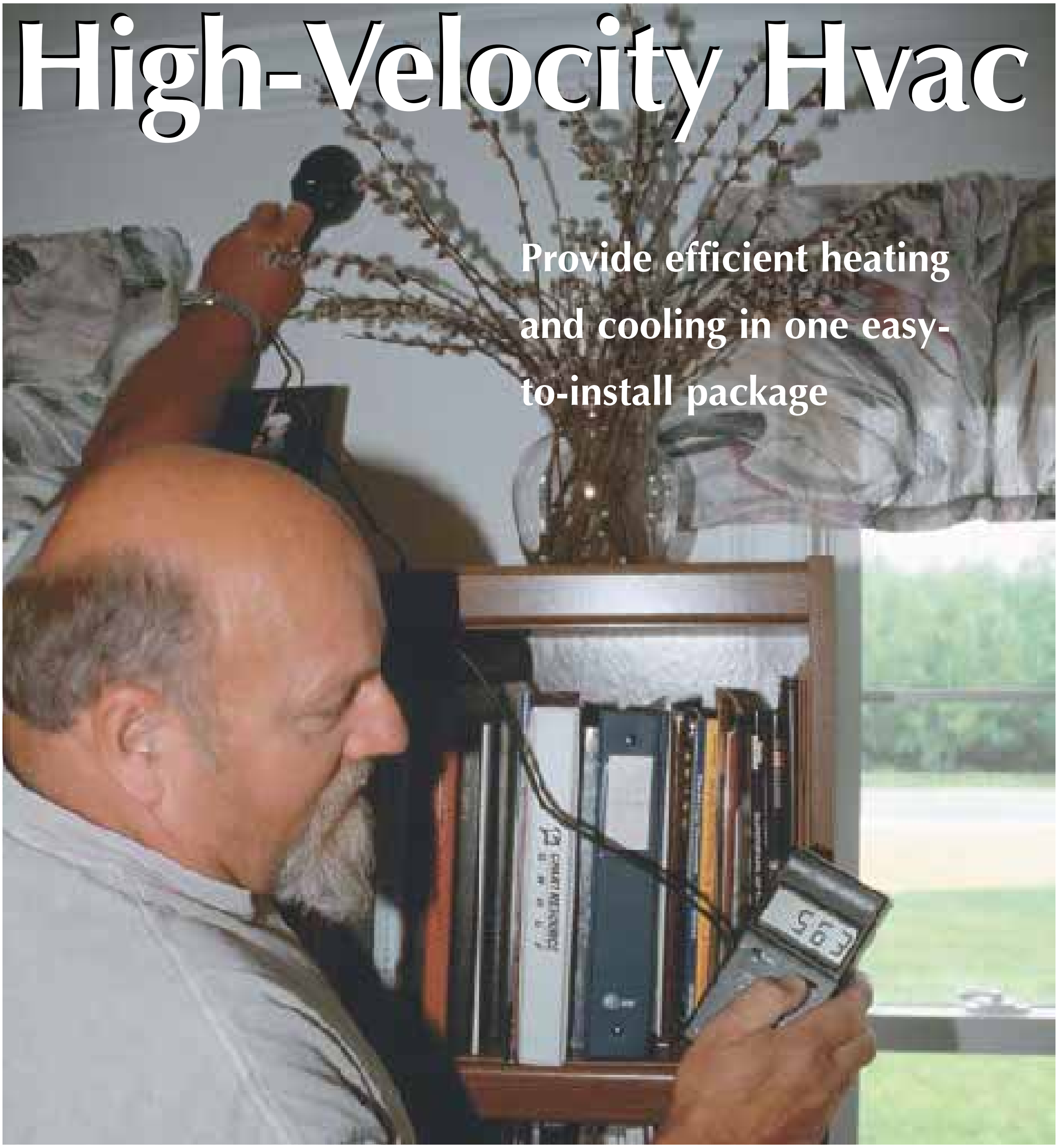
INSTALLING High-Velocity Hvac



Provide efficient heating and cooling in one easy-to-install package

by Thorp Thomas

For years, I was a staunch radiant heating installer who picked up a few air-conditioning jobs to fill in the slow summer months in New Hampshire. But a growing demand from my customers for year-round indoor climate control led me to look for a system that would accomplish heating, ventilation, and air conditioning in one package. I wasn't willing to make the compromises imposed by conventional systems, in which heating and cooling needs are practically in conflict — warm air rises and cool air settles, leaving no optimal place to locate the vents to satisfy both functions. I wanted a system that would work equally well in a chicken coop, a standard home, and a multimillion-dollar house. My search led me to the high-velocity system, a technology refined in the mid-1990s to its current reliable and efficient performance. Over the past six years, my crew and I have installed more than 300 high-velocity systems in both new and existing homes.

High Velocity vs. Conventional Forced Air

The most obvious difference between a high-velocity system and a conventional forced-air system concerns their basic operating cycles. In a conventional system, the air handler and boiler or condenser cycles on and off as the thermostat signals for heating or cooling, depending on the season. In a high-velocity system, on the other hand, the heating and cooling equipment cycles on and off as needed, but the air handler runs continuously to maintain pressure within the ductwork. This pressurized air is delivered through inconspicuous room outlets at speeds high enough to create a slipstream effect that keeps the room air thoroughly mixed (see Figure 1). This eliminates the stratification, or hot and cold spots, that can develop between operating cycles in a conventional forced-air system. The air temperature maintained by high-velocity conditioning varies by only about 1°F between the floor and ceiling of the average home. The constantly running blower is said to use about the same amount of energy as a 100-watt light bulb.

