Solving a Chimney Moisture Problem

JOE PONESSA

by Joe Ponessa

In September 1998, roofer Kevin Fischer, carpenter/painter Bill Coyle, and I were called to help out on an 80-year-old, three-story, wood frame house located in southern New Jersey. The house had a chimney-related moisture problem that had been worsening over a couple of years. Damage to the plaster-and-lath walls surrounding one corner of the chimney had first appeared on the second-floor ceiling and adjacent walls. By the time we got involved, damage had started to appear on the first-floor inside wall and ceiling near the chimney, under the area where damage had appeared on the second floor.

Although the ceiling damage had been repaired once before, it had reappeared and had been getting progressively worse, with wetness episodes coinciding with heavy rainfalls. It was obvious that rainwater leakage was a factor. We proceeded to make observations over the next several weeks. During this period, the weather was unseasonably warm most of the time, and rainfall was unusually low; in fact, it was the second-driest fall on record. But the problems continued.

Fischer installed a new roof in October and early November. That project included a tearoff of asphalt shingles and below that, cedar shingles installed on lath. It also included installation of new roof sheathing. During this work, it was noted that the flashing around the chimney was in bad condition. Also, the cricket, a small structure on the roof behind the chimney that deflects rainwater, showed considerable water damage. It was rebuilt.

With a new roof in place, the problem should have been solved, but it was not. The damaged plaster on the inside walls had been repaired, but within the next few weeks, dampness and stains appeared again.

A Roof Leak?

During the previous summer, we had thought it was certain that the damage was caused by a roof leak around the chimney. The damage had coincided with heavy rains, when the furnace wasn't operating, and the roof reconstruction had revealed leakage around the chimney. Fischer had found and fixed some leakage problems. We had therefore assumed that the roof leak was the source of the problem.

By mid-November, the moisture problem had reappeared in full force. While we all had confidence in Fischer's repair job, we felt that a continuing roof leakage problem could not be ruled out. However, the reappearance of dampness after the roof had been replaced indicated that the problem was not linked so closely with rainfall. We thought that perhaps there were smaller leaks, which would take longer to cause damage on the inside.

Another possibility we considered was that rainwater was soaking into the parging (mortar covering) on the brickwork above the roofline and migrating downward. This seemed unlikely, but just in case, Coyle applied waterproofing to the parging, which was inspected for cracks and treated to a bit of caulk. This didn't help.

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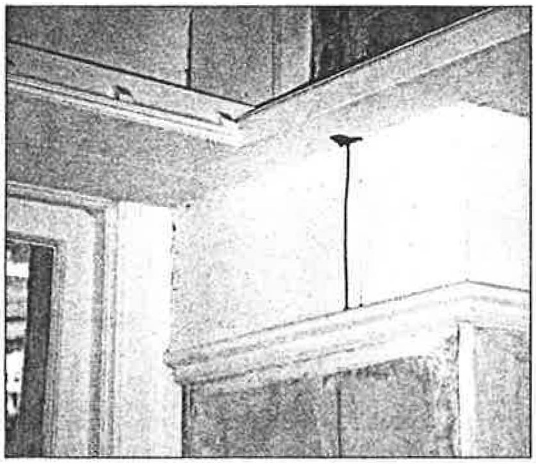
Wall damage that had appeared on the second floor around the chimney gradually worsened over time. It would reappear, even after the new roof was put on.

Condensation within the furnace flue became another option to consider. The natural gas furnace appeared to be about 15 years old, and was not a high-efficiency unit. The furnace is rated at 100,000 Btu input. It vents through a 6-inch fluepipe that connects to the brick chimney. The chimney has two flues with terra cotta liners; one flue serves the fireplace, and the other serves the furnace and the gas-fired water heater (see Figure 1). A chimney cap had been added to the chimney above the furnace flue when the roofing had been done to complement the existing cap above the fireplace flue.

Condensation can occur when ascending combustion gases meet cooler temperatures in higher parts of the flue, finally dropping below the dew point. It tends to occur in very cold weather, and/or when the chimney is mostly exposed to the outside. We thought condensation was unlikely here, since the weather had not been severely cold and the chimney was located on the inside of an exterior wall, providing some protection from outside temperatures. However, if the chimney was blocked, what otherwise would have been slight condensation could accumulate into heavy condensation because of the obstruction. We were inclined to rule out a blockage in this case, since we were occasionally able to view wisps of vapor emerging from the top of the chimney.

