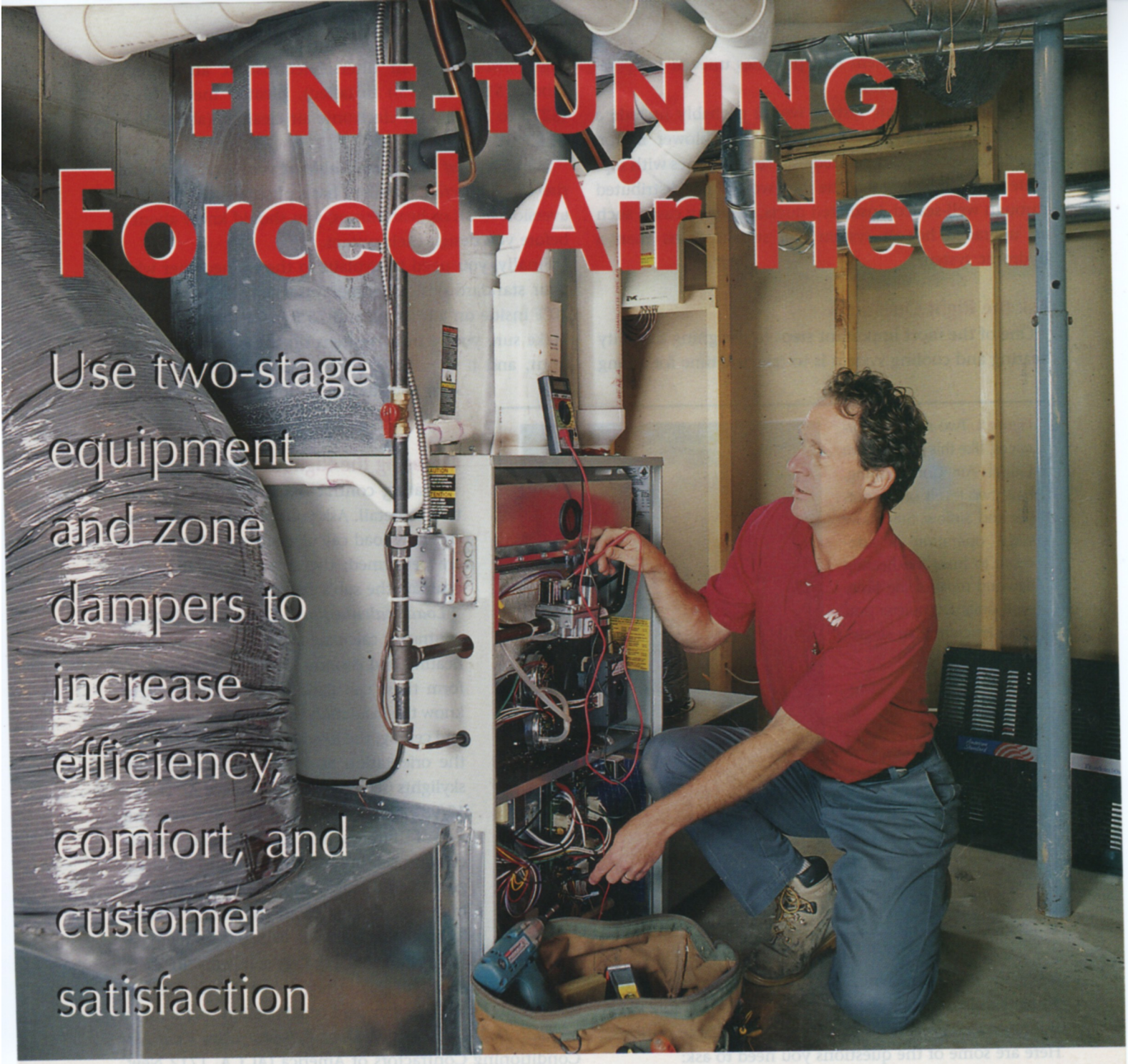
FINE-TUNING Forced-Air Heat

Use two-stage equipment and zone dampers to increase efficiency, comfort, and customer satisfaction



by Jeri Donadee

Hydronic, or hot water, heating has been standard for years in many parts of the U.S. It is seeing a surge in popularity at present, mainly because of the increasing use of radiant floor heating, which is known for providing even, comfortable heat. Yet contrary to popular belief, not every home in the free world needs hydronic heat to achieve this level of comfort.