Clean and quiet. Blower units are powered by energy-efficient 1/4- to 3/4-hp motors that generate little direct noise. A constant supply of fresh, outdoor air drawn into the return duct and pulled through high-grade HEPA filtration offers an exceptional degree of indoor air quality. Ambient dust is gradually eliminated from the home's interior once the high-velocity system is activated and never has a chance to settle in the ductwork due to the constant airflow.

Simple installation. High-velocity systems are also remarkably easy to install. Most of that ease comes from the simple ductwork; insulated, flexible ducts branch off a uniformly sized plenum, or main trunk (Figure 2, next page). The branch ducts are small enough to fit within conventional framing tolerances, eliminating the need for most framing modifications. The plenum may be installed in the basement, crawlspace, or attic and usually consists of a single-diameter run. Because velocity is developed at the outlets, bends and elbows in the ductwork have relatively little effect on the airflow — a key difference from conventional forced-air systems, in which every elbow must be factored in and deducted from the total allowable run.

System Sizing

The company we work with, Energy Saving Products (888/652-2219, www.hi-velocity.com), manufactures the Hi-Velocity Soft-Aire system and offers five different air handlers of increasing capacity (Figure 3, page 4). Each of the available air handler models is rated to supply a minimum and a maximum number of outlets. For example, the HV-30 unit supplies a minimum of 8 outlets and a maximum of 14; the HV-140 supplies a minimum 40 outlets and a maximum of 50.

