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There are two main data collection procedures when conducting pressure diagnostics on a home. First there are the tests that measure only the pressures created in the home with the equipment in the home. In other words, the actual blower door does not necessarily need to be set up. You will only need a few hoses and your manometer. For the purposes of this guide, it will be assumed that the blower door *is* set up in the front door of the home, but the fan cover is on. The second procedure is when you have the blower door fan running, create a 50 Pascal pressure difference and measure against that known pressure. At no point should your blower door fan and ANY other exhaust fan or air handler fan be running at the same time.

This guide should be used in conjunction with the DG-700 Digital Manometer color handout produced by the SouthWest Building Science Training Center.



STEP 1 - SETTING BASELINE & SETTING HOUSE INTO BASELINE MODE

Baseline Mode is having all exterior doors and windows closed, and all interior doors open. All exhaust fans and air handlers turned off. Your goal is to separate the indoors from the outdoors. During an initial assessment, you are simply collecting data. You should not fix anything to set up for pressure testing. If there is a manual or mechanical damper connected to an evaporative cooler, or to the duct work that separates an evaporative cooler from an air conditioning (AC) system you should close it. If no damper is present, then that is how that house has been operating and your data should reflect that. In the case of a doggy door, you should fasten it closed with some painters tape. It is important to maintain your “Adjusted Baseline” throughout all of the testing until you have completed the “CAZ” test. If you accidentally lose the “ADJ” under the “A” channel window, you must re-baseline your gauge before conducting a CAZ test.

Once the home is set up, follow the directions on *fig. 1. Setting Baseline*

- You should have a hose to the outside on your channel A ‘Ref’ port.
- All other pressure ports should be open.
- You will be monitoring numbers in the A channel window.
- Press “Baseline”
- Press “Start”

STEP 2 - DOMINANT DUCT LEAKAGE

Your next test will be to determine the “Dominant Duct Leakage”. Refer to Fig 2

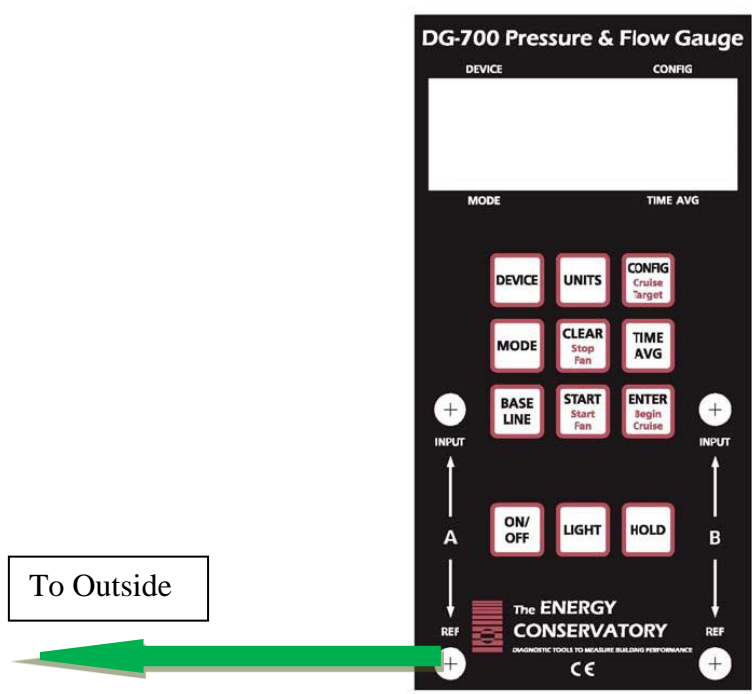


FIG. 2

You should notice that nothing is changing with how the manometer is set up, and nothing is changing with how the house is set up. You will be pressing no buttons on your manometer.

- Turn on air handler. If you have multiple Air Handlers, turn on “1” record number, then turn on “2” and record combination number, then shut down “1” to record the impact only the “2” air handler creates on the home etc.

STEP 3 - ROOM PRESSURE TESTING

This test is designed to see what happens to the pressure balances in the home when interior doors are closed. Refer to Fig 3.

