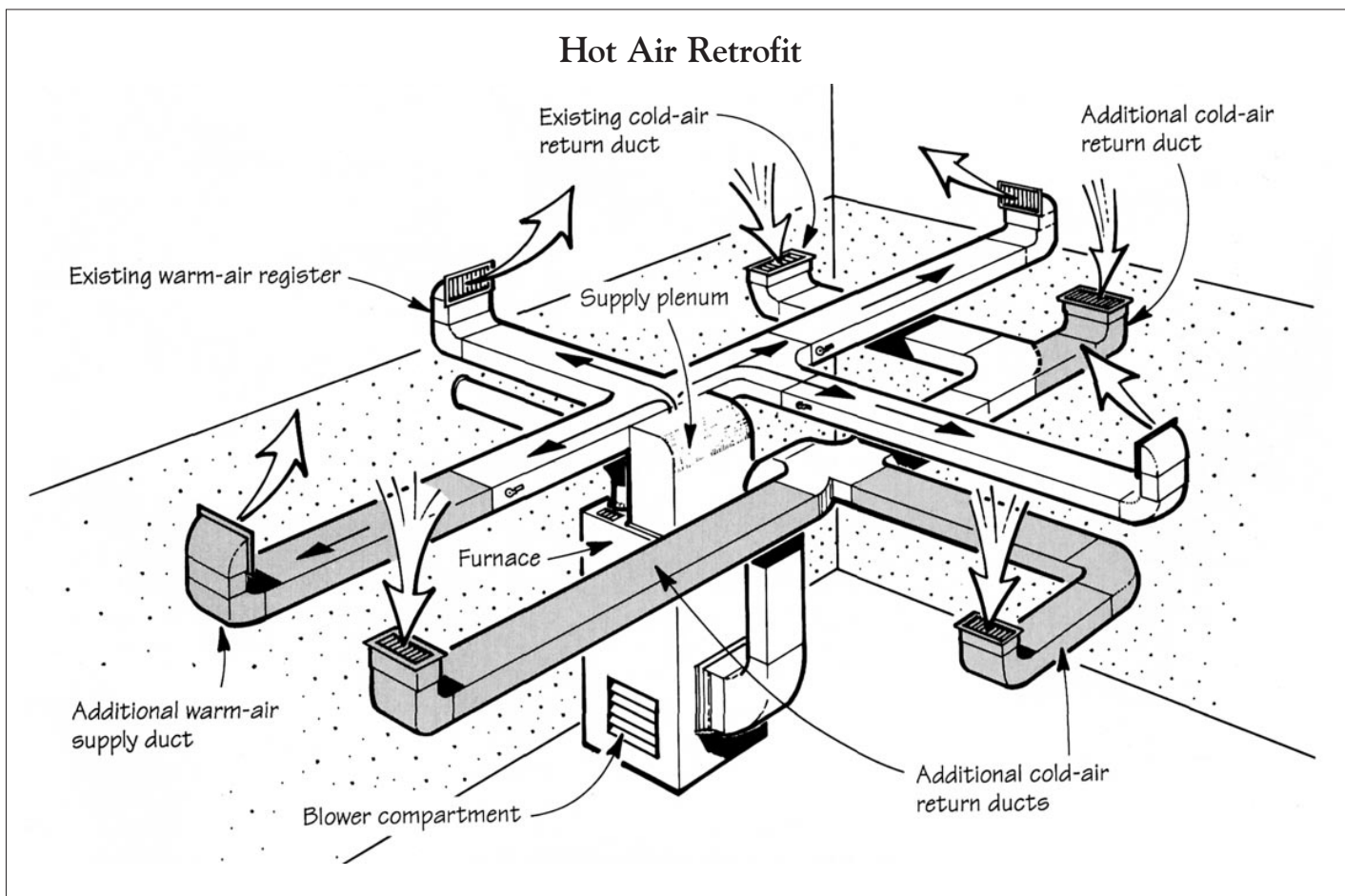


Figure 2. For a hot air furnace to operate at maximum capacity, the volume of the return air must equal the supply air. However, many residential systems are undersized on the return side, so if you add supply ducts you may need to add more than one return duct to balance the entire system.

