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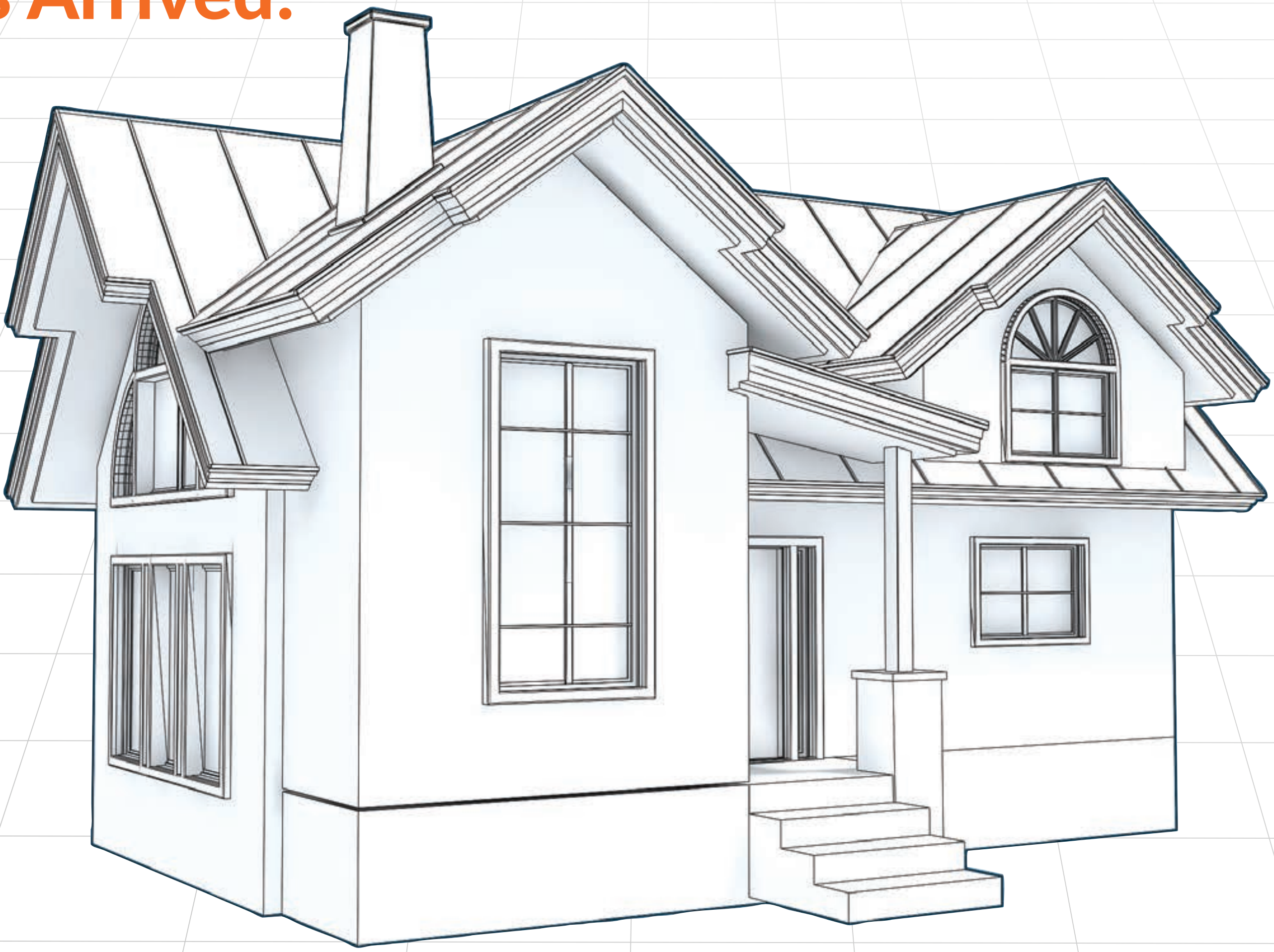

Diagnosing CAZ Failures

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Diagnosing CAZ Test Failures

by PAUL MORIN

Our industry has many programs that require us to perform safety tests on combustion appliance zones (CAZ) before and after we retrofit homes with energy improvements.

