VENTING Gas Appliances

by Bob Dwyer & Mark Gronley

For a safe gas flue, use the right materials, size by the book, and always perform a combustion test

Most furnaces, boilers, and water heaters going into homes today are not super-efficient "sealed combustion" or "direct vent" units. They are mid-efficiency "atmospheric-vented" appliances that use a regular vent or chimney, relying on natural buoyancy to carry the hot gases up the flue and out at the top.

But compared to yesterday's 65% efficient units, modern 78% to 83% efficient, naturally vented appliances keep more heat in the house and send less heat up the flue — and that makes things tricky. The cooler the flue gas, the weaker the draft and the greater the risk of back-drafting.

Cooler exhaust also increases the risk of condensation and corrosion in the vent. Gas burner exhaust is mostly carbon dioxide and water vapor, and in modern systems, that moist mix enters the flue at a temperature not far above its dew point of 140°F. If the moisture hits a cool surface, or just takes too long to reach the top of the system, it's likely to condense — and because the vapor contains trace amounts of oxides of nitrogen, the condensate is a weak nitric acid solution that can corrode masonry or metal (see Figure 1, next page).

If vents and chimneys get wet only occasionally and dry out quickly, damage isn't likely. But systems that get wet and stay wet can corrode badly, and fast. To minimize "wet time," modern vent systems have to be sized just right — large enough to handle the exhaust but small enough to warm up quickly, so that any condensation will dry up before the equipment shuts down and the flue won't stay wet between cycles.

Material choices affect vent function, too. Masonry chimneys that take a lot of heat to warm up and uninsulated single-wall vent pipe that allows excessive heat loss have limited usefulness with modern gas equipment. For the most part, those old materials are being replaced by insulated double-wall B vent, which warms up quickly and has an aluminum inner lining to resist corrosion.

Even with modern vent materials,

Figure 1. Condensation in gas flues is acidic and can attack vents and chimneys. Telltale white deposits and rust are signs of corrosion (top left), which can perforate vent pipe and allow fumes to leak (top right). Chimneys are especially vulnerable: Acidic condensate eats through tile flue liners (bottom left) and destroys brick masonry (bottom right). It takes 50,000 Btus to heat a masonry chimney above the dew point of gas appliance exhaust, while only 125 Btus are needed to warm a B vent flue.

the rules for designing and sizing vent systems are complicated. With modern systems, the old "common sense" rules of thumb can be a recipe for failure. In fact, following the latest rule book religiously isn't always enough. To make sure the system works the way the installer intended, a trained technician should use combustion and draft testing instruments to check each installation against the manufacturer's specs.

New Rules, New Problems

In the early 1990s, after the government raised efficiency requirements to 78% for gas boilers and 80% for gas furnaces, there was a rash of complaints about back-drafting and corrosion in flues. In response, the gas industry made another rule change: It replaced the old, simple ratios of vent and chimney sizing with an elaborate new set of vent-sizing lookup tables, based on extensive research by Batelle Laboratories and the Gas Research Institute (GRI). The goal was to make sure that flues not only would draw properly, but also would stay as dry inside as possible.

The new sizing tables are published in the National Fire Protection Association (NFPA) *National Fuel Gas Code* (www.nfpa.org), in model building codes, and in manufacturer handbooks and instructions. They're also the basis for computer software packages such as Elite Software's Gasvent (www.elitesoft.com), which automates the tedious process of cross-checking vent and appliance capacities.

The tables specify the height, lateral run, and diameter of vents and vent connectors for a whole range of situations, depending on the vent material and on the size and type of the appliance or combination of appliances being vented. And you can work the system in reverse: If you know the vent material, the vent diameter, and the horizontal and vertical layout of the vent system, the tables tell you what size appliance the vent can serve.

Unfortunately, many installers still don't understand why the new rules exist or how they work, and they also may not understand that changing venting materials can change the requirements. When we test and inspect installations in the field, we continue to see enough mistakes to know that a lot of "technicians" are still doing things "the way we've always done it" — with predictably bad results.