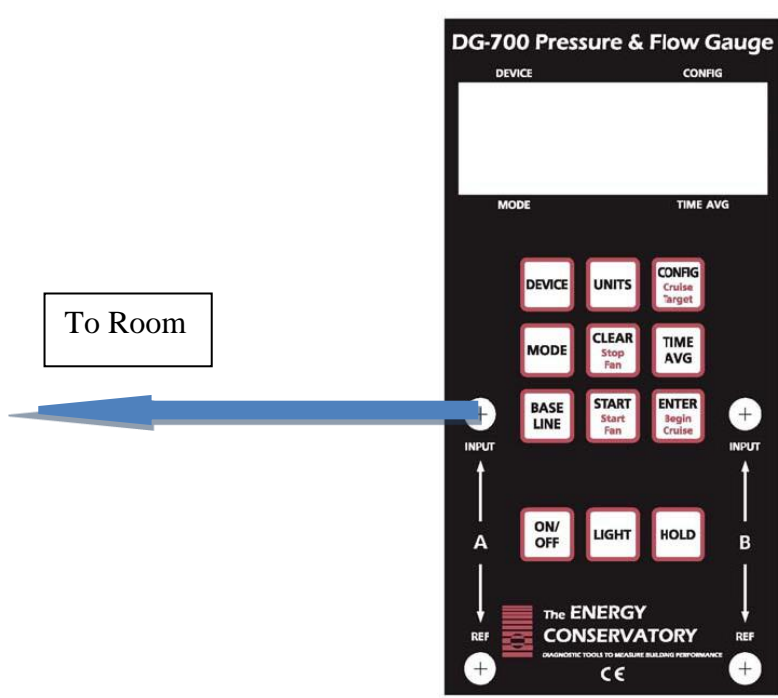


FIG. 3

You will be testing various ROOMS with reference to INSIDE.

For a room to qualify for a room pressure test, it must have a supply register, and / or a return register and / or an exhaust or supply fan and a door. This includes bathrooms and laundry rooms.

STEP 4 - "CAZ TEST"

NOTE: The CAZ test, as far as health and safety goes, is the single most important test an energy assessor performs. You **MUST** have a baseline on your manometer prior to performing this test. If you have no formal training in this area, **STOP**. You are not qualified to perform this test alone.

Refer to Fig. 4 – "CAZ Test" for manometer set up.

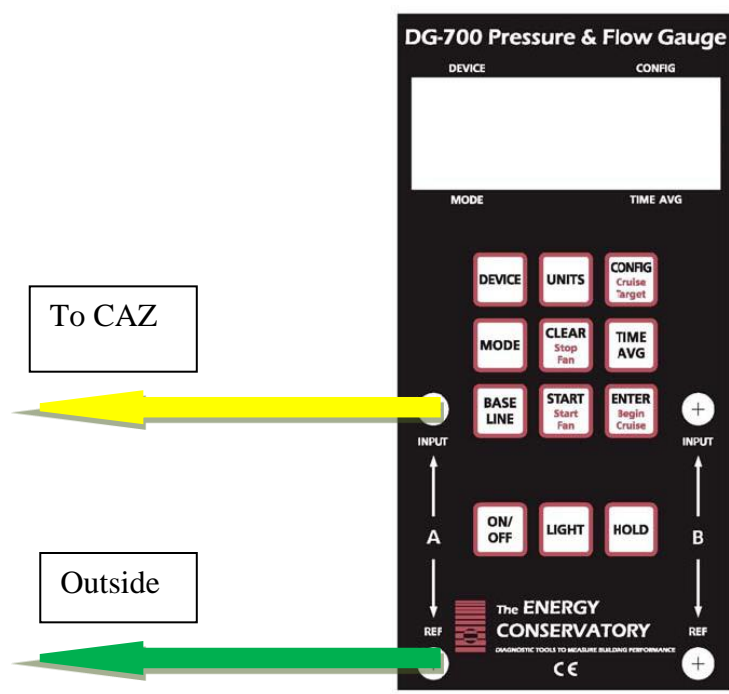


FIG. 4



STEP 5 - COMBUSTION SAFETY

Once your home is in “worst case scenario” that is when you will perform all “Combustion Safety Tests. These tests should only be performed by someone that has been professionally trained or Certified.

It is recommended that you use and follow the combustion safety process highlighted in the “Combustion Safety App” included in this field guide package.

SWS # **2.0201.1**

Emergency problems (e.g., gas leak, ambient CO levels that exceed 35 ppm) will be communicated clearly and immediately to the customer and appropriate solutions will be suggested

FUEL LEAK DETECTION:

- An electronic gas leak detector should be base lined outside in a clean air sample area before being brought into a CAZ area.
- Test all gas, oil or propane fuel lines at all connections and the entire lengths of any flexible piping for leaks. Any positive leak indications from an electronic detector should be verified with soap and water solution.
- Scope of work will specify any repairs needed to correct fuel leaks of any kind.



COMBUSTION AIR REQUIREMENTS:

- Combustion air will meet *IRC 2012 Section G2407.5* guidelines
- Volume of air indoors to supply a device will be no less than 50 Cubic Feet per 1000BTU's of input for all devices in the space. Air volume must be always accessible, and measured shell leakage of the building cannot be below 0.4 ACH.
- If outside air is to be brought into the CAZ, at a minimum you will supply two separate inlets. One that terminates within 12 inches from the ceiling, and another that terminates within 12 inches of the floor. If inlets are horizontal (through a wall) 1 Square inch, Net Free area will be provided for every 2000 BTU/hr input of all equipment in the CAZ, OR combustion air can be brought in vertically (From vented attic space) providing a minimum of 1 Square inch, net free area per 4000 BTU/hr of combined input for all atmospheric vented appliances.

