Fixing Bathroom Ventilation Problems

by Pete Glogowski

Often the fan is big enough, but the ductwork is nonexistent or poorly installed

In addition to new construction and remodeling, our company offers home energy assessments and any related energy-performance upgrades that may be needed. So we spend lots of time in attics fixing air-sealing and insulation problems, as well as addressing issues with bathroom fans. We often find that fans are vented directly into the attic area, or that the ductwork is poorly installed.

When hot, moist air is dumped into a vented attic in the winter, the water vapor generally condenses on the roof sheathing, starts mold growth, and eventually leads to structural damage. We also find that even when bathroom fans are exhausted to the outside, they're usually vented with flex duct, which is very restrictive to airflow.

A Common Complaint

The clients on one of my current remodeling jobs pointed out mold growing on the ceilings of their two bathrooms (**see Figure 1, next page**). The master bath was 110 square feet and had a sink, toilet, shower, and whirlpool tub. The shared bath was 40 square feet and had a sink, toilet, and shower. There was an odd-shaped patch of mold in the middle of the shared bath's ceiling, and mold and

mildew around the edges. Both bathrooms had 70 cfm fans.

Basic fan sizing. The first instinct of many homeowners is to assume that poor bathroom ventilation is caused by an undersized fan. Often this is not the case.

Properly sizing mechanical ventilation systems can get complicated fast. (The process is outlined in ASHRAE standard 62.2, "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings," which is a good resource.) But there are some rules of thumb that work pretty well for most residential bathrooms. For example, a guideline published by the Home Ventilating Institute (hvi.org) says that for bathrooms up to 100 square feet, you should provide at least one cfm for every square foot of floor space; above 100 square feet, HVI advises adding the requirements for each fixture, with toilets, showers, and bathtubs requiring 50 cfm each and jetted tubs 100 cfm. Another common recommendation is to ensure eight air changes per hour for bathroom ventilation; for normal 8-foot ceiling heights, this works out pretty close to one cfm per square foot.

Figure 1. Mold and mildew growing on the bathroom ceilings was all the evidence needed that the ventilation fans were not working effectively. The oblong stain on the ceiling of the shared bath (below) was curious.

Of the two fans in this house, one seemed to be adequately sized, and the other too small. Yet both bathrooms had mold problems. Because I do energy assessments, I have a blower door and a couple of manometers, which measure air pressure. A manometer used in conjunction with an exhaust-fan flow hood can measure the air pressure at the bath fans to within 10 percent accuracy (**Figure 2, next page**).

The flow hood (the Exhaust Fan Flow Meter, energyconservatory.com) is basically a plastic pan you place around the fan (or register); it has weatherstripping on the edges to make a tight seal and a sliding door that adjusts to accommodate various fan sizes. With the fan running, the manometer measures the air pressure inside the hood with respect to pressure in the bathroom, from which you can calculate the airflow between the two areas of pressure. I found that the master-bath fan was drawing 41 cfm and the shared-bath fan 43 cfm.

If you don't have a manometer, there's a simple test you can do: Turn on the fan and see if it can hold a single sheet of dry toilet tissue against the grill. If so, the fan is probably drawing at least 40 cfm.

Sloppy Ductwork

On climbing into the attic, I discovered that the two fans were connected to the same roof jack via a tee with no dampers in it — the master fan through a run of flex duct more than 23 feet long, the shared-bath fan through 26 feet of flex duct. It looked like the builder had tried to minimize the number of roof penetra-

Figure 2. The author checked the airflow of the two fans using a duct hood and a manometer. He found that the fans were working at only about 60 percent of their rated 70-cfm capacity.

tions and to conceal the vent on the back of the house.

There were also long runs of unsupported duct — places where condensed moisture could settle in the low spots. I've seen cases where these puddles freeze into solid blocks during the winter and block the airflow. (Also, in rare cases, standing water can spawn Legionnaires' Disease, so it's a good idea to be careful and wear a respirator when removing flex duct.)