Apples to Oranges

Hydronic heat is sometimes touted as more comfortable than forced-air heat. But since the typical hydronic system is significantly more expensive than the typical hot-air system — especially if cooling is included — this is an apples-to-oranges comparison. Customers willing to invest in a quality hot-air system, rather than a bare-bones package at the lowest price, will find that forced hot air can be as comfortable as hydronic heating.

The least expensive forced-air system usually includes a single-stage furnace with a single-speed blower motor. The entire house is ducted as a single zone, and therefore has just one thermostat. If the system is sized by a contractor who uses a rule-of-thumb formula to estimate heat loss and heat gain, the homeowner can end up paying high energy bills for a

noisy, inefficient system that provides uneven temperatures from room to room.

A quality forced-air system would probably include a two-stage furnace with a variable-speed blower motor. The house would be separated into several zones with separate thermostats, and the air would be distributed through well-sealed, insulated ducts. In many cases, such an upgraded hot-air system will still cost less than a hydronic system.

Ask the Right Questions

One of the most important steps to designing a quality heating and cooling system is to take the time for a long talk with the homeowner. Don't assume that you know what the customer wants and is willing to pay for. Most homeowners are not aware of all the available options. Here are some of the questions you need to ask:

What is your budget for this work? This is a tough one to get answered. Often the answer is, "Gee, I really have no idea." However, someone building a 2,500-square-foot home with a $7,000 budget is not looking at the same system as a person with a $12,000 budget.

What type of system do you have now, and what do you like and dislike about it? The answer to this question will tell you what the customers expect from their new system. Different customers have different priorities when it comes to efficiency, comfort, noise, and ease of operation.

Does anyone in the home have allergies? If the answer is yes, the customer may want to consider a high-performance air filter. There are three basic types of high-performance air filters: electrostatic air cleaners (about $100 to $150 installed), pleated media filters ($275 to $325), and electronic air cleaners (about $625 to $700).

What type of fuel is available at your site, and what fuel do you prefer? If a client has a phobia about gas or an aversion to oil or heat pumps, you should know about it before you design their system.

Finally, you need to explain to the homeowner what your standard design temperatures are — for example, 70°F inside on a 0°F day, and 75°F inside on a 95°F day. Make sure you're in agreement on these parameters up front, and if they have other ideas, incorporate them into your design, as long as their ideas are reasonable.

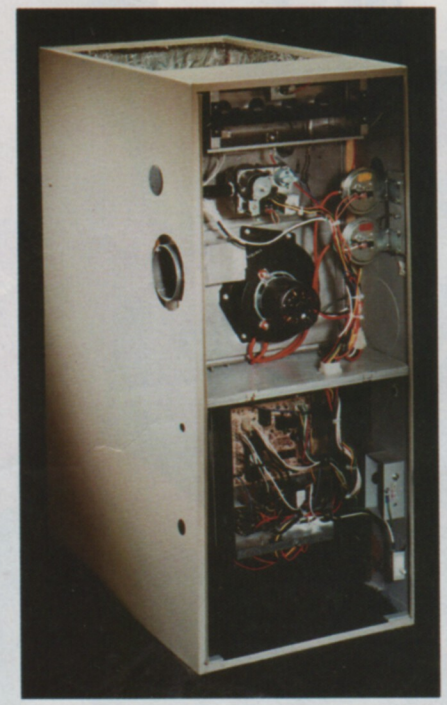


Figure 1. Two-stage gas furnaces, like this model from Goettl Air Conditioning, have two levels of Btu output and airflow. Since low stage operation is adequate to meet the heating demand most of the time, such units are quieter and more efficient than single-stage furnaces.

Choosing the Right Sub

Heating contractors vary in their attention to detail. Ask your prospective heating sub how load calculations and duct design are performed; the answers will help you evaluate the sub's expertise.

Load calculations. Does your heating contractor calculate accurate room-by-room heating and cooling loads? In order to perform these calculations, your sub needs to know the insulation values of the floor, walls and ceiling; the R-value of the windows; and the orientation and measurements of any skylights (see "Trouble-Free Forced Air Heat," 12/98). Many heating contractors still use rule-of-thumb square foot formulas for calculating heating and cooling loads. But since glass-to-wall ratios can differ significantly from one floor plan to the next, "square-footing it" is a dangerous practice.