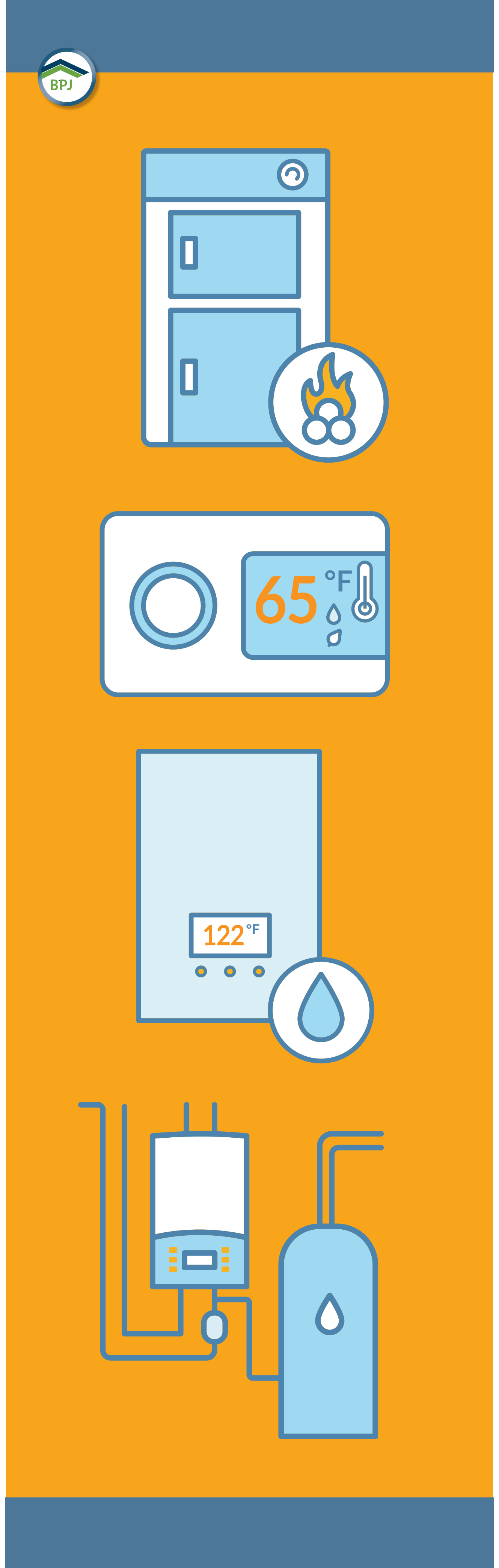
We perform these tests to determine if a heating system or domestic water heater are venting their exhaust gasses up the chimney properly, and to help ensure the health and safety of the homeowner and occupants. It is especially important to know systems vent properly when all exhaust devices and the air handler are running, and interior doors are in certain positions. In the worst-case scenario, a backdraft will suck dangerous combustion byproducts into the living space.

Performing a CAZ depressurization test is usually pretty straightforward, whether you follow the Building Performance Institute (BPI), Residential Energy Services Network (RESNET) or Weatherization Assistance Program (WAP) protocol. But what do you do if an appliance fails this test and exhaust gasses are coming into the home?

If there is enough money in the homeowner's budget to replace the failing natural draft appliances with power vented ones, the decision process is easy—replace them.

If you need to save these less efficient appliances, it gets complicated in a hurry. The potential cause of combustion spillage may be the condition and configuration of the combustion venting system, depressurization caused by many sources, or a combination of both of these.

To correctly diagnose the source of the problem and identify the best solution for the homeowner and their budget, you need to have enough information to figure out how exhaust devices affect a home's pressure. This requires examining the combustion system and testing for depressurization.



Diagnosing Combustion Venting Systems

Diagnosis should start with checking the condition and configuration of the combustion venting system.

Some defects are pretty obvious, like too many elbows, too little rise, and deteriorated or obstructed vent pipes. Referencing the National Fire Protection Association (NFPA) 54 National Fuel Gas Code is best when you're checking for compliance. You can view this code for free, after logging into the NFPA website (see "learn more").

Based on test data from thousands of homes near the Minneapolis-St. Paul International Airport that have been treated by a sound insulation program, a venting system in good shape that meets code should be able to withstand pressures up to the stated depressurization limits of the combustion appliances. If the appliances fail the spillage test at less pressure than the stated depressurization limits (see Table 1), it is likely that changes are needed to the combustion venting system, and the NFPA code is invaluable.

Depressurization Sources

The mass flow of air into a home and out of a home will always be equal. When an exhaust device is turned on, pressure will be induced to balance the flow of air in and out of the home. This pressure change may lead to spillage if the house depressurization is greater than the appliance's depressurization limits.