FLUE PIPE / EQUIPMENT INSPECTION:

- All flue pipes will be visually inspected to verify they are the right size.
- Slope a minimum of $\frac{1}{4}$ " rise per foot of run.
- Are free from blockage or excessive damage, leaks, disconnects, or other safety hazards.



SPILLAGE TESTING:

- In worst case depressurization mode, all non-mechanically assisted drafting devices must be tested for spillage at the diverter. If a device continues to spill flue gasses after 2 minutes, it must be tested again at natural conditions to determine if the failure is pressure induced or an issue with the device itself. Any failure of spillage testing requires specifications on how to mitigate the issue under any operating conditions.

UNDILUTED CARBON MONOXIDE TESTING:

- Carbon Monoxide production levels must be measured in all combustion appliances. In atmospheric, natural drafts appliances, this will be performed at the exhaust ports before the gases can mix with dilution air. In Mechanically Assisted or Sealed Combustion appliances this test is performed at the outdoor termination of the flue pipe.
- No appliance can exceed 200ppm undiluted, or 400ppm 'Air Free' at steady state efficiency.
- If CO levels exceed these limits in worst case conditions, they should be re-tested at natural conditions to determine if the failure is due to CAZ pressures or the device itself and appropriate actions to mitigate the problem should be added to the scope of work.

STEP 6 - EXTERNAL STATIC PRESSURE TEST

Refer to Fig. 6 for manometer set up.

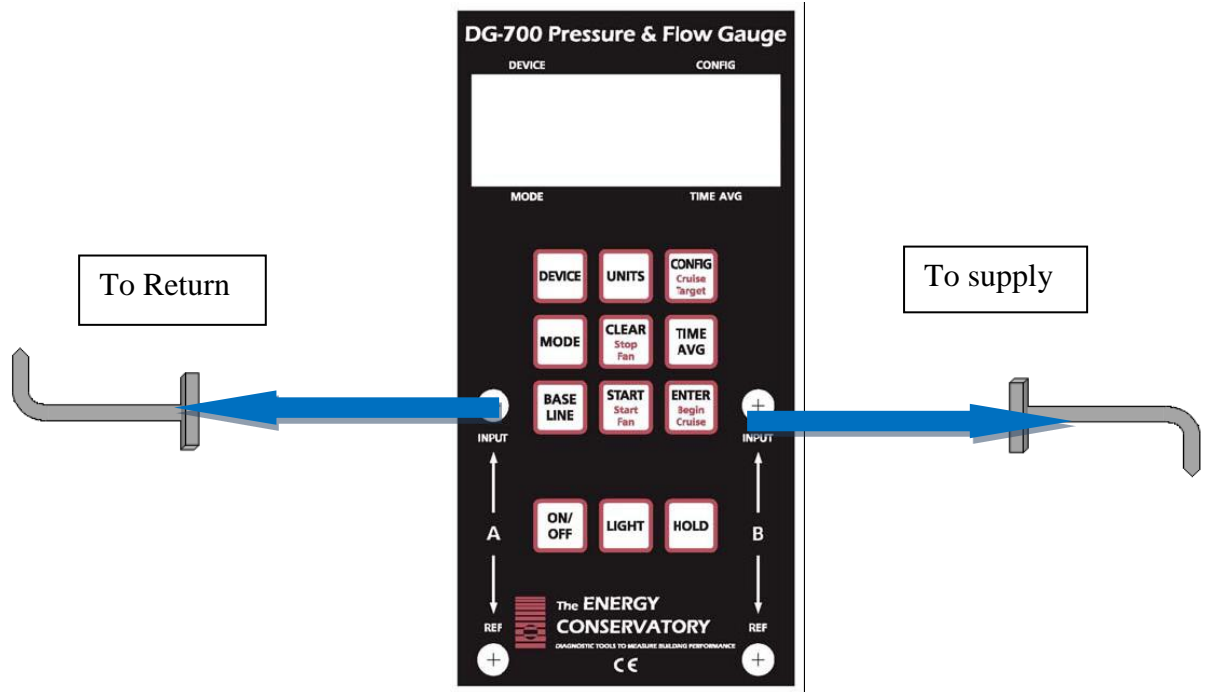


FIG. 6

The static test is meant to measure the static pressures created in the Air Handler itself when operating normally. There actually needs to be two tests performed. One with the air filter in place, and one with it removed and equipment operating without an air filter. In both cases, all interior doors of the home should be opened back up, and all the fans that were turned on for “Worst Case Scenario” should now be turned back off. Any supply registers that have been closed or covered should be opened up.