As if we needed further complications, there was a low spot in the guttering right next to the chimney area, where large amounts of water tended to overflow during heavy rainfalls. Although it was probably responsible for some water damage to the soffit there, this overflow did not wet the wall, nor did it saturate the foundation wall (if it had been drenching the wall, the water might have been conveyed to the chimney plaster). We decided to rule this out as a factor in the problem.

All things considered, getting clues from the appearance of moisture was difficult because of the apparent time lag between moisture production and its appearance on the finished wall.



When ceiling damage appeared on the first floor, reinforcements were called in to help.

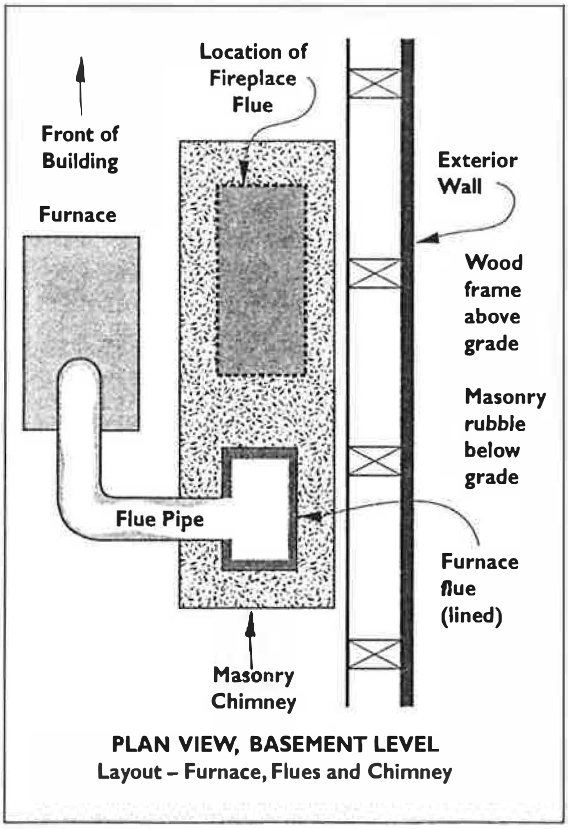
Tests and Observations

For a simple test of flue function, I held a lighted match at the draft diverter opening on the furnace while it was operating. Strong backdrafting—an indication of flue blockage—would have extinguished the match and propelled the smoke away from the opening. This did not happen, although the draft up the chimney did seem rather weak at the time. We attributed this to the fact that the furnace had not been running long enough to heat the flue properly. We only later realized that the draft may have been weak for other reasons.

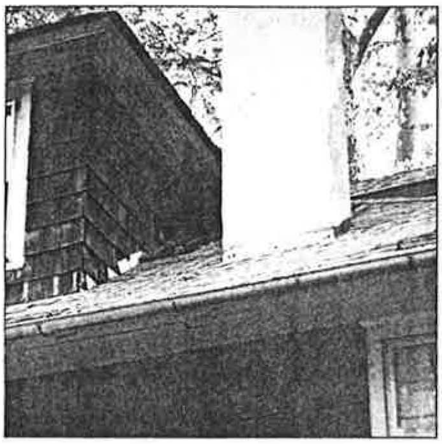
In the attic, a kneewall blocked observation of the chimney. In early January, we cut an access to observe the chimney and the underside of the roof deck. The new decking was mostly dry, except for droplets of moisture, apparently condensate (not leakage from the roof), on a few nails.

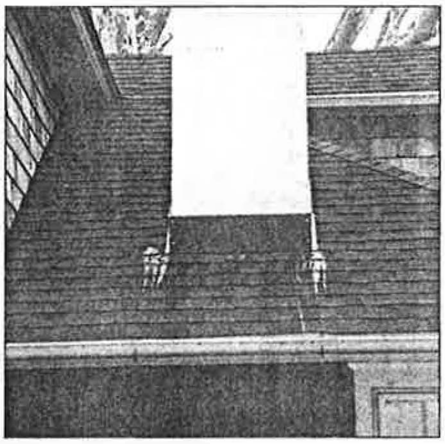
However, the chimney was a different story. It was immediately evident that the chimney behind the kneewall was quite wet. The bricks were wet to the touch, as if they had been doused with a hose, and the mortar was wet and somewhat crumbly. Also, there was a fair amount of wet, sandy mortar on top of the attic insulation adjacent to the chimney, indicating that the mortar was deteriorating. Since the entire height of the chimney in the kneewall area (about 3 ft) was wet, we began to think of the chimney as a giant wick, conducting moisture from its source—wherever that was—to most other regions of the chimney. The exposed portion of the chimney in the basement was not wet, however.