Duct design. Heating subs vary in their level of attention to duct design (see "Duct Design Basics," 12/95). The standard duct design manual is *Manual D — Residential Duct Systems* from the Air Conditioning Contractors of America (ACCA, 1712 New Hampshire Ave. N.W., Washington, D.C. 20009; 202/483-9370; www.acca.org).

One basic duct design error is inadequate return ductwork. A system with multiple return grilles is preferable to a system with a single, central return grille. Another basic error is supply ductwork that is not matched to the output of the furnace. In extreme cases, undersized ductwork is unable to remove the furnace's heat fast enough, causing the heat exchanger to overheat and crack.

Supply air vents should be placed where they can deliver air along the exterior perimeter walls, where the greatest heat loss and gain occurs. Avoid low sidewall supplies, which can cause drafts and result in dissatisfied customers.

electronic thermostat, but is capable of displaying the outdoor temperature and indoor relative humidity. It will precisely operate the system based on desired indoor temperature and humidity set points.

When this control is coupled with matching heat-pump components, it will regulate the variable-speed fan motor to maintain consistent air discharge temperatures.

Such systems can provide a minimum air temperature delivery of 100°F, up to a maximum of over 120°F — about 20°F warmer than previous-generation equipment. Most users report higher comfort levels with these warmer air delivery temperatures.

Several Zones

Many contractors do not recommend or install zoning equipment, due to the mistaken belief that zoning is complicated. But if the homeowner's lifestyle requires different temperature levels in different areas, zoning probably makes sense, especially in larger homes.

Another reason to zone is to provide good temperature control in any area of the house with much greater heat loss (or gain) than other areas of the house. Typical examples are areas with many windows or rooms that are oriented toward a different direction than most of the other rooms in the house (Figure 2). During your initial meeting with the owner, look for such areas — for example, a sunroom or a finished area above a garage.

How do you decide whether an area needs its own furnace, or just a zone off the main unit? Assuming you have sufficient capacity, it is usually less expensive to install (and always less expensive to operate) a zone off of the main system than to install a separate dedicated unit. In some cases, though, the location of the zone or the building's total heating and cooling loads may dictate a separate unit.

When designing a zoned system, the first step is to know the Btu and airflow demands of the zone. Once the actual air requirements are verified, the ductwork should be designed and installed at a slightly larger size (10% to 15% larger) than standard ductwork. Oversizing each zone's ducts helps to dissipate any extra airflow when only one zone calls for heating or cooling.

Zoning is accomplished by installing motorized zone dampers (Figure 3). Since the premise for zoning is to reduce the air going to the area where the temperature is satisfied and deliver air to the area that needs the heating/cooling, each zone will need dampers. Manufacturers of zone dampers include Carrier, Jackson Systems, and Robertshaw Controls (see "Duct Tape, Mastic, and Zone Damper Suppliers," page 31).

If there is room for a dedicated trunk line to serve the zone, it is usually easier and cheaper to install a zone damper in the trunk line. In that case, the individual branch lines that are tapped off the dedicated trunks will not require zone dampers. When there is no room for a dedicated trunk line, the area can be zoned by installing a series of dampers in the branch lines serving the area, and then controlling the dampers together with a multi-damper enabler. Usually, the enabler is purchased from the zone damper supplier.

A multi-zone system requires individual thermostats to regulate the temperatures of each zone. The low-voltage thermostat wire is fed to a main zone panel. Wires are then run to the equipment and each zone damper. High and low temperature sensors are usually placed in the supply-air plenum to serve as unit safeties in the unlikely event of a zone damper failure.

Figure 3. Motorized zone dampers, like these examples from Jackson Systems, are available for both round ducts (left) and rectangular ducts (below).

Supply ductwork is the only part of the system with dampers. When one zone calls and gets supply air, the returns are still being drawn from the entire home. Therefore it's important to locate adequate returns in each zone. Two-story homes should have a combination of high and low return grilles.