These tests are performed by drilling two 5/16" holes into both the supply and return plenums as close as you can get to the air handler without drilling into an Air Conditioning coil. Insert a draft probe into each hole insuring that both probes are pointing *into* the air-stream. In other words, your probe in the supply plenum would be pointing TOWARDS the air handler, while the probe in the return plenum would be pointed AWAY from the air handler. To switch the units of measurement on a DG-700 simply press the "Units" button once. You will record a number that looks similar to this: .5000 Repeat this test with the air filter removed and record that number as well. Most heating and cooling air handler equipment has a manufacturer's tag with the model number and serial number on it. Usually on that same tag you will also find the "Max External Static Pres. xxxx iwc"

Because you are testing pressures separately on both channels of your manometer you can simply add the two numbers together ignoring the "-" (Negative) sign. For example

$$\text{Supply} = 0.350 \text{ iwc}$$

$$\text{Return} = -0.410 \text{ iwc}$$

$$\text{Total TESP} = 0.760$$



Compare your number to the number on the tag. This will tell you if the duct system is operating at excessively high static pressures due to an undersized return system among other things. You will notice that the number increases with an air filter and even more with dirty filters. Both the supply and the return sides should be about Half of the max pressure recommended by the manufacturer.

Alternatively, you can look up the “Blower Performance Chart” provided by the manufacturer of the air handler unit. This chart estimates the volume of air the unit is moving based on the Total External Static Pressure. ACCA standards recommend an air flow in air conditioning units to be between 350-450 CFM per ton of air conditioning capacity. It is recommended in hot dry climates that you get to the higher end of that range for optimum efficiency.



STEP 7 - INITIAL BLOWER DOOR

First step in preparing for an initial blower door test is to set the house back into BASELINE mode. Note that you should still have a baseline on your gauge before conducting this test. All exterior doors and windows should still be closed, and all interior doors should now be open, and exhaust fans OFF, from the static pressure testing. Your air handler can now be turned off. You should set all atmospheric combustion appliances in the home to OFF or PILOT and place your car keys on the water tank so that you cannot drive away without returning all equipment to operation positions.

As an energy assessor, you must now make a decision as to whether you want to “pressurize” or “de-pressurize” for your testing. Here are some considerations.

If any of the following conditions exist, you CANNOT depressurize:

- You find mold anywhere in the home
- You find Vermiculite insulation in the attic
- You suspect any friable asbestos is present in the home
- There is a fire burning in a fireplace within the home
- You suspect there may be lead dust from lead based paint in the home

You may NOT want to depressurize if there are any ashes in a fireplace within the home, however wet newspaper carefully laid out will usually hold the ashes down on a



depressurization test. When looked at carefully, there are really only two benefits to

De-pressurization testing.

1. The blower door is designed to give you access to the rings in the fan only when set up in De-pressurization mode.
2. You can feel infiltration on your skin when the door is operating at 50pa.

When you consider the dollar value of infiltration repair in some climate Zones in Arizona, being able feel infiltration is not really much of a benefit, but the potential to pull Mold spores, Lead dust, or Asbestos into the family's living space is quite a downside. If you do choose to Pressurize with the blower door, check for 'Up-Ducts', and temporarily hold all exhaust fan dampers closed with tape. Make sure that the manual gates that can be closed are in fact closed, and the spring or barometric controlled dampers are temporarily held closed.

NOTE: In order to 'Pressurize' for blower door testing, you MUST turn the entire fan around. You CANNOT flip the flow reversing switch that is on some fans, this will give very in-accurate numbers.