One unknown factor was the status of the tile furnace flue liner. This looked OK where it exited the top of the chimney, but I learned that sometimes such liners are installed only at the top of chimneys. It is also well known that the combustion products of a gas flame are pretty corrosive, especially if they condense in the flue. While bricks and mortar are most susceptible to the corrosive effects of condensate, it can eventually damage terra cotta flue tiles, as well. We were not able to check



The chimney contains two exhaust flues, one serving the fireplace on the first floor and one serving the furnace and water heater in the basement.





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After the leaky roof *(left)* had been repaired *(right)*, ice was visible emerging from beneath the flashing on the chimney exterior. This occurred even during a relatively dry period.

the condition of the flue tiles within the chimney.

Closing In

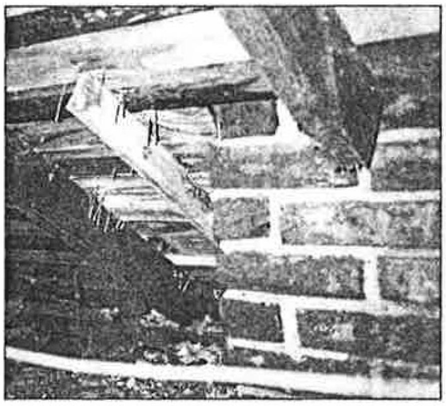
Up until early January, when the kneewall was opened, we did not think there was strong evidence of a flue blockage. The fact that we had found no definite signs of blockage when we checked for it indicates how important it is to use carbon monoxide testers and to install CO alarms in houses with combustion appliances where backdrafting may occur—as in this home. (Luckily, by the time this possibility became apparent, occupant safety wasn't a pressing concern—the house was unoccupied for most of the period after late October.)

More clues came to the surface after a 3-inch snowfall, followed by a night of freezing rain, caused no noticeable change in the wetness of the wall. This demonstrated to us how unlikely it was that a leak in the roof was sending water along the outer surface of the chimney.

A few days after this precipitation, a cold front moved in, with nighttime temperatures in the teens and daytime temperatures in the low to mid-20s. Observing the chimney exterior at the roofline on the second morning of this cold spell, I noticed a couple of small streams of ice creeping out from beneath the flashing. This ice continued to form and enlarge throughout that day and into the next, while still there was no rain. The continuing accumulation of ice, in the absence of rain, was pretty strong evidence that condensation, and not rainwater, was the source of the moisture.

We returned to the attic—and then we saw it! A droplight had been placed on top of the insulation next to the chimney, the better to observe the chimney and sheathing. In this raking sidelight, shining at a right angle to our line of vision, we happened to notice a small but unmistakable jet of steam blowing out from a small void between the bricks! The vapor was formed as the moist combustion gas met the cold attic air. This was a pretty definite sign of an obstruction in the flue backing up combustion gas and increasing the pressure inside.

It was tempting to think that the obstruction had to be substantial in order to drive a small blast of steam out through a crack in the chimney wall.



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Deteriorated mortar can be seen in this inside view of the chimney at the attic level. The new sheathing and old framing are also visible. A small stream of steam, not visible in this photo, was emerging from the chimney.

And yet, when we repeated the match/smoke test at the furnace, we still found no sign of backdrafting. Also, we did observe a faint plume of steam emerging from the top of the chimney, indicating some degree of flow. Perhaps the obstruction created a pressurized pocket that caused the small steam jet. The amount of steam leaking into the kneewall space was trivial, and the space itself was not wet—only the chimney.

It turned out that the chimney was absorbing all the condensate from the inside—that is, because of the blockage, the flue gas moisture was building up inside the brick furnace flue, which basically absorbed it like a sponge (the brick was porous, and the flue liner and mortar were both somewhat degraded). Thus it leaked out, through the bricks, into the walls.

At this point, the owner decided to have a metal liner installed in the furnace flue. During this work, an obstruction was found in the flue. The chimney workers described it as an assemblage of sticks and twigs, along with some leaves. In all likelihood, it was a squirrel's nest.

Ultimately, we realized that there had been two problems: rainwater leakage around the chimney, due to a flashing problem, and a chimney obstruction that led to considerable condensation. We don't know if the condensation problem had existed long enough to have caused damage to the cricket. In any case, both problems are now solved. The wall and ceiling plaster has been repaired again, and it remains dry.