Where the flex duct exited the fans, the fiberglass batt insulation had been loosely stuffed over the top (**Figure 3**). This made it easy for cold attic air to get underneath the batts, creating a cold ceiling where bathroom moisture condensed and caused mold to grow. It also explained the oblong patch of mold in the center of the shared bath ceiling.

Basic duct design. To precisely size ducts, you have to figure out the air resistance, or static pressure, of the pipe and fittings, which involves either a lot of math or a static-pressure calculator (there's one at the HVI website). Fortunately, for the typical residential job, this is not necessary. I try to keep duct runs and fittings to a minimum, and when in doubt, I can always contact the technical support line of the fan manufacturer.

I prefer smooth metal duct, which has less friction loss than either metal or plastic flex duct. The most important point to remember is that fittings create a lot of static pressure; for example, in one equivalent-length

Figure 3. Fiberglass insulation, because it had been loosely laid over the bath fans, did not contact the drywall. Not only did this insulate poorly, but it allowed cold winter air to reach the ceiling board (above). The ductwork, the wiring, and the fan itself made the area difficult to insulate properly (left).

Figure 4. The home's two bath fans originally shared a common rooftop vent termination. To improve performance, the author installed a new gable vent for the shared-bath fan (top), placing the hood under the rake overhang for protection from the weather (above). The master-bath fan was vented to a new roof termination nearby (left).

chart that's posted online (panasonic.com/consumer_electronics/ventilation_central/howtosize.asp), a 90-degree elbow is counted as 15 feet of straight duct and a wall termination jack as 30 feet.

Because they are approximations, published equivalent-length numbers vary, as do recommendations for total duct length. In fact, manufacturers test their fans to a predetermined static pressure, not a specified length of duct. So it's always a good idea to check with the fan manufacturer if you think the duct run is getting too long. My rule of thumb is that if I use more than a straight 10-foot section of rigid duct, the actual flow rate of the fan will be less than the rated value.

New Strategy

I have occasionally connected two bath fans to the same vent hood, but I use a wye fitting, not a tee. There must also be backdraft dampers on the individual lines to prevent one fan from blowing into the other. Because I don't know a lot about the performance and durability of dampers, I prefer to run exhaust fans to individual vents. My first choice is always to exit a gable wall, with the vent hood preferably tucked up under the overhang to give maximum protection from the elements. My second choice is to exit through the roof; while any roof penetration is a potential leak, sometimes it's unavoidable. My last choice is to vent through the soffit. Since I'm in a cold climate, I want to avoid introducing any heat source below the snow-covered eaves, and the soffit vent on vented roofs would also allow some of the hot, moist bathroom air to get pulled back into the attic.

Luckily, the customer on this job chose performance over aesthetics, and we decided to abandon the original shared roof jack and run each of the fans to a new individual termination jack (**Figure 4**). For the master bath, this meant a new roof vent a few feet away from the fan. For the shared bath, we found a spot on an

Figure 5. Canned spray foam seals the fan to the drywall ceiling (left). Duct mastic seals connections in the pipe (above). Pipe seams were placed up to prevent condensation from leaking out.

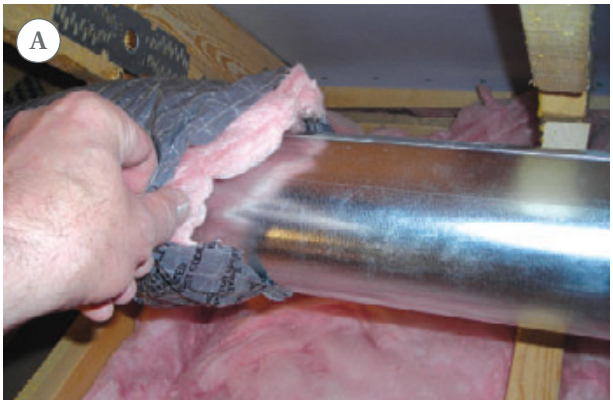

Figure 6. Although insulated plastic flex duct doesn't perform as well as rigid metal duct, it's a handy source for insulation. The author slips the flex duct over the end of the rigid duct (A) and gradually slides it into place as the plastic inner sleeve comes out the trailing end (B). Between the joists around the fan (C), hand-placed cellulose provides excellent coverage (D).