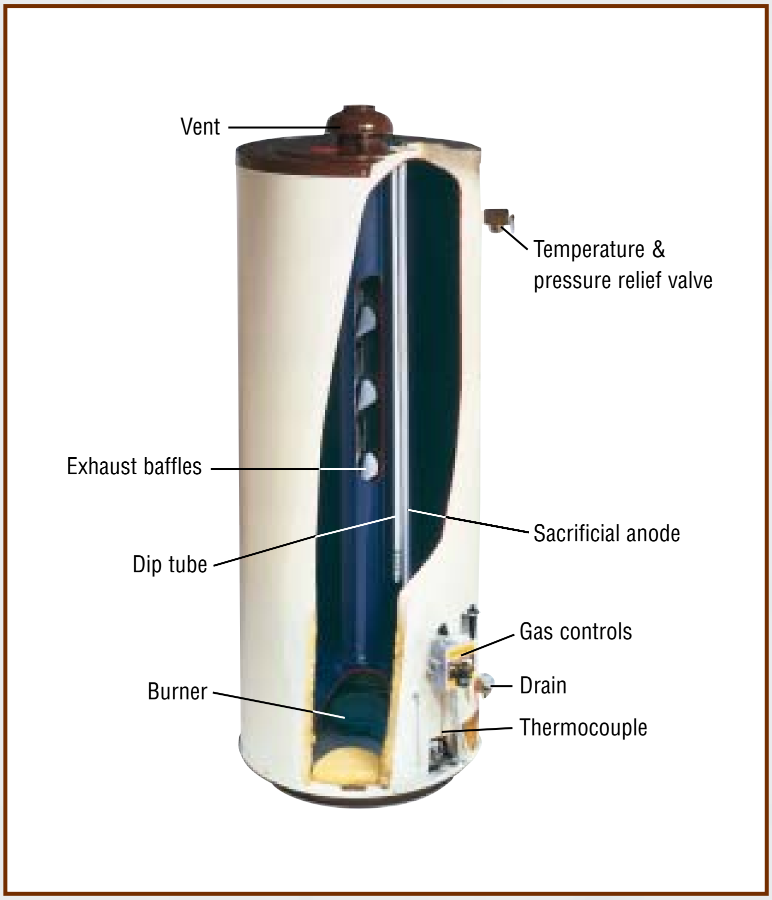


Figure 2. Fan-assisted Category I furnaces (above) use an inducer fan to overcome air resistance in the combustion chamber but do not pressurize the vent system. No dilution air is introduced, so the exhaust is damp and condenses readily. Draft-hood water heaters (right) rely on natural draft to bring in combustion air, and the draft hood allows dilution air to mix with flue gases, wasting some energy but creating a drier flue gas. The two types have different vent size requirements but can be common-vented on a single flue as long as sizing rules are followed.

Gas furnaces, boilers, and water heaters are safe and reliable when everything is done right. But builders and remodelers should be extra careful to use hvac technicians who thoroughly understand and follow the rules, and who check every installation with professional instruments.

Complex Range of Options

There's a wide range of choice in appliances and vents. But for every combination of equipment type and vent material, the basic goals and limits apply: The vent must be able to provide sufficient draft for the equipment; it must be warm and dry enough to avoid damaging corrosion; and it must be fire safe. The sizing tables and other venting rules aim to achieve that safety and durability, but in providing for the whole range of choices, the rules have become complicated.

Appliance types. Most mid-efficiency furnaces and boilers are "fan-assisted" units, which use an inducer fan to push or pull air through the combustion chamber (Figure 2, previous page). The fans help overcome resistance to airflow within the appliance and create turbulence for better combustion and heat exchange, to boost efficiency. But they don't pressurize the vent system: Once the exhaust leaves the unit, it still needs the negative pressure of buoyancy in the vent to draw it out of the house.

Water heaters have slightly less stringent efficiency standards, so most of them still use the old draft-hood technology and rely on natural convection to pull air into the combustion chamber. The draft hoods let dilution air enter the flue, which provides some drying (but at the cost of lower total efficiency).

One cubic foot of natural gas supplies about 1,000 Btus of energy. Fan-assisted units need about 15 cu.ft. of air to fully combust that 1 cu.ft. of fuel, producing about 16 cu.ft. of cool, damp exhaust. Draft-hood units require an additional 14 or 15 cu.ft. of dilution air for each 1 cu.ft. of fuel consumed, producing roughly 30 cu.ft. of relatively drier exhaust products for the flue to handle. (The ratios are slightly different for propane, but the principle is the same.)

This difference between fan-assist and draft-hood performance has an effect on venting requirements. Because a draft-hood appliance creates a large volume of exhaust, it needs a taller or larger-diameter vent than a fan-assisted

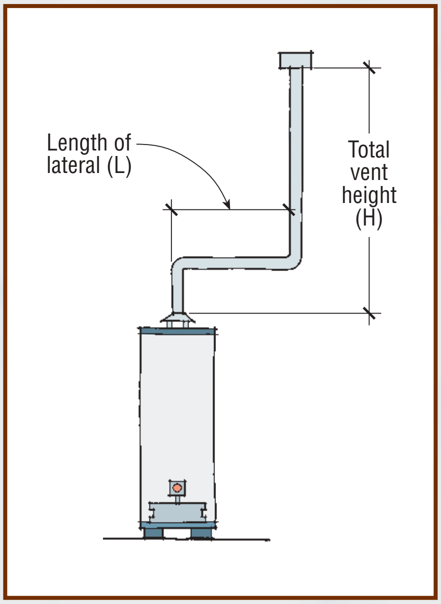


Figure 3. Vent height, vent lateral run, vent diameter, and vent material all must be factored into the sizing match between an appliance and its vent system. In general, tall B vents with no lateral runs offer the greatest freedom of choice for appliance size. Lateral runs, elbows, and single-wall vent pipe sharply degrade vent performance and restrict appliance selection. In the example of a 10-foot vent height with a 5-foot lateral run (circled in table), a 4-inch B vent and B vent connector can serve any fan-assisted appliance larger than 32,000 Btu/hr and smaller than 113,000 Btu/hr. Increasing the vent diameter to 6 inches raises the minimum to 52,000 Btu/hr and the maximum to 280,000 Btu/hr. But using a single-wall vent connector shrinks the maximum to 111,000 Btu/hr while raising the minimum to 76,000 Btu/hr. Fan-assisted appliances are ruled out for masonry chimneys regardless of connector type.