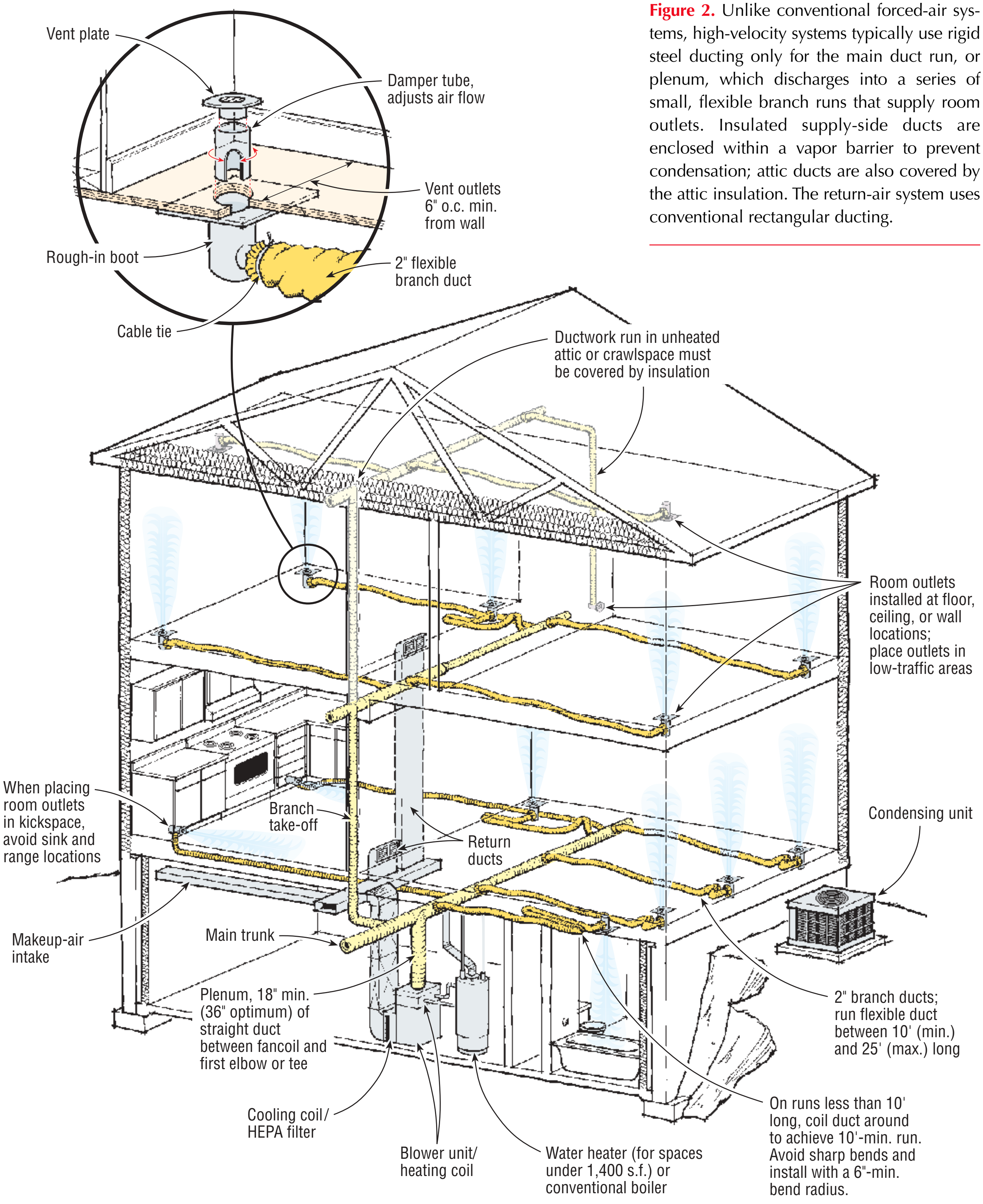
As with any heating or cooling system, the first order of business is to calculate the heat loss and gain for the whole house and for each room in the conditioned envelope. With that information in hand, we select the appropriate air handler from the chart provided by the manufacturer, for the calculated load (Figure 4, page 5).

Room outlets. To calculate the number of room outlets for a heating-only system, we divide the whole-house Btuh heating load by the minimum number of outlets for the selected air handler. This provides the number of Btuh delivered by each outlet. Once we have this information, finding the right number of outlets for any given room is basically a matter of dividing the room load by the per-outlet figure and rounding the result

Figure 1. Continuously blowing outlets provide heating and cooling and can be installed high or low on the wall, as well as in the ceiling or floor. Placement isn't as important as providing an accurate number of outlets per room and avoiding blockage. The outlet grid design imposes laminar air flow, correcting noisy vents.

High-Velocity Hvac System

Figure 2. Unlike conventional forced-air systems, high-velocity systems typically use rigid steel ducting only for the main duct run, or plenum, which discharges into a series of small, flexible branch runs that supply room outlets. Insulated supply-side ducts are enclosed within a vapor barrier to prevent condensation; attic ducts are also covered by the attic insulation. The return-air system uses conventional rectangular ducting.



up to the nearest whole number.