Extra air. When only one zone in a multi-zone system calls for heat, there needs to be some way to dissipate the

Figure 4. Sheet-metal duct joints must be screwed together before mastic is applied.

extra cfm output of the furnace. Some brands of zone control ignore this problem, and let the high airflow howl through the small duct. Other brands will allow for the other zone(s) to open slightly and allow for the air to "leak" into areas that do not actually require conditioning. A third option is to install a bypass damper that allows the excess air to be recirculated back to the return. How the "extra" air is handled is a matter of contractor preference. The surplus air issue is much less of a problem with a two-stage gas furnace or a two-stage heat pump, especially one with a variable-speed fan — one more reason for installing two-stage equipment.

Doing Ductwork Right

In unconditioned spaces like crawlspaces and attics, use insulated duct for both supply and returns. For ducts in conditioned spaces, insulation is highly recommended, but not required. During the cooling season, uninsulated metal ducts can become cold enough to sweat.

Minimizing leaks. Many studies have shown that the typical forced-air system has leaky ductwork. Leaky ductwork wastes energy dollars and can lead to pressure imbalances in a house. An excellent resource for information on duct sealing can be found at www.greenseal.org/endisc.htm.

Joints in sheet-metal duct should be screwed together and sealed with mastic (Figure 4). Using mastic is always good practice, although some contractors omit mastic on ducts in conditioned spaces. Four water-based duct mastics are Glenkote 181, Hardcast Versi-Grip 181, RCD, and Uni-Mastic 181 Duct Sealer. Duct mastic has the consistency of mud and is spread with gloved hands or a paint brush (Figure 5). Wide gaps in ductwork can be bridged with fiberglass tape before applying mastic.

Joints in rigid fiberglass duct (duct board) should be sealed with a UL-181 heat-activated tape, like Ideal Tape #490 (Figure 6). Heat-activated tape works better and lasts longer than the aluminum pressure-sensitive tape (See "Duct Tape Update," page 29).

Keep flex duct short and fat. Insulated flexible duct is usually much faster to install than rigid duct. However, flex duct must be sized right and installed properly. Flex duct should be supported every 4 to 6 feet. Flex duct has high friction losses because of the coiled interior spring liner, so sharp bends should be avoided. The diameter of

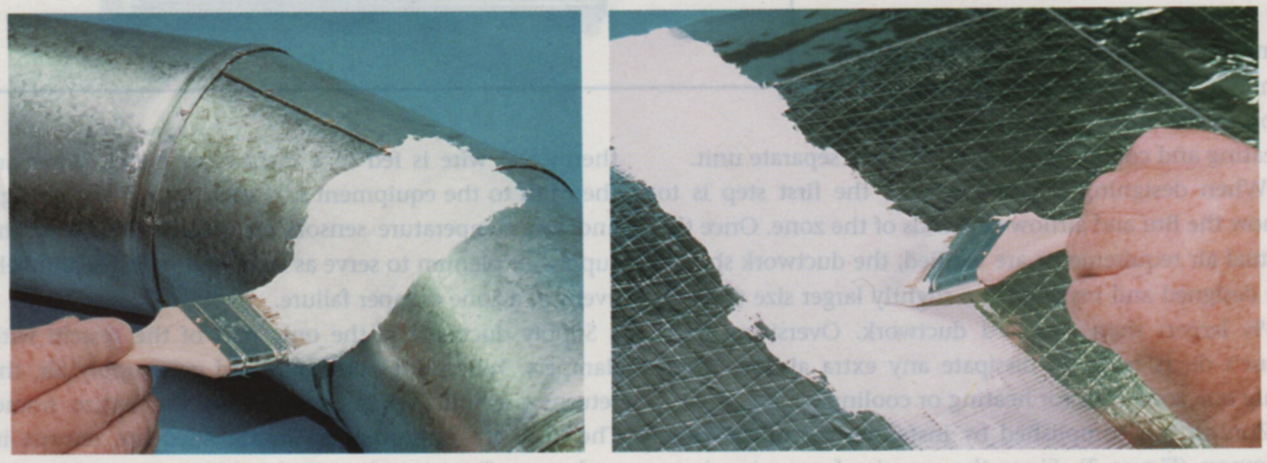


Figure 5. Joints in sheet-metal duct should be sealed with mastic, which can be applied with a paint brush (left). When mastic is used on duct board, the joint should first be bridged with fiberglass tape or scrim (right).