Figure 7. To ensure that lingering moist air is exhausted after a shower, the fan's on/off switch (far left) can be set to turn off at various periods. A humidistat (left) wired in parallel will also turn on the fan when needed.

east-facing gable wall, under the north-facing rake overhang. This will provide maximum protection from the prevailing northwest winds and reduce the chance of sleet and ice freezing the vent flap shut.

Installing the Ductwork

Typically the fan is located between two ceiling joists or trusses, with the exhaust port parallel to the framing members. Some fan manufacturers recommend running at least 2 feet of straight rigid duct before the first elbow so that the exhaust air can build some velocity. I usually follow this recommendation, but I try to turn the duct up and out of the insulation as quickly as possible. I bring it to its high point, then elbow to a horizontal position and gently pitch the duct down until it exits the house, to make sure that condensation drains toward the outside. (I once had a customer call me to fix a "roof leak" above the bathroom; it was actually condensation running down bath fan duct, which rose for about 12 feet before terminating through the roof.)

I use nylon straps to hang the duct — they're much easier to work with than metal strapping. Each joint gets secured with at least three self-tapping screws and sealed with either water-based mastic or metal tape (**Figure 5, previous page**). I also make sure all the seams in the duct face up to minimize the chances of condensed water leaking out.

Insulation

It's critical to insulate any metal exhaust duct to minimize condensation and conductive heat losses from the house. I've tried various fiberglass insulations that are wrapped and taped around the duct but have been disappointed with them all. They're difficult to install, and the tape will probably fail in time due to the radical temperature swings that happen in an attic.

Now I buy 4-inch insulated plastic flex duct (the same nasty stuff we remove in most retrofits) and use that to insulate metal ducts (**Figure 6, previous page**). I cut off a workable length — typically less than 10 feet — and slide the insulating sleeve over the rigid metal duct. As you pull the insulation over the metal duct, the inner duct coil compresses and can be pulled out the trailing end. You have to install the insulation as you install the ductwork, a section at a time. Sometimes I can use the old flex duct I'm removing to insulate the new rigid duct.

The section of duct between ceiling joists is tricky to insulate; you can do it with fiberglass batts if you cut and fit it meticulously. Instead, I bring a small bag of cellulose into the attic, hand-shred it, and place it around the section of duct near the fan.

Controls

It's generally recommended that you run a bath fan during a bath or shower and for 20 minutes afterward to remove all the water vapor. I know in my own home it took some effort to get my teenagers to even use the fan during their showers. But then, after they caught on, they would forget to turn the fan off, exhausting warm air from the house all day long in the winter.

So I typically replace the single-pole fan switch with a push-button electronic timer that operates the fan at 10-, 20-, 30-, and 60-minute intervals. I sometimes add a humidistat wired in parallel; if the homeowner forgets to start the fan with the timer or selects too short a time interval, the humidistat will turn on the fan (**Figure 7**). My customers like the automation option, although they usually have to adjust the humidistat in the spring and fall to account for the seasonal change in ambient relative humidity.

Some manufacturers are now adding humidistats to their fans. In the past, I've ordered controls from EFI (efi.org), but recently I've noticed that some of the box stores have started carrying electronic timers.

Testing Out

Because we're doing ongoing work with this client, I decided to improve the ducting first, measure the results, and then later upsize the fans if needed. After we finished the installation, the master-bath fan, now venting up through the roof, was pulling 68 cfm through 4 feet of 4-inch rigid duct with one elbow. The shared-bath fan, now vented to a gable, was drawing 62 cfm through 21 feet of 4-inch rigid duct with two elbows. We increased the bathroom exhaust by roughly 50 percent just by replacing the flex duct with rigid duct. The customer reports that the mirrors are no longer fogging up during showers.

Pete Glogowski *is a builder and remodeler in Charlton, N.Y. He is president of Summit Construction of NY.*