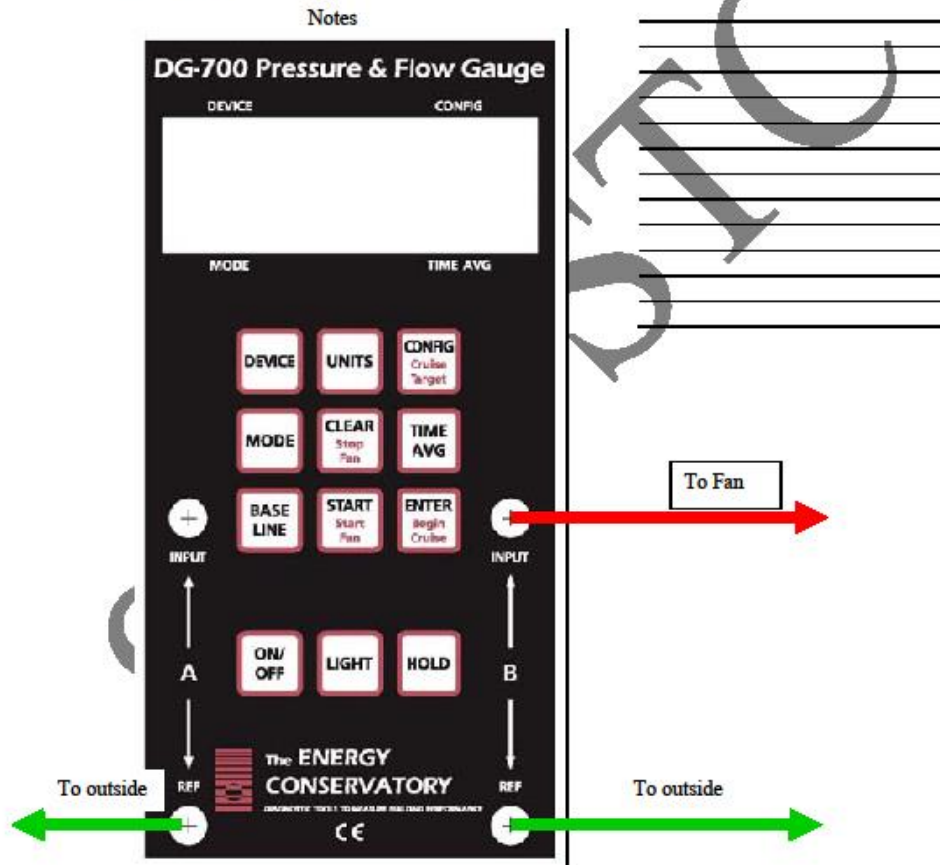
To “Pressurize” see fig 7

To “De-Pressurize” see fig 8 for manometer set up.

Initial Blower Door Test (Pressurize) *Turn Fan Around to Blow Air Into Building*

Channel A: Input open to house, reference to outside and establish 50 Pascals difference.

Channel B: Input to fan tap, reference to OUTSIDE, record fan pressure in Pascals and whole house CFM 50.



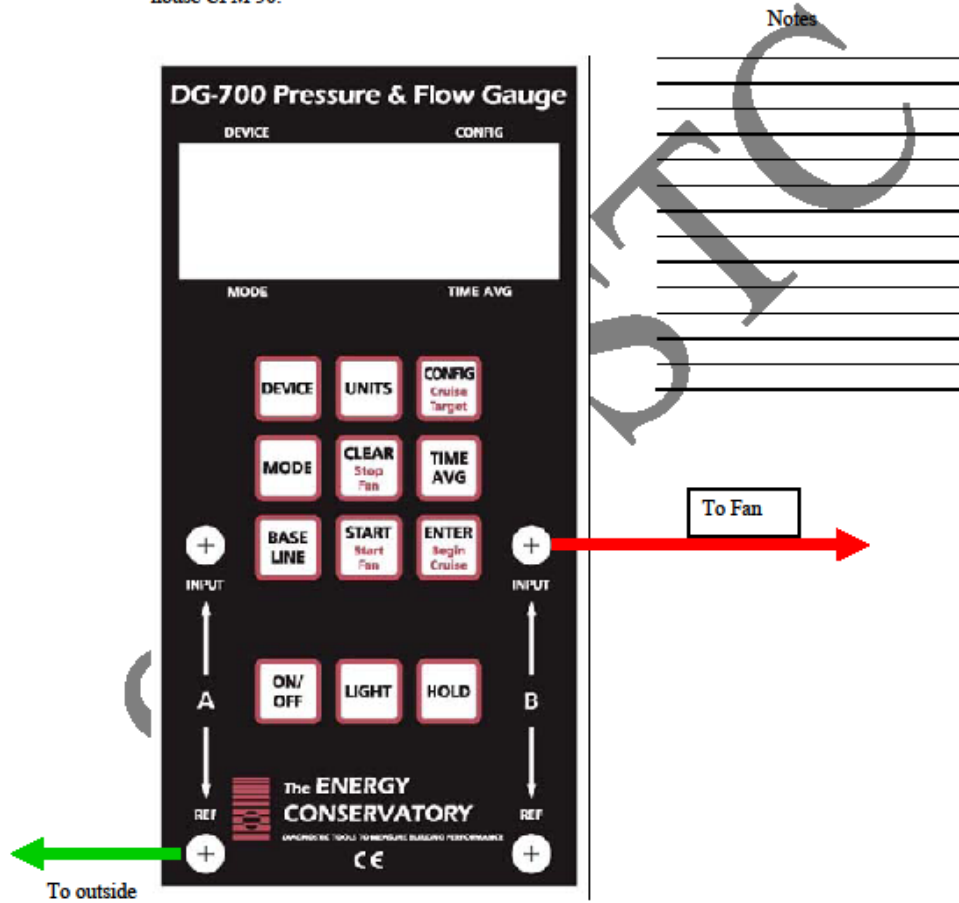
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FIG 7

Initial Blower Door Test (Depressurize)

Channel A: Input open to house, reference to outside and establish 50 Pascals difference.