The most common exhaust devices found in a home are:

- **Clothes dryers, power vented appliances, bath fans, and kitchen fans**
- **Supply duct leakage to the outside**
- **Powered attic fans** that blow air from the attic to the outside
- **Whole house fans** that blow air from the house into an attic—these are designed to be operated with windows open, so make sure homeowners are aware of that
- **Radon fans, heat recovery or energy recovery ventilation systems** may also affect pressures

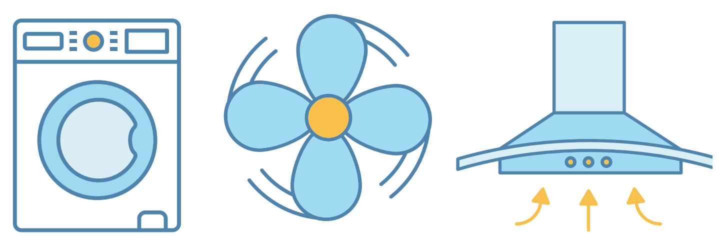


Table 1. House Depressurization Limits

Appliance type	Depressurization limit
Individual natural draft water heater (WH)	2 Pascals
Natural draft WH and induced draft (ID) furnace/boiler	5 Pa
Natural draft WH and induced draft (ID) furnace/boiler	5 Pa
Individual natural draft furnace/boiler	5 Pa
Individual ID furnace/boiler	15 Pa
Power vented and sealed combustion appliances	>25 Pa

Source: *CEE Appliance Safety Test Methods*, MAC Part 150 Residential Sound Insulation Program, Minneapolis, Minnesota (bit.ly/2RbQ84U)

Closing interior doors can also have an effect on house pressures in a couple of different ways:

- It makes the volume of the building that the fan draws from smaller and therefore tighter, so fans will have a greater effect on pressures.
- When you have supply registers in rooms with no return grilles, that room will be pressurized and increase leakage to the outdoors. This additional leakage to the outdoors will cause the other parts of the home to go more negative.

The key to diagnosing these complex interactions is to document the change in pressure at each step: clothes dryer, bath fans, kitchen fans, air handler, and door closures. When the measured house depressurization exceeds the depressurization limits, you need to know how much reduction in total exhaust flow you need to get you below the limit. This will help you prioritize the remedial work.

Putting the Depressurization Numbers into Proportion

To find the exhaust flow of devices, you will need to measure the pressure changes caused by each exhaust device or measure the exhaust flow directly.

Documenting pressure changes is pretty straightforward on a calm day. On a windy day, use time averaging or graphing software to ensure better accuracy. Converting the change in pressure caused by the air handler and door closures into CFM of exhaust flow gives you a way of comparing that effect to the effect of the other exhaust devices.

Accurately converting exhaust devices' induced pressures to flow requires a multipoint blower door test and the use of software. There are many software options. Below is an example that shows how to use it.

This example has a clothes dryer, bath fan, kitchen fan, and an air handler. We turn on the clothes dryer first because it is

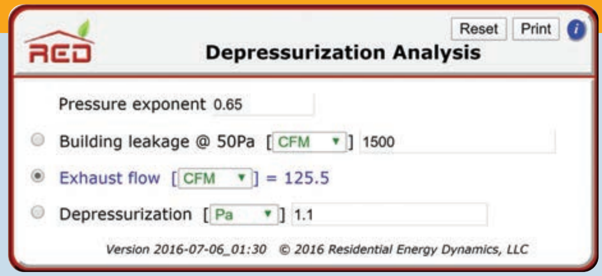


Figure 1. Tool to determine exhaust flow CFM.

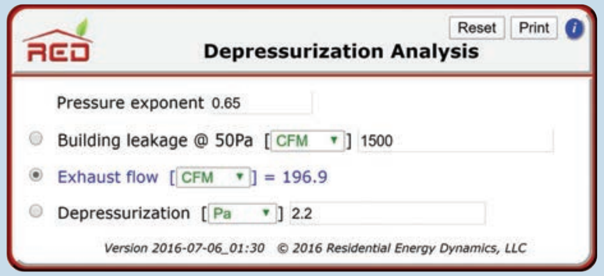


Figure 2. Measure the pressure change with the dryer and bath fan on.