In a dual system — one that will handle both heating and cooling — the number of outlets calculated for one function may differ from the number for the other. In our area, such a discrepancy usually occurs because more outlets are required for cooling. That's not a problem, though — we simply default to the cooling figure, which has no adverse effect on the heating side.

Heat-Transfer Efficiency

High-velocity heating systems are typically run at the same 150-180°F temperature range as conventional systems. In some homes, though, we use a standard water heater as the heat source, rather than a conventional boiler, so the system can provide domestic hot water as well as heat (Figure 5, page 6). In that case, we lower the operating temperature to 140°F or even 120°F and install a tempering valve to prevent scalding.

Although Energy Saving Products recommends using a water heater as a heat source only for spaces under 1,400 square feet, we've used this approach successfully in well-insulated larger spaces as well. But if you're going to use a water heater, it's important to take that into account during the design phase, because the lower temperatures mean fewer Btuhs per outlet, so more outlets will be needed.

On the cooling side. The rule of thumb for conventional air-conditioning systems is that it takes 400 cfm of forced air per ton of load to properly evaporate the refrigerant and provide effective heat transfer. In a high-velocity system, though, the same level of cooling can be achieved at a flow of 250 cfm, thanks to the higher static pressure in the ductwork. In effect, the air is packed more tightly, so fewer cubic feet have to pass through the cooling coil to remove an equivalent amount of heat. Because the air stays in contact with the coil for longer than it does in a conventional system, high-velocity systems remove more humidity from the air, leading to greater comfort even at higher operating temperatures.

Condensing unit. We can use just about any maker's condenser with the air handler, which arrives ready for both heating and cooling with no additional relays required. This allows us to tailor each system to the specific needs of our customers. Some want quieter units, some want higher efficiency; others don't require as much cooling and simply want to keep costs down.

The unit of measure used to define the efficiency of different air-conditioning units is the SEER, or seasonal electrical energy rating. Commonly available units are rated at 10, while the highest-performing units rate as high as 18. (These ratings don't represent the total theoretical range, but rather what the market supplies. And while the most efficient units are rated as high as 18, in practice you can only reach level 14 on a split, field-installed system.) A higher SEER value becomes more important in warmer climates with high electrical costs.

Minimizing system noise is another important consideration. The higher the SEER number, the bigger the unit becomes and the slower the fan has to turn, resulting in much quieter operation. An insulating blanket on the compressor also helps to dampen noise. To balance noise and comfort, we usually recommend a unit rated at 12 SEER in our southern New Hampshire area.

Duct Runs

In a high-velocity system, the complicated supply-side trunk system is replaced by a simple plenum where pressurized air is gathered, stored, and distributed equally to all outlets (Figure 6, page 6). In most of our installations, that main run is a constant diameter throughout — typically 8-inch-diameter, 28-gauge metal duct.

Figure 3. The system's air handler, or blower unit, can be installed in a horizontal, hi-boy, or counterflow attitude and located to maximize usable floor space. A conventional system isn't as lenient in its placement.

Choosing the Right Air Handler

Sample Heat Loss & Gain Calcs

	Master Bed	Master Bath	Bed #2	Bed #3	Bath	Family Room	Kitchen	Nook	Rear Entry	Foyer	Dining	Total
Btuh Loss	13,790	2,585	5,009	3,496	1,453	10,748	3,368	12,174	2,300	5,758	6,558	67,239
Btuh Gain	8,952	1,083	2,724	1,599	475	6,648	2,459	5,928	642	2,361	3,776	36,647