Channel B: Input to fan tap, reference to inside, record fan pressure in Pascals and whole house CFM 50.



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FIG 8



Once you are all set up, choose which ring you feel will be appropriate for the home you are testing. There are a couple rules of thumb that many people like to use. The reality is that it is in fact just a guess at this point. My experience has been that starting with the 'A' ring is a good guess. To start you should turn your rheostat clockwise increasing the fan speed until you achieve 50Pa on your 'A' channel. This is the HOUSE With Reference To Outside. From this point forward, all testing will be performed with the house at this 50Pa pressure differential with reference to the outside.

At this point a couple of things must happen. First you should verify that you have a minimum of 25Pa on your 'B' channel. If you do, you can skip ahead to the next step. If however you're 'B' channel is less than 25Pa, you will have to add another flow ring to your fan to increase the pressure inside the fan housing in order to produce an accurate CFM Flow number. Once you have 50Pa on your 'A' channel and a minimum of 25Pa on your 'B' Channel you will need to push the "MODE" button. This will switch the 'B' channel window from 'Pa' to 'CFM'. You should also notice that at the top left hand side of that same window you will see "OPEN". This is referring to your fan configuration. If you have an open fan, then the number you see above 'CFM' in the 'B' channel window is your CFM50 number. If you had to use a flow ring to get to this point you will have to tell the gauge which ring is in the fan. Press the "CONFIG" button and you will see the word "OPEN" scroll through the options available to the DG-700. You would press the button once for "A" ring, twice for "B" ring and so on. If you accidentally skip past your ring, just keep pressing "CONFIG" and you will see it



scroll back to its original setting. The number you need here is pretty simple. It is a “CFM@50Pa” number.

If you are unable to achieve 50 Pascal’s due to a very leaky home, you can push the “Mode” button again for a calculated flow at an estimated 50 Pascal’s.

This is the whole house leakage number and is very important in weatherization for a few reasons. If you look carefully at the two windows in your manometer, you will see how this number is formed.

AIR SEALING BUDGET PROCEDURE

Let’s say for example that the test reads:

2000CFM50

The “2000” is the number in the ‘B’ channel, and directly below that you will notice “CFM”. In the ‘A’ channel, you should always see “50” and below that number “Pa”. So when you break it down, you have **2000** Cubic Feet per **Minute** moving through the fan at **50** Pascal’s of pressure.

The Weatherization Assistance Program has established within its priority lists, dollar amounts that can be spent when dealing with infiltration you find with your ‘CFM50’ number. The following procedure explains what to do with your ‘CFM50’ number to determine how much money can be spent to seal these holes. Let’s use the previously



mentioned number of 2000CFM50 as an example. You can calculate how much to seal, and how much you can spend to accomplish that goal.

2000CFM50...Blower door reading
1100CFM50...Where I want to be.

900CFM50...Infiltration sealing
~~900~~.....Square inches to
seal

~~900~~ x \$35.00 .Budget

I have \$315.00 max. To seal 900CFM50

Can you seal 90 square inches of holes in the shell of this building for less than \$315 dollars? That includes the time and materials to find *and* seal these penetrations. An effective tip is if you see a hole that you think is actually shell leakage, tape it off with Duct Mask and re test your home. If the infiltration drops 100CFM50 for example, ask yourself: Can I seal that hole for \$35?

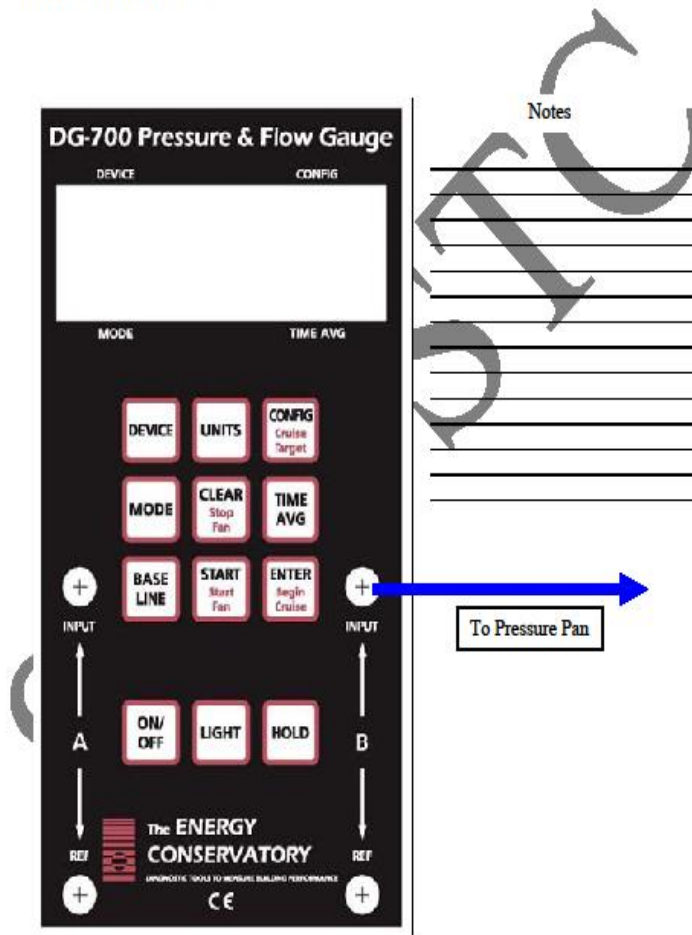
Remember: this dollar amount varies greatly depending on climate zone AND building type. Consult your priority list for building type and climate zone to determine your specific dollar amounts.