Next Time

Hindsight is best, and this was a good opportunity to learn some lessons. What will we do differently next time?

The most direct evidence could have been obtained from looking into the flue to check for possible obstructions. This can be done from the top, or from below by removing the flue pipe leading from the furnace and using a mirror to look for a clear path to the sky (this may not be effective if there is an offset in the chimney). Dropping a

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Thorough Diagnostic Testing of Vented Appliances

The attempt to solve this chimney moisture problem is a good example of why proper diagnostic tools are the best investment a home performance contractor can make. We asked home performance contractor Stewart Selman to outline a whole-house approach to problems like this.

Home diagnostics is always easier and more accurate with the use of modern diagnostic tools. Having conducted over a thousand tests with such tools, I have come to learn the ins and outs of using them effectively. Here's my advice on what tools you need and how best to use them. These procedures are not intended for wood-burning or gas fireplaces, although many of the procedures and principles would be the same.

Recommended Tools

Analog or digital manometer
Blower door
Camera (optional)
Chemical smoke
Cordless drill with assorted nut drivers and bits for making probe holes in vents
Data logger such as the Energy Conservatory Automated Performance Testing System
Flashlight or head lamp
Laptop computer (optional)
Mirror
National Fuel Gas Code (available in book format and CD-ROM)
Professional quality CO detector
Stepladder
Screws
Static pressure probes
Stopwatch
Tubing for connecting manometers and and/or the data logger
Temperature probes

The Scope of Your Job

The entire venting system should be analyzed. This means analyzing:

- the combustion appliances—water heater, boiler, furnace, space heaters;
- the vent connectors from the appliances to the common vent and chimney, including the type and condition of the chimney cap—if there is one; and
- the effects of depressurization caused by exhausting appliances or pressure imbalances (if there is forced air)—a good venting system should be able to withstand small amounts of depressurization without continuous spillage of combustion product, while excessive depressurization is another issue.

My suggested (but not written in stone) procedure is to consult with the occupants and then document the vent system design:

- Take photos of the entire system inside and outside.
- Draw diagrams.
- Document venting materials — for example, single-wall metal or B-vent—and the size of venting structures.
- Document the rise, run, and fittings.
- Record the nameplate input Btus of the combustion appliances.
- Use the *National Fuel Gas Code and Handbook Set, 1996 Edition* (www.nfpa.org or Tel:(800) 344-3555) as a resource for analyzing system design.
- Take the venting apart at the chimney to inspect the condition of the liner and offsets (first check with your local code officials to see how they feel about this).
- Check for obstructions. If the venting is in a deteriorated condition, it should be replaced anyway. If venting falls apart while you're inspecting it, it could turn into your repair cost. You may want to dismantle other parts of the venting system to check for blockages or other defects, such as improper cutout of the hole where the saddle meets the common vent.
- At some point in your visit, clock the appliances at the meter while each one runs alone, in order to get actual gas input. A venting problem can result if the venting system is not sized large enough to handle the total Btu input of all the connected appliances operating simultaneously. Check the tables provided in the *National Fuel Gas Code*. Overfiring or underfiring of the combustion appliance could also cause high CO production.

Performance Testing

Even if the vent system is sized properly and appears to be in good condition, performance testing is necessary. Both qualitative and quantitative methods should be used. One of the most basic qualitative methods is the use of chemical smoke. Taking quantitative measurements using readily available instrumentation such as analog or digital manometers is essential. Higher-tech equipment—such as a data logger hooked up to a laptop computer that can measure and generate graphs of draft, temperature, and CO—is ideal.

Determining Pressure Basics

At a minimum, you want to measure pressure from vents with respect to the combustion zone, and pressure from the combustion zone with respect to the outside.