Single Appliance, Continuous B Vent

		4-inch-diameter vent			6-inch-diameter vent		
Vent height	Vent lateral	fan min.	fan max.	nat max.	fan min.	fan max.	nat max.
10'	0'	0	175	100	0	447	255
	2'	17	118	81	26	289	195
	5'	32	113	77	52	280	188
	10'	41	104	70	67	267	175
15'	0'	0	191	112	0	502	285
	2'	15	136	93	22	339	225
	5'	30	130	87	49	330	217
	10'	40	121	82	64	315	208
	15'	48	112	76	76	301	198

Single Appliance, Single-Wall Connector to B Vent

		4-inch-diameter vent			6-inch-diameter vent		
Vent height	Vent lateral	fan min.	fan max.	nat max.	fan min.	fan max.	nat max.
10'	0'	57	174	99	120	444	254
	2'	59	117	80	119	287	194
	5'	76	111	76	148	277	186
	10'	97	100	68	188	261	171
15'	0'	56	190	111	116	499	283
	2'	57	136	93	115	337	224
	5'	75	128	86	144	326	217
	10'	95	116	79	182	308	203
	15'	NA	NA	72	220	290	192

unit of the same Btu rating. Oversizing, however, isn't a problem: A vent serving a draft-hood unit can only be too small, not too large.

A vent that serves a fan-assisted appliance, on the other hand, can be too small *or* too large. Because its exhaust gas is relatively cool and damp, the fan-assisted unit won't warm the vent quickly enough to prevent damaging condensation (and with fan-assisted equipment, there's no drying airflow through the system when the unit's not running). So for each vent configuration listed (height, lateral run, and diameter), the tables show both a minimum and maximum allowable Btu rating for fan-assisted equipment ("fan min." and "fan max."). For draft-hood equipment, the tables show only the largest equipment permitted on the vent ("nat max.") — there is no minimum. For two appliances "common-vented" on the same flue, the tables provide a complex range of options depending on whether the setup involves two "fan" appliances, two "nat" appliances, or one of each.

Vent materials. The sizing tables also must account for the different behavior of different vent materials. Masonry chimneys take a long time to heat up and are prone to condensa-

Single Appliance Connected to Masonry Chimney With B Vent Connector

Vent height	Vent lateral	4-inch-diameter connector: fan min.	4-inch-diameter connector: fan max.	4-inch-diameter connector: nat max.	6-inch-diameter connector: fan min.	6-inch-diameter connector: fan max.	6-inch-diameter connector: nat max.
10'	2'	NA	NA	61	NA	NA	162
	5'	NA	NA	57	NA	NA	147
	10'	NA	NA	50	NA	NA	137
15'	2'	NA	NA	67	NA	NA	178
	5'	NA	NA	62	NA	NA	163
	10'	NA	NA	55	NA	NA	151
	15'	NA	NA	48	NA	NA	138
Minimum chimney area		19 square inches			38 square inches		
Maximum chimney area		88 square inches			198 square inches		

Single Appliance Connected to Masonry Chimney With Single-Wall Vent Connector

Vent height	Vent lateral	4-inch-diameter connector: fan min.	4-inch-diameter connector: fan max.	4-inch-diameter connector: nat max.	6-inch-diameter connector: fan min.	6-inch-diameter connector: fan max.	6-inch-diameter connector: nat max.
10'	2'	NA	NA	61	NA	NA	161
	5'	NA	NA	56	NA	NA	147
	10'	NA	NA	49	NA	NA	137
15'	2'	NA	NA	67	NA	NA	178
	5'	NA	NA	61	NA	NA	163
	10'	NA	NA	54	NA	NA	151
	15'	NA	NA	46	NA	NA	138
Minimum chimney area		19 square inches			38 square inches		
Maximum chimney area		88 square inches			198 square inches		

Figure 3. See caption previous page.

tion, so they can serve only a very restricted range of appliance sizes (and seldom if ever can handle a fan-assisted unit by itself). Chimneys on outside walls are especially problematic and should generally be relined with a listed metal liner for use with gas. B vent (the standardized, listed double-wall insulated vent pipe material) is by far preferable to masonry and permits a much wider range of equipment sizes. B vents and chimneys each get their own sizing table in the code.

Single-wall metal vent connectors, though still in wide use as the least expensive choice, also limit both the minimum and maximum sizes of equipment permitted on a given size of vent. They lose heat more quickly than B vent connectors, weakening the draft and raising the risk of condensation wherever they're used. They're also less fire safe: They require a 6-inch clearance from combustibles, compared to 1 inch for B vent, and they can't run in a concealed space or through an unheated attic or crawlspace. In general, single-wall vent connectors are best avoided, in spite of their lower cost. Still, sizing tables are provided for single-wall vent connectors, either with masonry chimneys or with B vents.