Air-Handler Specs

	HV-30	HV-50	HV-70	HV-100	HV-140
Btuh @ 180 E.W.T.*	41,000	52,300	73,800	105,000	138,200
Btuh @ 160 E.W.T.	33,800	44,400	62,900	86,300	113,800
Btuh @ 140 E.W.T.	26,500	37,500	49,500	68,700	89,500
Btuh @ 120 E.W.T.	19,300	29,500	38,000	49,600	65,300
Btuh @ 40 E.W.T.	18,700	24,000	30,300	46,400	66,900
Thermal Exchange Cooling MBH**	12-18	18-24	30-36	42-60	60
Supply-Air Size & Max Length	8-60"	8-70"	8-80"	10-100"	10-120"
Return-Air Size Needed	10"	12"	12"	14"	16"
Minimum Outlets	10	14	20	30	40
Maximum Outlets	14	20	29	45	50

*E.W.T. = Entering water temperature
**MBH = Per thousand Btuh
Adapted with permission from Energy Saving Products's installation manual

Step 1. Select the air handler needed to handle the whole-house heating load. Given the whole-house heating load of 67,239 Btuh and assuming an entering water temperature of 180°F, the smallest unit capable of handling the load is the HV-70, which has a maximum Btuh capacity of 73,800.

Step 2. Calculate the number of vent outlets needed to handle the heating load. Divide the whole-house heating load by the minimum number of vents for the selected air handler to arrive at the Btuh provided by each outlet — in this case, 67,239 divided by 30, or 2,241. To find the number of outlets needed to heat a given room, divide the heat loss figure for the room by that per-outlet figure. In the case of the family room, for example, this works out to 10,748 divided by 2,241, or about 4.8. Since you can only have a whole number of outlets (although you can restrict the flow of individual outlets to balance the heating or cooling output), that's rounded up to 5.

Step 3. Verify that the air handler selected in Step 1 also has the capacity to handle the expected cooling load. According to the specifications chart, the HV-70 air handler comes up slightly short in terms of cooling: It's designed to provide 30,000 to 36,000 Btuh of cooling (indicated on the line headed "Thermal Exchange Cooling MBH," which refers to thousands of Btuh of cooling in systems equipped with condensing units), compared to a calculated whole-house cooling load of 36,647. In order to provide enough cooling capacity, it's necessary to step up to the next largest model, the HV-100, even though it's unnecessarily large from a heating standpoint.

Step 4. Calculate the number of vent outlets needed to handle the cooling load. Divide the Btuh cooling capacity of the air handler (not the whole-house load figure, as in the heating calculation in Step 2) by the minimum number of outlets. The result, 42,000 divided by 30, or 1,400, is the cooling output of each outlet. Dividing the family-room heat gain figure of 6,648 by the per-outlet figure of 1,400 comes out to 4.7, which again rounds up to 5 outlets. Where the outlet figures for heating and cooling in a room don't match — usually because of large expanses of glass or appliance loads — go with the higher figure.

Figure 4. Once heat loss and gain have been calculated on a room-by-room basis, sizing the air handler and the number of vent outlets needed to heat and cool each room is a four-step process.

Figure 5. An operating temperature of 120° to 140°F permits use of a standard water heater to supply the fancoil unit. Slower passage of air over a larger than conventional coil surface enables higher coil-to-air heat transfer. Because of the lower temperatures, all ductwork must be completely insulated to retain operating efficiency.

The system's reliance on constant air pressure, rather than air volume, mandates absolutely airtight ductwork. We carefully seal every joint and plenum-to-branch connection with duct tape that's been rated by SMACNA (Sheet Metal and Air Conditioning Contractors' National Association) (Figure 7). We find that a visual inspection is really all it takes to confirm joint tightness. The core duct is metal, wrapped in an insulating sleeve with a vapor-proof cover. We also completely tape the vapor barrier to prevent condensation from forming on the ductwork.

In high-velocity's infancy, one of the problems noted was a tendency of some outlets to whistle in service. To prevent noise generation at the outlets, experimentation has proven that the 2-inch-diameter branch ducts must be a minimum of 10 feet long. When the distance from plenum to outlet is less than 10 feet, the flexi-duct can simply be coiled back upon itself to provide the minimum 10-foot length (Figure 8, next page).