- Insert the probe (preferably a static pressure probe) for your vent measurement at least 2 ft from the draft hood and twice the diameter distance from a fitting (locate the probe hole before the common vent). For example, if there is a 4-inch, 90° fitting, insert the probe 8 inches past that fitting. Often it is not possible to locate the probe in this manner, but do the best you can. Also be careful about drilling into the B-vent. Code officials and others frown upon this practice. If no other options are available, get a measurement at a drip tee in the chimney or some other location. When you're done, plug the hole with caps that are available from HVAC supply houses, or use a 1-inch-by-1-inch lag bolt.
- Close the house to the exterior and take base pressures.
- Establish worst case pressure. Document the effects that exhaust fans—such as dryers, kitchen fans, and bathroom fans—exert on the house's pressure. If there is a forced-air system in the house, operate that as well. Doors should be left in a position that starves the combustion zone of air. (Using smoke, determine if air moves toward the combustion zone. If it does, shut the door.) Record the worst case pressures.
- Start the combustion appliance that is the focus of the test (for example, the water heater).
- Record if spillage stopped, and if so, how long it took.
- Use smoke at the draft hood as a qualitative measurement to determine proper flow direction.
- Measure CO.
- Record the pressure (allow five minutes to reach steady state, although it could take less time).
- Turn off exhaust appliances one at a time, starting with the largest. Save the dryer for last. Record vent and combustion zone/outside pressures at each point.
- Measure draft during base conditions. If there was spillage in the worst case, recheck for spillage during base conditions.
- Start any other appliances that are commonly vented (for example, the furnace).
- Check for spillage (vent capacity problems often appear here).
- Record measurements and turn off commonly vented appliances (the furnace, in this case).
- If there wasn't a full backdraft, create it with a blower door and record the CO levels in the space (don't do this if the furnace is fueled by oil).

With these kinds of thorough, professional diagnostics, you will have all the information needed to make any repairs or improvements on the home. In addition, you will have documented a baseline that is useful in implementing and comparing subsequent remediation measures. As always, take precautions to protect yourself and your clients from hazardous conditions—for example, monitor the ambient CO levels.

Keep the occupants informed about test results and any hazardous conditions you find. Do not leave the premises without informing the occupants/homeowner of potentially hazardous conditions, and have them sign off on having been notified. If you have to, turn off the combustion appliances and their fuel sources. Leave the occupants/homeowner with the information they need to fix the problem.

—Stewart Selman

Stewart Selman of Stewart Selman & Associates does house diagnostics in the Twin Cities area of Minnesota.

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weighted line through the chimney from the top could also have been useful to identify a blockage. However, given the risk involved in propping an extension ladder against the top of a chimney whose structural integrity is uncertain, a top inspection might be done with a smaller, stepladder on the roof, placed against the chimney.

Using a match or other smoke source to detect a backdraft at the furnace flue has worked for me in the past, at least for a major obstruction. However, in the absence of a strong pull in either direction (after waiting for the flue to warm up) the result should be taken as equivocal. Thus, it would have been better to use some more sophisticated tools and diagnostic equipment (see "Thorough Diagnostic Testing of Unvented Appliances," p. 43).

It would also have been interesting to place a CO detector next to the furnace flue. (CO_2 would be a more sensible gas to measure, but it would require a separate meter.) However, with a clean, properly adjusted burner, CO levels might not be excessive, so this would not always be a foolproof test of backdrafting. Backdrafting would have been, in this case, a definite signal to investigate the chimney further. Other factors (for example, operation of ventilation equipment elsewhere in the house without makeup air) can cause backdrafting, but those factors weren't relevant here.

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insulation, and drywall are discussed thoroughly but simply in a way that any apartment dweller can understand. The booklet also contains tips on how to conserve energy by setting the furnace and water heater at optimal temperatures or by using fluorescent lighting. Especially useful is the chapter on how to make the best use of one's refrigerator, dishwasher, washer/dryer, and air conditioner. Currently, only the Midwest edition has been written, but there are plans to write other regional editions in the future. Nevertheless, much of the information in this booklet would be useful for anyone who wants to save energy in a home, and for rehabbers who want ideas on their next projects. The booklet is available (in both English and Spanish) for $10.00 from the Chicago Rehab Network, 53 W. Jackson Blvd., Suite 740, Chicago, IL 60604. Tel:(312) 663-3936. Web site: www.eren.doe.gov/buildings/residential/mwhndbk.htm.

Web Site for Energy Ideas. The Northwest Energy Efficiency Alliance's Energy Ideas Clearinghouse (EIC) has a new technical solutions database that can be accessed at www.energy.wsu.edu/eic/. The Energy Solutions page discusses topics ranging from appliances to HVAC to water heating. An energy library catalog, EIC publications, and other resources can be obtained through the Library page. Most useful is the Jobs page, which, when we read it, listed more than 80 jobs across the country pertaining to the energy field. If you want to find out about energy-related events, you can search for them on the Events page. Northwest Energy Efficiency Alliance, Tel:(800)411-0834, ext. 235; Web site: www.nwalliance.org.