Using the Sizing Tables

In matching equipment to vents, the pitfalls are many. Too small a vent diameter, and you won't have enough draft; too big, and you might get condensation. Too long a horizontal connector, too short a vertical vent, too low a connection to the vent, too many elbows, too small a vent diameter, or all of the above, and the vent won't draw. A setup that will work with B vent might not work with a masonry chimney; one that works with double-wall insulated vent connectors might not work with single-wall vent connectors.

The sizing tables reflect all of that complexity, with more than ten different tables that apply to different situations. We're not going to teach everybody how to use the sizing tables like a pro with this article. That takes training and practice, and even experienced professionals find it easier to use a computer. But we'll give you a few examples just to clarify the idea.

A single appliance. Let's start with the simplest case: a single appliance connected directly to a vent or chimney. You could connect it to a B vent with a B vent connector, to a B vent with a single-wall connector, to a masonry chimney with a B vent connector, or to a masonry chimney with

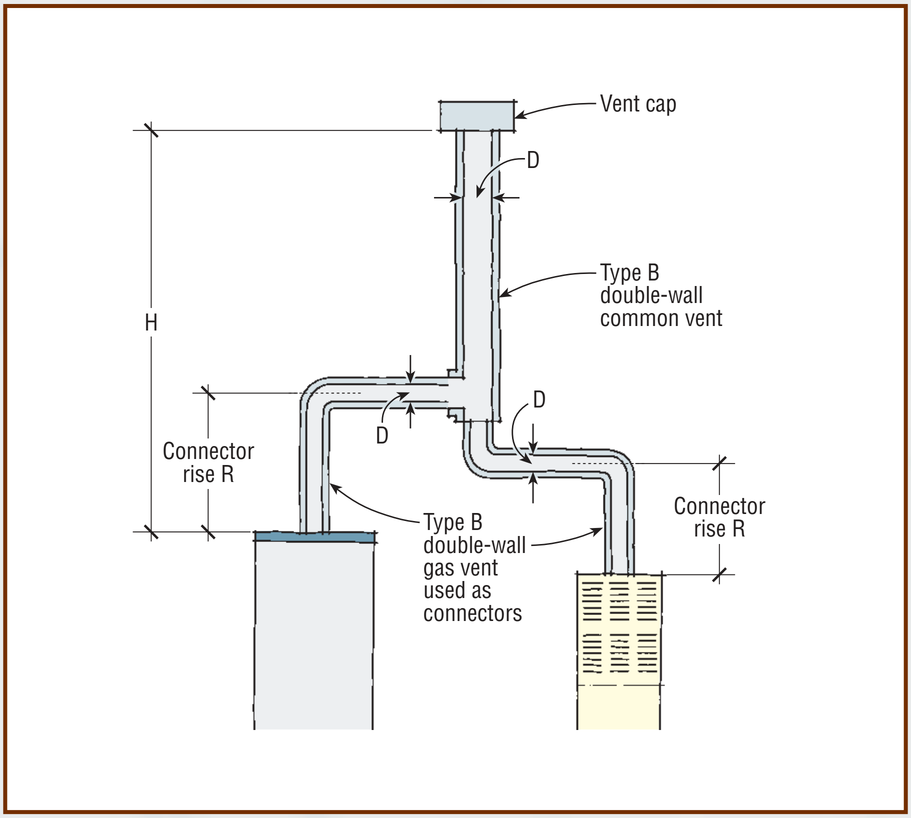


Figure 4. When two units are common-vented, each vent connector must be sized independently, and vent connector capacity dictates appliance size ranges. Again, single-wall vent connectors sharply restrict the choice, and for practical purposes fan-assisted units will nearly always require B vent. Given a 10-foot vent height and a 3-foot connector rise (circled in table), a B vent connector could handle a fan-assisted unit between 37,000 and 92,000 Btu/hr (for 4-inch-diameter pipe) or between 69,000 and 220,000 Btu/hr (for 6-inch-diameter pipe). If single-wall connectors were used, the appliance on the 4-inch connector would have to fall between 89,000 and 91,000 Btu/hr — essentially no choice at all. Increasing connector diameter boosts both the maximum and the minimum, leaving the allowable range quite narrow. Many units would be too large for a 4-inch connector and too small for a 6-inch connector (see next page for charts).

a single-wall connector. The tables show you how big an appliance you can use in each case, for various heights, horizontal runs, and diameters of vents.

Figure 3 on pages 4 and 5 shows just a small section cut from the appropriate sizing table for each of those four options. We're showing what the table tells you for either a 10-foot or a 15-foot vent rise, with a range of horizontal runs. If the rise falls between 10 and 15, you're allowed to interpolate — but let's not go there.

Common venting. Now let's add a complication: two appliances common-vented on a single flue (Figure 4, this page and next page). The table now has to consider "vent connector rise," and it matters whether we've got two "nat" appliances, two "fan" appliances, or one of each.

