

User Tip #4: Using the Blower Door subtraction method for estimating duct leakage.

For years, technicians have been using a simple Blower Door comparison test to estimate residential duct leakage to the outside. The technique, called Blower Door subtraction, involves conducting two whole house Blower Door airtightness tests with and without the supply and return registers and grills sealed off from the house. A subtraction of the sealed register test from the unsealed register test provides an estimate of duct leakage to the outside.

Researchers now realize that the Blower Door subtraction test has a number of drawbacks with respect to the accuracy of test results. Accuracy is reduced for two reasons. First, subtraction will typically underestimate duct leakage due to connections between the duct system and the interior of the house which are not sealed when the registers and grills are temporarily sealed. The Blower Door subtraction method assumes that once the registers and grills are taped off, the duct system is effectively outside of the pressure envelope of the house, and as a result the Blower Door does not measure any duct leakage in that configuration. However, connections between the duct system and the interior of the house cause a certain amount of duct leakage to be measured even with the duct system sealed from the house. The amount of underestimation due to this phenomenon is a function of how well the duct system is connected to the structure of the house.

Secondly, because Blower Door Subtraction involves subtraction of two separate Blower Door test results (using the same Blower Door), the accuracy of the test result is a function of the repeatability of the Blower Door measurements. The error due to repeatability further clouds the accuracy of your subtraction test. So now that we know there are shortcomings to Blower Door subtraction, is there anyway to improve our leakage estimate using the subtraction technique?

There is a technique to alleviate the underestimation problem associated with Blower Door subtraction. The subtraction duct leakage estimate can be modified by taking one additional pressure measurement. The pressure measurement needed is the pressure between the duct system and the house with the registers and grills sealed and the Blower Door depressurizing (or pressurizing) the house to the target pressure of 50 Pa. This measurement can be taken at the supply or return plenum, or at a supply register or return grill by punching a small hole through the masking tape and inserting a pressure tap or hose connected to a pressure gauge. Once this pressure is measured, an appropriate subtraction correction factor can be used to modify your original subtraction duct leakage estimate. A table of correction factors for Blower Door subtraction is shown below.

House to Duct Pressure in Pascals (taped off)	Subtraction Correction Factor (SCF)
50	1.00
49	1.09
48	1.14
47	1.19
46	1.24
45	1.29
44	1.34
43	1.39
42	1.44
41	1.49
40	1.54
38	1.65
36	1.78
34	1.91
32	2.06
30	2.23
28	2.42
26	2.64
24	2.89
22	3.18

Let's look at an example to illustrate use of the subtraction correction factor (SCF). You have performed a subtraction test and found the following:

- CFM50 (ducts open) = 3,250 *
 - CFM50 (ducts sealed) = 2,825 *
 - Pressure between the ducts and the house (ducts sealed) = 40 Pa
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- From the Table above, the SCF for 40 Pa is 1.54
 - Initial Duct Leakage Estimate = $3,250 - 2,825 = 425$ CFM50
 - Modified Duct Leakage Estimate = $425 \text{ CFM50} \times 1.54 = 655$ CFM50

* If ducts run through attics or crawlspaces, be sure the attic or crawlspace is effectively outside when the blower door is operating - i.e. attic to outside pressure=0.

In this case, our modified duct leakage estimate is 54 percent larger than the original Blower Door subtraction estimate. This means we would have underestimated duct leakage to the outside by 54 percent without using the correction factor.

Now how about repeatability error. On a day with only slight wind, our experience is that the repeatability of manual Blower Door test is about +/- 3% of the unsealed whole house CFM50 value when using the same gauges for both tests. For the example above, a repeatability error of 3% means we have an error of approximately +/- 97 CFM50 ($0.03 \times 3,250$ CFM50) in our leakage estimate. But we must also apply the correction factor calculated above to the 97 CFM50 which increases the error to +/- 149 CFM50 ($97 \text{ CFM50} \times 1.54$). Thus our final subtraction leakage result is 655 CFM50 (+/- 149 CFM50). This means the actual leakage in the duct system is somewhere between 506 CFM50 and 804 CFM50. And in very windy weather, repeatability error will increase much larger than the 3% shown here.

Note: If you are using an APT system to conduct your Blower Door test, repeatability errors will typically be reduced below the 3% quoted above, and the APT system will provide you with an estimate of the measurement uncertainty.

Do all of these problems mean that I shouldn't be using the subtraction method to estimate duct leakage? Not at all. If you need to quantify duct leakage and are comfortable with the relative imprecision of the subtraction technique, subtraction makes good sense. Of course you should always use the correction factors listed in the table above when using the subtraction method, to account for underestimation. If accuracy is important, much greater precision of duct leakage estimates can be achieved by using the Minneapolis Duct Blaster and directly testing the duct system.

And a final word of caution when using the subtraction method, if the measured duct to house pressure is less than about 20 Pa (meaning the duct system is very well connected to the house structure), we suggest that Blower Door subtraction (modified or not) can not be relied upon to provide meaningful duct leakage estimates. This commonly means that Blower Door subtraction can not be used in houses which use building cavities for a significant part of the duct system (e.g. basement houses which use panned under ceiling joists for return ducts). In these cases, the duct system must be tested directly with a Duct Blaster.

In applications where a duct leakage estimate is not needed at all, use of a blower door and a pressure pan is probably the ideal setup. In this case, duct leakage can be quickly checked by depressurizing the house to 50 Pa and taking a quick pressure pan reading at each register or grill. Inspection standards can also be set using this procedure. For example, the duct system might pass inspection if all registers and grills have a pressure pan reading of 1 Pa or less. This technique provides crews and inspectors with excellent measurement feedback, but simply does not quantify the leakage in the system.