To prevent distortion and reduced air flow, we limit bends in the flexi-duct to a 6-inch radius. However, branch runs must also be no longer than 25 feet. Note that the Btuh output of branch runs between 15 and 25 feet long is reduced. During the planning stage, it's necessary to deduct 10% from the output of a 15-foot branch run, 20% from a 20-foot run, and 35% from a 25-foot run. This restriction plays an important part in the layout of the plenum, and it may also necessitate increasing the number of vent outlets in a particular area to provide enough heating or cooling.

Minimal structural changes are called for to accommodate branch ducts because the flexible duct is small enough to fit within conventional wall framing and can easily wrap around obstacles.

Return air. Unlike the supply side, the return side of a high-velocity system uses conventional rectangular ductwork. A sizing chart directs the system design and must be followed to the letter. The pressurizing supply side and the depressurizing return side must be balanced within a 10% plus-or-minus vari-

Figure 6. A single-diameter, minimally sized plenum stores and distributes pressurized air to the branch ducts at an equal rate. A conventional system relies on progressive step-downs in the size of the main trunk to maintain a relatively equal volume of airflow at each vent, making installation far more labor intensive.

Figure 7. Airtight ductwork is absolutely essential to the function of a high-velocity system. The author seals every joint in the ductwork with a clear, SMACNA-rated tape. Careful and attentive application ensures an airtight joint and makes leak testing unnecessary.

ance. An oversized return duct will prevent the blower from producing enough static pressure to support the high-velocity effect.

Proper sizing of the return ducts and grilles also helps to prevent noise. We find that sizing the return grilles generously will keep things quiet. If a particular fancoil has a recommended return-air size of 113 square inches, for example, we prefer to install a grille that is 10% to 20% larger — 124 to 135 square inches — to prevent velocity noise.

Figure 8. Branch ducts must be no shorter than 10 feet long and no longer than 25 feet. The flexi-duct can be coiled back upon itself to provide the minimum duct length, with no reduction in performance.

Figure 9. The author uses a standard blast gate to regulate fresh, outdoor makeup air entering the return plenum at a rate of about 10% of the total volume. Return air is drawn through a HEPA filter and conditioned before being returned to the living space.

Makeup air. In a conditioned building envelope, air displacement follows two routes: exfiltration and infiltration. Conditioned air escapes, or exfiltrates, by every available path — through seams, gaps, open doors and windows, kitchen and bath exhaust ducts, etc. To replace the escaping air, fresh air must infiltrate the envelope by similar means. Infiltrating air is usually cold in the winter and is contaminated by airborne dirt and pollutants.

To create a controlled system, we introduce an exterior-mounted passive air inlet into the return duct. This makeup air is drawn through the HEPA filters, across the cooling or heating coil, and distributed throughout the house. We adjust the inlet opening to account for roughly 10% of the return air supply, which is controlled by a simple blast gate (Figure 9). The high-velocity system produces a slightly positive indoor pressure, effectively blocking infiltration drafts.

Room Outlets

Room outlets can be located on the floor or ceiling, on interior or exterior walls, and even in kickspaces. But careful placement of the outlets is important for homeowner comfort.

Under the influence. Each room outlet has a "zone of influence" that's about 8 inches in diameter and can be felt at a distance of 4 to 5 feet from the outlet. These streams of moving air keep the room air circulating to prevent stratification, but they shouldn't be allowed to play directly against the home's occupants. Moving air has a chilling effect (that's why fans keep you cool and weather forecasters like to talk about the wind-chill factor), so a stream of cool air can seem uncomfortably cold, while a stream of heated air may not seem warm enough.

For the sake of comfort, outlets should be located in room corners, out of main traffic patterns. We avoid installing kickspace outlets below a sink or range, or in any other area where they're likely to blow on someone's feet. We also avoid areas likely to be obstructed by furniture, drapes, rugs, plants, or other objects. With proper planning, the occupants will have no sensation of air movement. Broad outlet distribution is preferable, but not essential, for proper function. We've clustered three outlets within an existing abandoned floor duct with complete success.

Thorp Thomas *owns and operates Heatkits, Inc., in Exeter, N.H.*