Of course we still have all the various vent types to choose from: B vent or masonry chimney, B vent connector or single-wall. As you see, chimneys don't give you much choice compared to the B vent options.

Improving the venting arrangement can widen your equipment options (Figure 5, pages 8). If the table won't permit the appliance you need, try to increase total vent height or connector rise by repositioning the appliance or rerouting the vent. Consider the options carefully: Common-venting two appliances with a single vent often lets a vent handle more total Btus and conserves material, but if it takes too many elbows and horizontal runs to accomplish, you may be better off giving each unit its own straight vent. That way, neither unit will ever have to operate alone on a flue that is sized for two.

You can see why a lot of hvac contractors don't use these tables. It's a real pain in the neck. But with software available to automate the process, there's no excuse for a professional to ignore the rules. And most cases aren't that complicated — once you get the hang of the system, you can home in on working solutions without too much trouble.

However, it's important to realize that the tables don't account for every possibility. They don't include the effect of elbows in the system, for example: Each table assumes no more than two 90-degree bends, and vent capacity is reduced by 10% for each additional 90. And all the main table numbers are based on vents that run inside the house: Vents placed outside the walls are more prone to failure. (There are some special tables for masonry chimneys on exterior walls, but the allowable unit minimums are quite large; it's always better to reline the chimney with a listed metal liner instead.)

With experience, people learn how to make adjustments when the tables limit

Figure 4. Continued from previous page

Connector Sizing for B Vent Connector (two appliances sharing one B vent)

Vent height	Connect or rise	4-inch-diameter connector fan min.	fan max.	nat max.	6-inch-diameter connector fan min.	fan max.	nat max.
10'	1'	34	78	50	65	189	113
	2'	36	86	59	67	206	134
	3'	37	92	67	69	220	150
15'	1'	33	89	53	64	220	120
	2'	35	96	63	66	235	142
	3'	36	102	71	68	248	160

Capacity of Common B Vent Using B Vent Connectors

	4-inch vent fan + fan	fan + nat	nat + nat	6-inch vent fan + fan	fan + nat	nat + nat
10' vent height	110	97	79	243	194	178
15' vent height	125	112	91	283	228	206

Connector Sizing for Single-Wall Connector (two appliances sharing one B vent)

Vent height	Connect or rise	4-inch-diameter connector fan min.	fan max.	nat max.	6-inch-diameter connector fan min.	fan max.	nat max.
10'	1'	NA	NA	50	182	186	110
	2'	84	85	59	189	203	132
	3'	89	91	67	197	217	148
15'	1'	79	87	52	177	214	116
	2'	83	94	62	185	230	138
	3'	87	100	70	193	243	157

Capacity of Common B Vent With Single-Wall Vent Connectors

	4-inch vent fan + fan	fan + nat	nat + nat	6-inch vent fan + fan	fan + nat	nat + nat
10' vent height	NA	94	76	237	189	174
15' vent height	121	108	88	275	221	200

their choices. Reconfiguring the vent to increase total vent height or connector rise is one way to increase a vent's capacity when a large appliance is called for. This may be more economical than using a larger-diameter vent.

Do's and Don'ts of Venting

The rules are based on some fairly simple ideas: Hot air rises, and flue gases will condense if they cool; a strong draft is good, and condensation is bad. The important ideas are to supply plenty of combustion air, to keep the flue warm and dry, and not to restrict the flow of exhaust in the flue. If you try to maximize all the good influences and minimize all the bad influences, most systems will fall well within the permissible range in the tables. A few basic do's and don'ts will take you a long way toward getting good results:

• Never use unlined chimneys. Avoid

masonry chimneys even with tile liners. Reline chimneys with listed liners or B vent.

• Avoid single-wall vent connectors if possible. If you must use a single-wall connector, choose a corrosion-resistant brand. Single-wall vent pipe cannot pass through unconditioned space (attic or crawlspace) and cannot run through concealed spaces. It must be readily accessible for inspection, cleaning, and replacement.

• Keep the vent or chimney within the conditioned envelope.

• Keep appliance locations warm.

• Maximize total vent height (in all cases provide at least 5 feet of vent above the highest draft hood or flue collar).

• Maximize vertical connector rise off the appliance (Figure 6).

• Avoid long horizontal runs.

• Maintain correct pitch in horizontal connectors (no sag). Support vent connectors properly.

• Avoid elbows.

• Use 45s and 60s instead of 90s — two 45s equals one 90 (Figure 7, next page).

• Use wyes rather than tees.

• Consider independent venting for separate appliances.

• Avoid oversizing equipment.

• Plug any unused openings in the chimney or vent.

• Observe required clearances.

• Use an approved firestop system wherever B vent passes through a wall or floor. Never run single-wall vent pipe through any wall or floor.

• Don't share flues with oil, coal, or wood. Mark all gas vent systems clearly to prevent their use by any other type of appliance.

• Do not allow two vent connectors to enter a main vent or chimney opposite each other. Instead, offset the connections.

• Terminate vents well away from walls and well above steep sloped roofs. Use UL-listed vent caps, not locally made or DIY caps.