Straight-Duct Equivalents for Common Duct Fittings

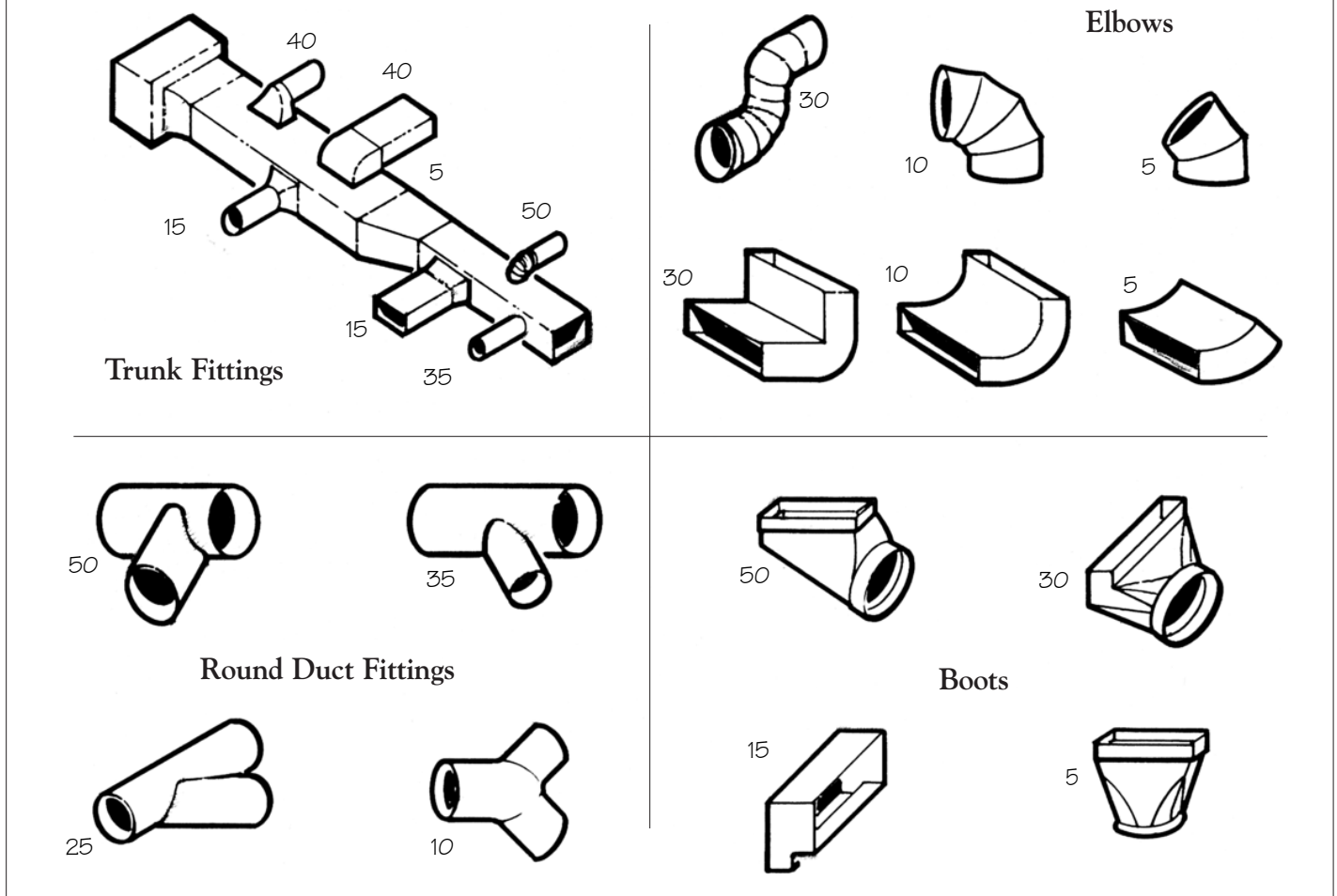


Figure 3. When planning duct runs, use the “equivalent length” value (the number next to each fitting) to account for the friction loss of fittings. A round 90-degree elbow, for example, has the same resistance to air flow as 10 feet of straight duct.

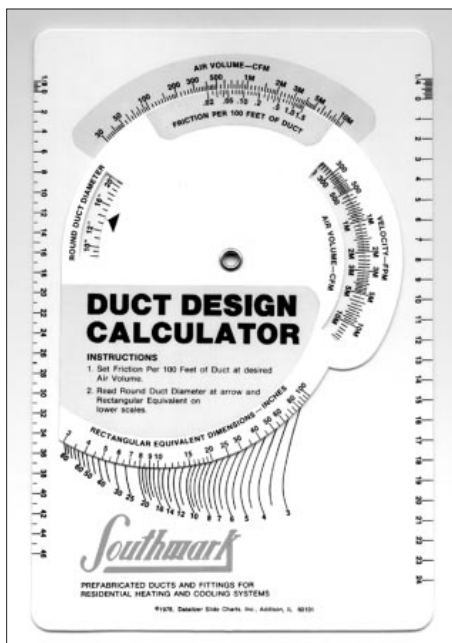


Figure 4. To determine the proper size of ductwork, and to convert between round and rectangular shapes, hvac designers use a duct design calculator like the one shown here.

backdrafts or is plugged. Spill switches are especially important in houses with powerful exhaust-only appliances. A typical 400 cfm downdraft kitchen exhaust fan, for example, or a central vac system can create enough negative pressure in the house to downdraft the chimney and fill the house with deadly carbon monoxide.

Finally, make sure the furnace has enough combustion air. If you're cutting off some of the combustion air — by partitioning off the furnace, for instance, when finishing a basement — you may need to bring in more air. Solutions include replacing the furnace with a sealed combustion unit or cordoning off the old furnace and bringing in a dedicated combustion air supply. I often use a standard wall cap (without the backdraft damper) cut into the rim joist with a length of duct running into the room. If you'd rather not create a permanent air leak, many duct manufacturers make combustion air hoods that mechanically

open and close in sync with the cycle of the furnace. Whatever you do, remember that once you alter any part of the system, you're liable for the entire system. Spending a few extra dollars here is cheap insurance.

Establishing goals for the system up front makes it easier to add on to the existing system. Work with a reliable subcontractor or hvac designer to review the capacity and safety of the existing system, and compare their procedures to the process outlined here. In many cases, improving efficiency will offset the added heating load of the addition you are building. On smaller projects, you may even want to run the ductwork yourself, using your designer's layout. Bring a box of band-aids and don't forget to turn off the basement light when you're done. ■

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