STEP 8 - PRESSURE PANS TESTING

SEE FIG 9

Pressure Pan With Blower Door at 50 Pascals

Channel B: Measure leakage at each supply and return register in Pascals with hose input WRT inside of house



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FIG 9



In this test you are looking for the answers to two main questions.

1. Is the duct system leaking?
2. Where is the location of the majority of the leaks?

This test will NOT tell you how much leakage there is, only that there is leakage, and the approximate location of that leakage.

You will notice that at this point we have removed our green reference hose from the 'A' channel reference port. You are now able to disconnect yourself from the blower door by removing the pressure hoses from the manometer. DO NOT ADJUST THE RHEOSTAT. If left alone, the blower door will maintain the 50Pa pressure difference between the indoors and outdoors. Though you will no longer see it on your manometer, that pressure is there.

NOTE: This test only works if the home is at 50Pa of pressure. If you could not achieve that pressure you will have to use an alternative method to estimate duct leakage or temporarily seal shell leakage, or run a second blower door so that you can achieve 50Pa of pressure.

You must now hook up your pressure pan to the 'B' channel input tap with a pressure hose. Starting from the blower door, you will want to go clockwise around the house,



ground floor first then second floor clockwise from the top of the stairs and record ALL the pressures you find in EVERY supply and return register. Any reading of 1.0Pa and over is an indication of a leaky duct system. The larger the number the closer to the leak you are in most cases. The goal of the WAP program is to see the duct system become as leak free as possible. Less than 1pa at all supply and return registers indicates a “relatively leak free system”.

Note: If two registers are within 6’ of each other in the same run, you should tape one register off completely and just record the pressure in the other register. If your pressure pan does not completely cover any register, it is acceptable to tape that register off enough to where your pressure pan will then completely cover it.

ESTIMATING TOTAL DUCT LEAKAGE

Estimating Total Duct Leakage to the Outside:

Because your priority lists, or a computer modeling software will require a total duct leakage measured @25Pa or @50Pa you can use the “Pressure Pan / Duct Sealing potential calculator” included in this field guide to calculate a total leakage number based on average pressure pan readings collected in this test.

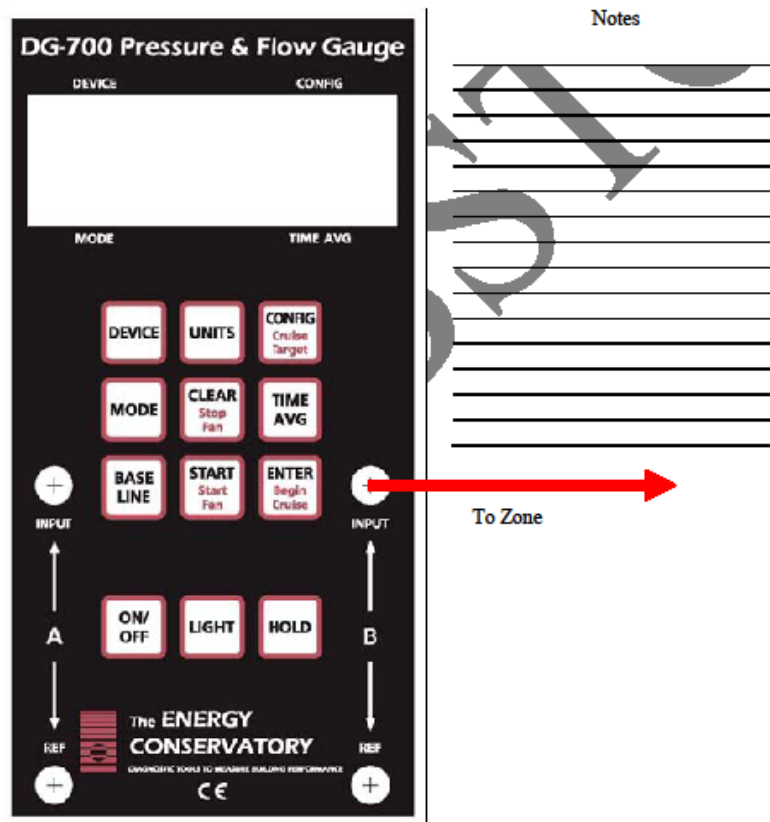
STEP 9 - ZONAL PRESSURES (aka. Pressure mapping)

See FIG 10

Zone Pressures With Blower Door at 50 Pascals

Channel B: Insert probe with hose into zone WRT interior of house to determine if zone is connected more to outside or inside.