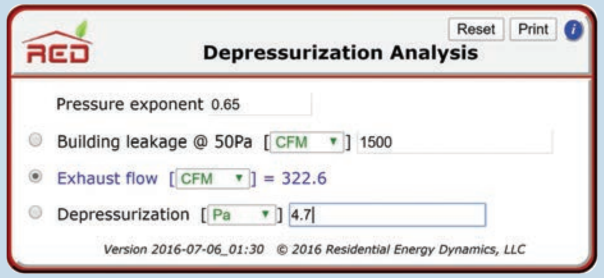


Figure 3. Measure the pressure with the dryer, bath fan, and kitchen fan on.

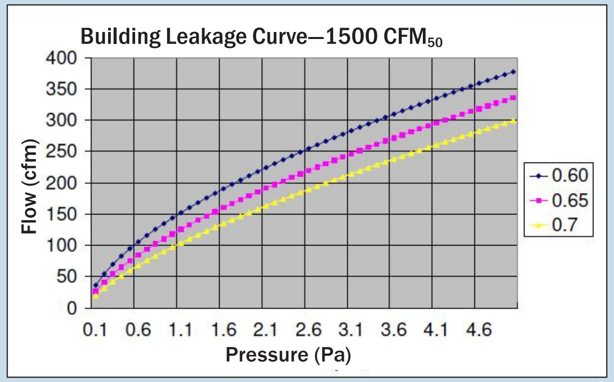


Figure 4. This building leakage curve demonstrates the relationship between pressure and flow for homes with the same 1,500 CFM_{50} leakage and different flow exponents (n values).

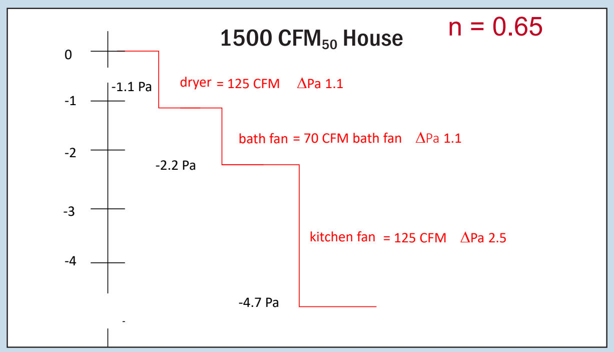
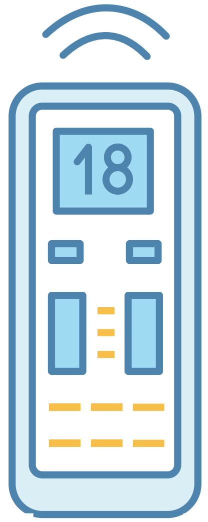


Figure 5. This example demonstrates how pressure and flow do not change at the same rate. While the dryer and kitchen fan have the same flow at 125 CFM, the pressure change on the house is very different, at 1.1 Pa and 2.5 Pa, respectively.



typically used most often, and we are not likely to make any remedial changes to it. Make sure to clean the lint out of the dryer before turning it on to get the maximum flow. If the home has a single-pipe power vented furnace or water heater, that would be turned on second.

Because we are trying to determine exhaust flow CFM, click on that row in the tool (see Figure 1). Next enter the pressure exponent (0.65) and the CFM_{50} (1,500) as determined from a multi-point blower door test, and the change in pressure caused by the clothes dryer (1.1 Pa). (Note: this is the baseline adjusted depressurization due to the clothes dryer.)

From that information, the software determined that the clothes dryer's exhaust flow is 125.5 CFM. For simplicity's sake, let's round all numbers to the closet 5 CFM. Let's call it 125 CFM.

Next, measure the pressure change with the dryer and bath fan on. Enter the new depressurization number, 2.2 Pascals (Pa) (see Figure 2).

Round the exhaust flow results to the closest 5 CFM, making it 200 CFM. The clothes dryer exhaust flow was 125 CFM, which means the bath fan's exhaust flow is 75 CFM. Notice that it took 125 CFM to induce the first 1.1 Pa and only 75 CFM to induce the second 1.1 Pa.

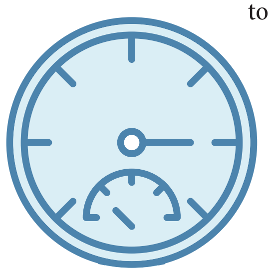
Next, measure the pressure with the dryer, bath fan, and kitchen fan on. Enter the new depressurization number, 4.7 Pa (see Figure 3).