Adding Height Improves Vent Performance

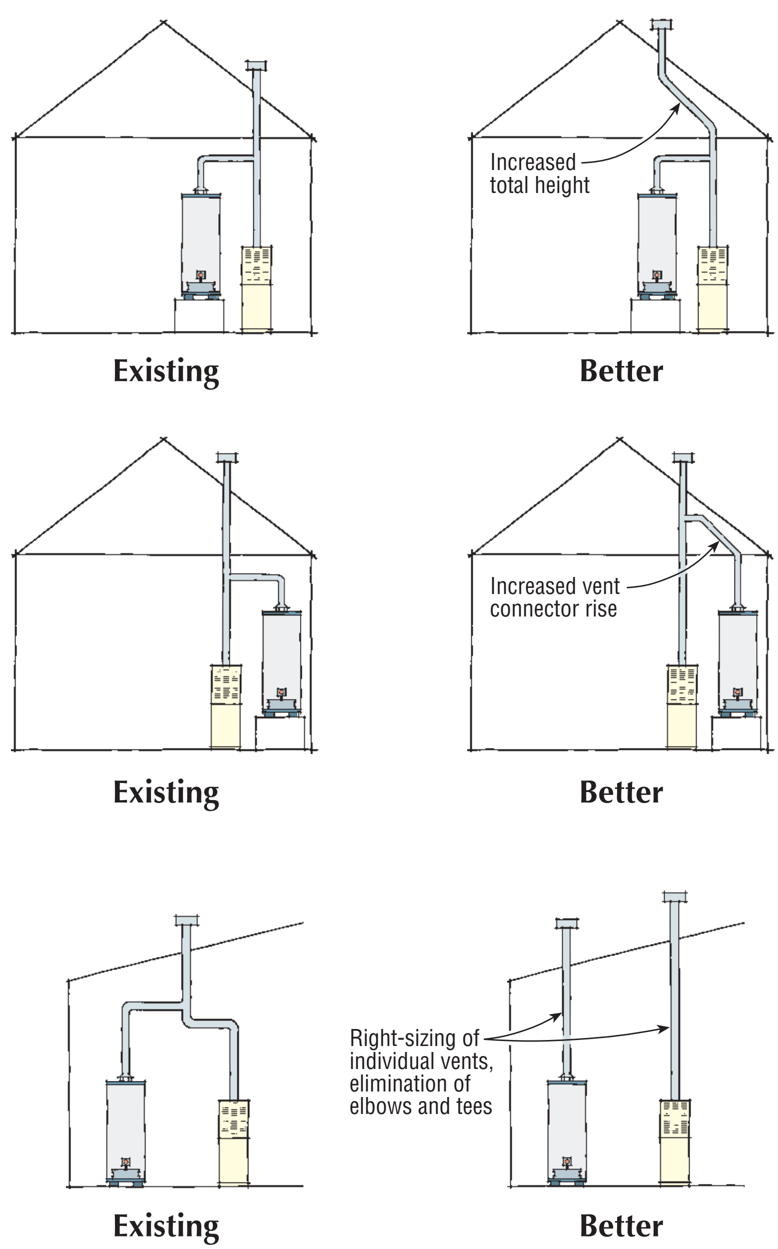


Figure 5. Reconfiguring the vent to gain total height or connector height can improve the performance of a common vent. Venting each unit separately can also improve reliability, because it right-sizes each vent, whereas the common vent is oversized whenever either appliance operates alone (and requires lateral runs and elbows that degrade performance).

Use Headspace to Boost Connector Rise

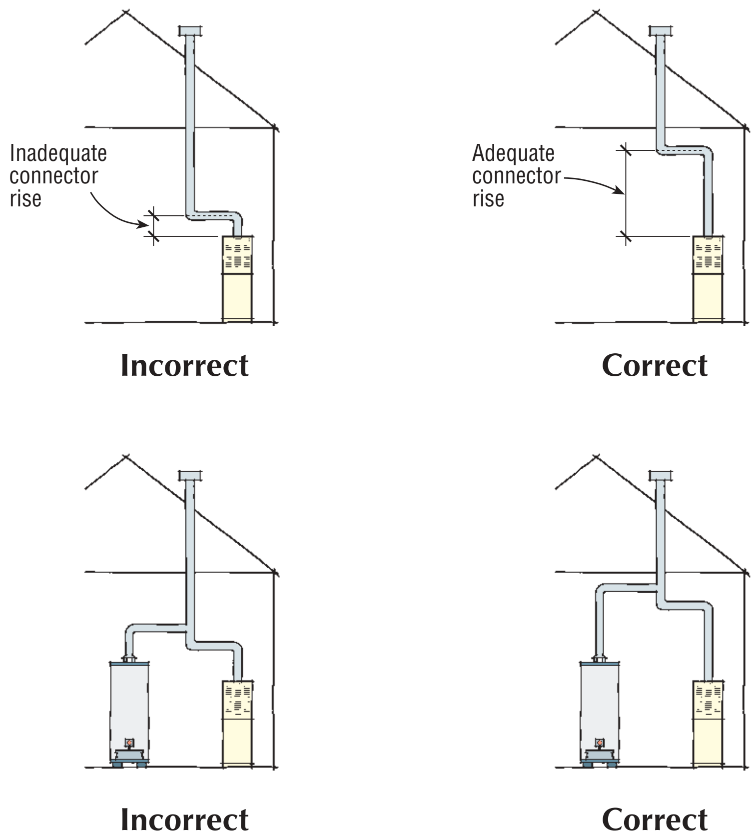


Figure 6. When space allows, always maximize the rise of the connector directly off the appliance — this helps to develop a strong draft. A minimum of 1 foot is required, but more is better.