- 0-10 Pascals indicates zone is inside envelope
- 40-50 Pascals indicates zone is outside envelope



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FIG 10

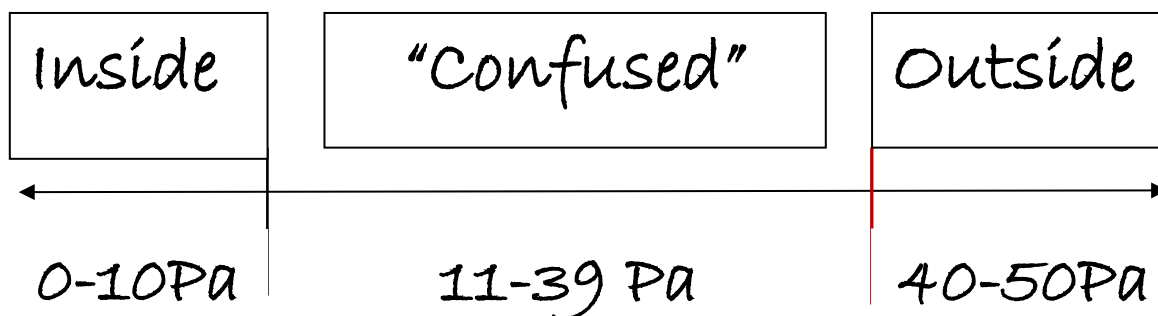


NOTE: House must be at 50Pa for this test to work properly.

The Zonal tests or “Pressure Mapping” are the tests that show the energy assessor where the *actual* air barriers of the home are located. Up to this point, we generally assume that the sheetrock on the inside of the exterior walls, the ceiling and the floor make up the surfaces that separate the inside conditioned air from the outside. Zonal tests will demonstrate where the air barriers are located in reality. You cannot visually *see* air barriers, but your manometer can.

Note: Although the WAP only requires you to *report* the zone that contains the duct system, that in no way implies that only one zonal test needs to be taken. A good energy assessor will take upwards of twenty quick tests or more and determine *exactly* where the actual air barriers are for better or worse.

When determining air barriers, there is a scale that tells you what is inside the pressure boundary and what is outside that boundary, and what is neither in nor out, but ‘confused’.





With a pressure hose connected to your manometers 'B' Channel 'Input' Tap, and the other end attached to your pressure probe or pressure pan, and with the blower door still running the house at a 50 Pascal pressure difference with the outside. You can begin testing any area's you suspect may have faulty pressure boundaries as well as verifying areas where the pressure boundary should in fact be. Good areas to always test are:

1. Drop soffits
2. Chases
3. Interior walls
4. Archways
5. Wet walls
6. Ceilings
7. Floors (if home is not slab on grade)
8. Interior walls alongside staircases
9. Build-outs around showers and baths

In general, what you are looking for is that anything that *should* be inside your home e.g. Interior walls and soffits are in fact inside the pressure boundary. Meaning you see readings of 10 or less Pascal's on your manometer. Whereas areas that *should* be outside the home e.g. Attics, attached garages and crawlspaces, are reading above 40



Pascal's on your gauge. If you have attended quality professional building science training, you will know that in direct contact with your pressure boundary should always be a continuous thermal boundary. That is easy to spot. It's the insulation. At ANY time, if you know there is insulation covering a plane, and a zonal test shows that plane is less than 40 Pascal's, that insulation is NOT performing properly. Conversely you may test a ceiling plane and get a reading of above 40 showing that the ceiling plane is an effective air barrier, but later on in your audit you see that the insulation is up at the roof deck, you are in fact looking at an un-insulated attic. The thermal boundary must be 100% continuous around the envelope of the building (exterior walls, floor and ceiling / roof deck) and the pressure boundary must be 100% continuous around the envelope, and most importantly, the pressure boundary and the thermal boundary must be in 100% contact with each other to perform properly. While your eyes can locate the thermal boundaries, only your manometer and blower door can locate the pressure boundaries. So take lots of tests. Find the pressure boundaries everywhere in that home and determine if it is in contact with the thermal boundary. That is why this test is also known as 'Pressure Mapping'.