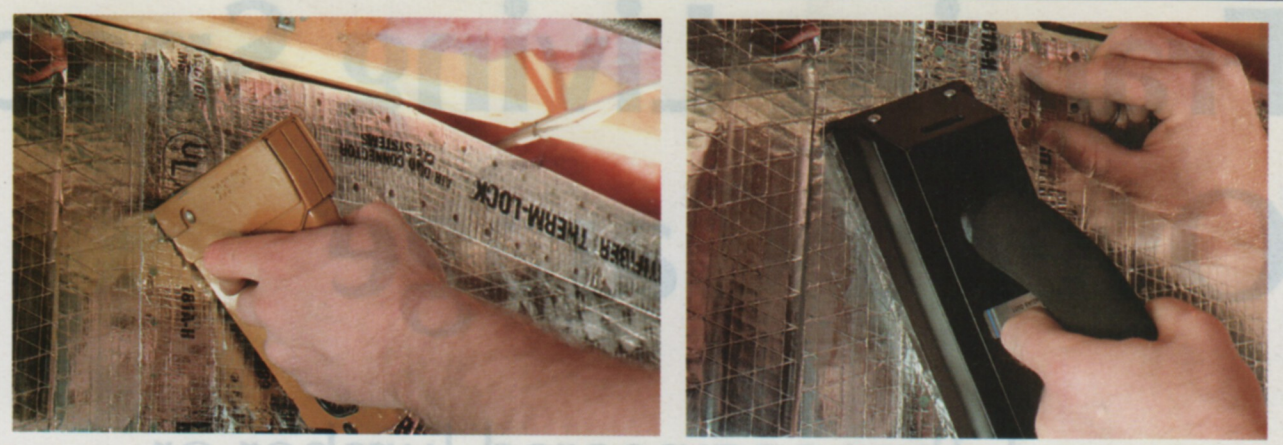


Figure 6. The female end of a duct board joint is pulled taut and stapled through to the male end (left). The joint is completed by applying heat-activated tape, which is warmed with an Amcraft duct board iron (right).

flex duct must be adequately sized for the airflow required, especially for runs longer than 12 feet.

Avoid pressurized rooms. If a room has a supply grille but no return grille, the room can become pressurized. To avoid this problem, such rooms need a low-resistance path for the return air. Verify that the door is undercut by 1 1/2 to 2 inches or that transfer grilles are installed in a partition between the room and the hallway.

Costs

How much will the suggested upgrades cost? The cost of upgrading a 100,000 Btu/h gas furnace from a single-stage unit to a two-stage unit with a variable speed fan is between $750 and $900. A 3-ton air-source heat pump with a 10 SEER efficiency rating can be upgraded to a two-stage unit with a 14.9 SEER rating for an added cost of about $1,900.

Customers who choose the upgrades will reap returns on their investment: not only increased comfort, but energy savings from the improved efficiency of the equipment.

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Duct Tape, Mastic, and Zone Damper Suppliers

Amcraft
5144 Enterprise Blvd.
Toledo, OH 43612
419/729-7900
www.amcraftinc.com
Amcraft 7150 heat seal iron for sealing heat-activated duct tape

Carrier
P.O. Box 4808
Syracuse, NY 13221
800/227-7437
www.carrier.com
Zone dampers

Hardcast Carlisle
903 W. Kirby
Wylie, TX 75098
888/899-5062
www.hardcast.com
Versi-Grip 181 duct mastic

Ideal Tape
1400 Middlesex St.
Lowell, MA 01851
800/284-3325
www.idealtape.com
UL 181 heat-activated duct tape

Jackson Systems
100 E. Thompson Rd.
Indianapolis, IN 46227
888/652-9663
www.jacksonsystems.com
Zone dampers

McGill AirSeal
2400 Fairwood Ave.
Columbus, OH 43207
800/624-5535
www.unitedmcgill.com
Uni-Mastic 181 Duct Sealer mastic

RCD
2850 Dillard Rd.
Eustis, FL 32726
800/854-7494
www.rcdmastics.com
Duct mastic

Robertshaw Controls
100 W. Victoria St.
Long Beach, CA 90805
800/232-9389
www.robertshaw.com
Zone dampers

TACC
Air Station Industrial Park
Rockland, MA 02370
800/503-6991
www.taccint.com
Glenkote 181 duct mastic