Avoid 90° Elbows

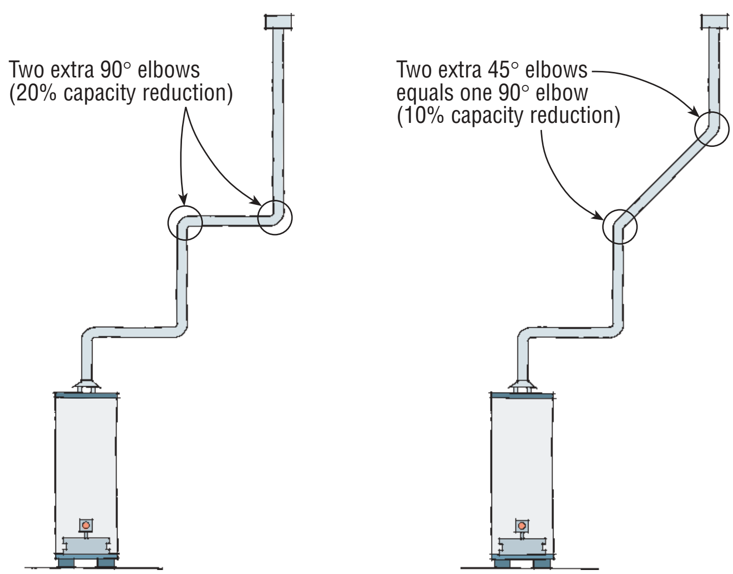


Figure 7. When elbows are needed, 45-degree or 60-degree bends are preferable to 90-degree bends. The sizing tables assume two 90-degree elbows per appliance, and each additional 90-degree elbow reduces vent capacity by 10%. The two extra 90-degree bends in the left-hand example reduce the vent's capacity by 20%; if 45-degree bends are used instead, the capacity reduction is only 10%.

A Case of Backdrafting: Why Makeup Air Matters

Many years ago, we encountered a case of carbon monoxide poisoning that helped open our eyes to the importance of looking at the whole house as a system, not just at the appliance by itself. We also gained more appreciation for using test instruments to check system performance — both in testing the indoor air for carbon monoxide, and in testing the functioning of the appliance with combustion analyzers and draft test equipment.

The house was a one-story ranch with a full basement. Built in the late seventies, it was an early example of very tight construction — as we discovered. The husband in the family worked every weekday, and the wife stayed home with their two preschool children.

The wife had persistent health complaints — she felt headachy and tired all the time. The husband usually felt fine — except on weekends.

When we checked the appliances, located in a large, open basement, we found all the settings correct, but there was severe corrosion in the furnace and telltale damage around the draft hood of the water heater, indicating a lot of spillage. Theoretically, the huge open basement was an "unconfined space" with plenty of combustion air — but this was back before codes began to require makeup air vents in homes with tight construction. And this house was tight. A blower door test found only one tiny leak, at a can light in a bedroom closet.

It turned out that the wife followed a regular routine: She did all the family's laundry every Monday. The washer and dryer ran all day. This meant that the water heater ran all day, too — with its vent having to fight the suction of the dryer vent. Once defeated by the dryer, the water heater never reestablished a draft in the flue — it continued to run backwards all week.

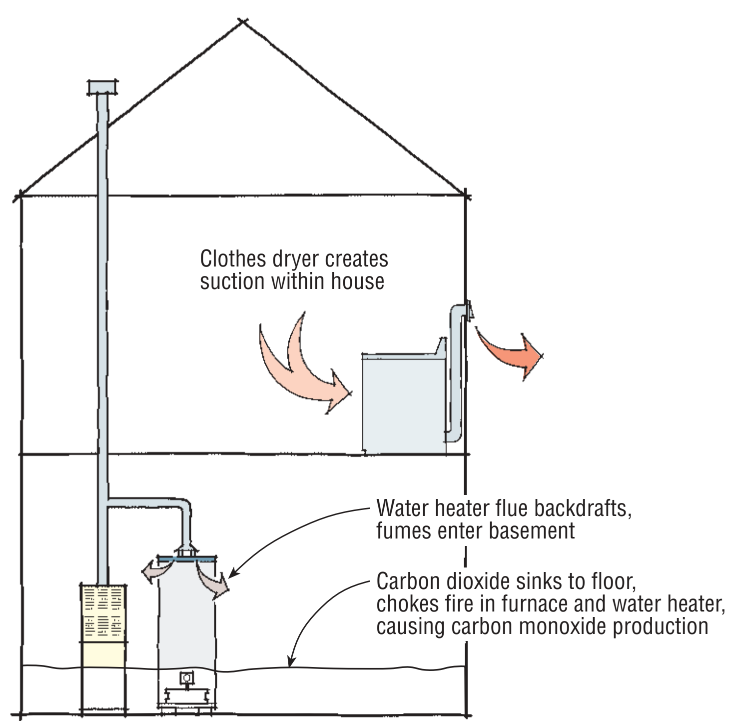
At first, the water heater would burn cleanly. But the carbon dioxide it produced, being heavier than air, would settle to the bottom of the basement and gradually displace oxygen (see illustration). As the CO_2 rose to cover the appliance air intakes, it began to starve them for oxygen, and they began to have incomplete combustion, producing carbon monoxide. The wife's symptoms were caused by CO poisoning — the husband was able to clear his system during his workdays outside the house and felt sick only on weekends.