Round the exhaust flow results to the closest 5 CFM, to 325 CFM. The clothes dryer and bath fan total were 200 CFM, which means the kitchen fan is 125 CFM. Notice that it took 125 CFM to induce the first 1.1 Pa and the last 125 CFM induced 2.5 Pa.

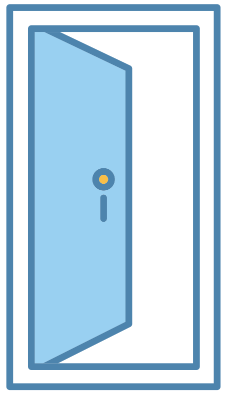
Pressure and flow do not change at the same rate, and this is an important concept to understand (see Figures 4 and 5). It is easy to think that because the kitchen fan changed the pressure by 2.5 Pa, it must have a larger flow than the dryer, which changed the pressure by 1.1 Pa. But the flows are the same. Turning on the kitchen fan last changes the pressure more and allows you to get a more accurate CFM estimate.

Air Handler and Door Closure

Once you determine flow from exhaust devices, the next step is to leave the exhaust devices on, turn on the air handlers, and check door positions. This will set up the house in a way to determine which door has the biggest impact on the total depressurization of the CAZ.



With the exhaust devices and air handlers on, start with the door that is farthest away from the CAZ appliances. Close that door and if the room is pressurized, keep the door closed; if not, leave it open. You can



use a smoke puffer or pressure gauge to determine this.

Work your way toward the CAZ, checking all doors. Closet doors can be left closed. The last door you will check is the CAZ door. After all door positions are set, record the total depressurization caused by exhaust devices, air handler and door closures (6.5 Pa in this example). With the house set up in this condition, we will turn on the smallest Btu appliance and check for combustion spillage at the draft hood of that appliance.

After this process is complete, you have learned:

- The dryer flow is 125 CFM
- The bath fan flow is 75 CFM
- The kitchen fan flow is 125 CFM
- The total induced pressure, including the air handler and door closures, is 6.5 Pa

Possible Solutions to CAZ Failures

For the home in the example, let's assume there is an induced draft furnace and natural draft water heater sharing a chimney, so the depressurization limit is 5 Pa based on house depressurization limits (see Table 1). In our test, the home's depressurization is 6.5 Pa and exceeds this limit, so remedial work is recommended to get the depressurization below 5 Pa.

To increase the depressurization limit, if you change the natural draft water heater to a power vent water heater, the depressurization limit will change from 5 Pa to 15 Pa, and the problem is likely solved. That was easy. If you want to keep the natural draft water heater, you have options, but it gets complicated.

Some possible solutions are:

- **Undercut the doors or add transfer grilles to eliminate the pressure induced by closing doors.** According to the depressurization analysis, this will reduce the depressurization to 4.7 Pa, less than the limit. If the home fails the spillage test after this change, you may need to reduce depressurization further or make changes to the venting system.
- **Reduce the kitchen fan flow so the induced pressure is less than 5 Pa and then check for combustion spillage.** One method to reduce flow is to disconnect the power to the existing kitchen fan and install a 100 CFM metal inline fan in the kitchen fan's ductwork.

Reducing the flow from an exhaust fan is not an ideal solution, but your options are limited. Powered makeup air fans interlocked with kitchen fans or add-on draft inducers for furnaces and water heaters are other options.

TEC

Power vent water heaters and chimney-top draft inducers are two devices that can help alleviate depressurization limit overages in homes with natural draft appliances.

Established protocols give you a standardized way of setting up a house and performing a CAZ test in a repeatable and effective manner. If the water heater or heating system fail the combustion spillage test, you will need to gather additional information before developing a remedial action plan.

Following the processes listed in this article will help you gather better data to guide your decision-making process. Also, make sure to measure carbon monoxide levels in gas appliances and make recommendations if levels are high, and check that homes have proper carbon monoxide detectors to further improve homeowner health and safety.

Paul Morin *had 15 years carpentry experience building new homes before becoming a weatherization auditor. Paul also worked for the Center for Energy and Environment for over 12 years diagnosing home performance issues, including 6 years in the airport Sound Insulation Program. He has been with The Energy Conservatory since 2009 in technical support and sales.*

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>> learn more

National Fire Protection Association website: bit.ly/2FJayRB.

An example of easy-to-use depressurization software is www.redcalc.com/depressurization-analysis.