The equipment had to be replaced. Beyond that, we had to build a tight enclosure for the equipment, a mechanical room in the basement — and we cut ducted air supply vents into the band joist, one low and one high. The family's health cleared up.

Today, the solution we applied is required by code in tight houses, although we don't always see the rules enforced.

We still run into that family from time to time, and it's a nice reward to think of the many years of good health they've enjoyed as a result of what we were able to do.

Defeating the Vent



• Never connect positive-pressure vent systems to a negative-pressure vent system.

• Isolate appliances from house indoor pressures and provide an air supply from outdoors.

• Always test combustion products and draft after installation.

Air supply. An 80,000-Btu/hr appliance consumes 15 to 30 cu.ft. of air per cu.ft. of fuel. To burn 80 cu.ft. of gas in an hour, it requires 1,200 to 2,400 cu.ft. of air. In the winter, furnaces and water heaters can easily gulp enough air to empty and fill a 12x20-foot room with an 8-foot ceiling some six or eight times a day.

Ultimately, that combustion air needs to come into the house from outdoors. The codes require the mechanical room to have inlet vents for air, and if the house is tightly built, those air vents have to communicate with the outside. Depending on their location, the openings are required to provide a free vent area of 1 square inch for every 1,000, 2,000, or 4,000 Btu/hr of the total input rating of the appliances in the enclosure (see "Makeup Air for Combustion Equipment," 12/99).

If the space the appliances are in communicates with house air, depressurization of the house may affect the performance of the appliance in spite of the makeup air openings. So it's best to isolate the mechanical room from the rest of the building with tight walls and a door, as well as to allow easy passage of air to and from the outdoors.

Testing Combustion and Draft

After installing or replacing any gas heating appliance, it's important to make sure it's working properly. Affordable modern equipment like Bacharach's "Fyrite Pro" can directly measure the important parameters that tell you how the unit is functioning (Figure 8).

The new instruments work in real time. Instead of a momentary snapshot, it's like having a video: By placing the instrument probe directly into the flue gas stream, the technician can watch the readings change from moment to moment through the appliance's whole cycle of operation, from lightoff through warmup, steady-state operation, and shutdown. He can also see the effect of adjustments in fuel pressure or combustion air supply as he makes them, or even watch the effect of opening a window or door or turning an exhaust fan on or off to change the house air pressures.

The instrument directly reads room air temperature, stack temperature, draft pressure, flue gas carbon monoxide (CO), and flue gas oxygen. From that input it automatically computes combustion efficiency, flue gas carbon dioxide (CO_2), flue gas carbon monoxide content referenced to 0% oxygen ("air free" CO), percent of excess air, and differential temperature. The technician can then compare the readings with the manufacturer's acceptable ranges and adjust the unit accordingly.

It may take some fiddling to find the optimum settings. Often the gas pressure is set too high or too low, or the air intake needs adjustment. If the unit refuses to work properly after all the adjustments have been tried, there's trouble: The flue should be inspected for blockage, the room air pressures analyzed, and the unit checked for mechanical failure.

Depressurization test. The vent tables are based on a neutral-pressure environment, but in the real world units may face negative air pressures in the house. Compared to the power of a kitchen vent or dryer vent, the draft for a Category I appliance is weak — only about -.02 to -.04 inches of water column. Anything that can depressurize a building could easily reverse a flue, and the less heat in the flue, the more likely that is to happen. To make sure it won't, we need to run a "worst-case depressurization" test.

Starting with a cold flue, we close all the doors and windows, then turn on anything in the house that creates negative pressure — all the exhaust fans, the dryer, the central vac, and any other appliances (you may need to run hot water to make the water heater start). Then we start up the furnace and take a new set of measurements with our test instruments. If the unit doesn't run within manufacturer specs with the exhaust fans running, further steps are needed to isolate the equipment from house air pressures and provide combustion and makeup air.

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Figure 8. Modern test equipment can measure flue gases and analyze appliance performance in real time. The instruments will detect poor draft in the flue or combustion problems and help technicians pinpoint the cause.