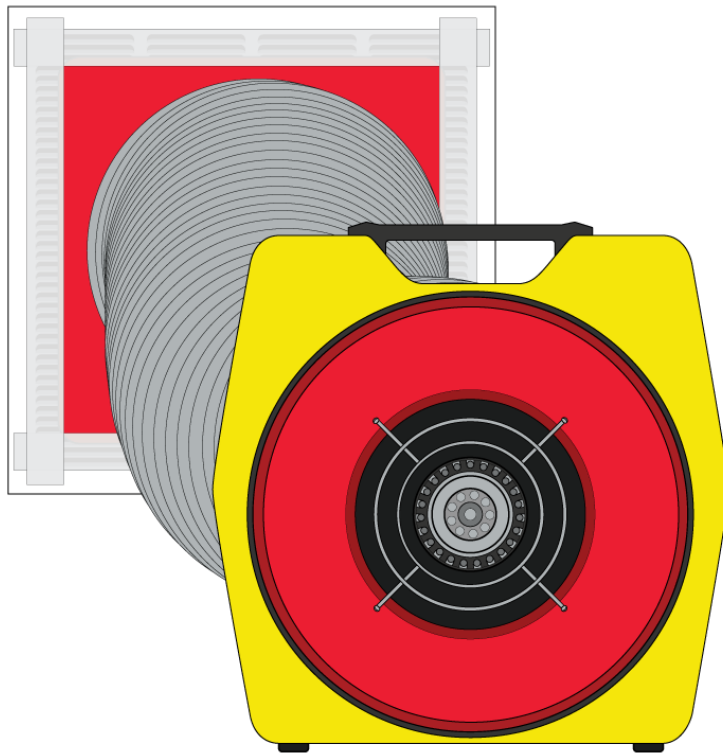


# Model 200

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## DucTester Operation Manual for Residential Applications

rev-2015-01-22



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## Table of Contents

<b>Important equipment-related safeguards .....</b>	<b>7</b>
<b>Important occupant safeguards during testing .....</b>	<b>7</b>
<b>1. DucTester System Equipment.....</b>	<b>9</b>
<b>Duct testing systems (US240, EU240, UK240) .....</b>	<b>9</b>
<b>1.1 The calibrated DucTester fan .....</b>	<b>9</b>
1.1.1. Range Configurations.....	10
1.1.2. Retrotec calibrated fan: Model 200.....	11
<b>1.2 Digital Gauge .....</b>	<b>12</b>
<b>1.3 Flex Duct .....</b>	<b>12</b>
<b>1.4 Additional included duct testing equipment.....</b>	<b>13</b>
1.4.1. Grill Mask for sealing registers .....	13
1.4.2. Umbilical for connecting fan and DM-2 gauge .....	13
1.4.3. Flange for connecting flex to ductwork at register .....	13
1.4.4. Toolbag keeps all testing components in one place.....	14
1.4.5. Tubing Accessory Kit .....	14
1.4.6. Power Cord .....	14
1.4.7. 9v Power Supply adapter for charging DM-2 gauge.....	14
1.4.8. Additional accessories for the DucTester .....	15
<b>2. Why measure Duct Leakage?.....</b>	<b>19</b>
<b>2.1 Energy loss .....</b>	<b>19</b>
<b>2.2 Duct sealing saves money .....</b>	<b>19</b>

2.3	Problems from duct leakage: .....	19
<b>3.</b>	<b>Locating Duct Leaks .....</b>	<b>20</b>
3.1	Types of duct leakage tests .....	20
3.2	What is duct leakage to the outdoors? .....	20
3.3	What is duct leakage to the indoors? .....	20
3.4	How much duct leakage is acceptable under existing Codes? .....	21
3.5	Set up your DucTester for duct leakage testing .....	24
3.6	Unpack, connect the gauge to the DucTester .....	24
3.6.1.	Charge the gauge .....	24
3.6.2.	Make all connections on the gauge and fan .....	25
3.7	Blue Tube location matters when testing leaky ducts .....	26
3.8	Connect the DucTester to the Duct System .....	27
3.8.1.	Connect the Flex Duct to return register .....	27
3.8.2.	OR Connect the Flex Duct to the air handler cabinet .....	28
3.8.3.	OR Connect the Flex Duct to a ceiling level return using a Flow Hood .....	28
3.9	Prepare the Duct System for a test.....	28
3.9.1.	Before beginning the duct leakage test.....	28
3.10	Install Range Ring on fan.....	29
3.11	Select a test direction .....	30
3.11.1.	Setting up for depressurization .....	30
3.11.2.	Setting up for pressurization .....	30
<b>4.</b>	<b>Set up the gauge to display Duct Leakage Results.....</b>	<b>31</b>
4.1	Mode setup for duct testing in the US.....	31
4.2	Mode Setup for various standards around the world.....	32
4.3	Setting up the DM32 gauge for Duct Testing .....	33
4.4	Setting up and using the DM-2 gauge for Duct testing .....	33
<b>5.</b>	<b>Conduct the Duct Leakage tests.....</b>	<b>35</b>
5.1	Total Duct Leakage .....	35
5.2	Duct Leakage to Outdoors with 2 gauges and 2 fans.....	36
5.2.1.	Method #1: Set both duct and house to -25 Pa (or 25 Pa).....	36
5.2.2.	Method #2: Set duct to house pressure to 0 Pa (using DucTester gauge) .....	37
5.3	Duct Leakage to Outdoors with 1 gauge and 2 fans .....	38
5.4	Combined Total Duct Leakage and Duct Leakage to Outdoors Method .....	41

5.5	If no Results are displayed (TOO LOW or ---).....	41
5.6	Cannot achieve test pressure .....	42
6.	Restore the house to pre-test conditions after testing is complete .....	43
7.	Create a Duct Leakage Test Report with Potential Energy Savings .....	44
7.1	Get the Excel spreadsheet based software to run on your system .....	45
7.1.1.	Enable Macros (with Office 2007) .....	45
7.1.2.	Enable Macros (with Office 2010) .....	45
7.1.3.	Showing/Hiding the Ribbon .....	46
7.1.4.	Enter test information and results into green cells .....	46
7.2	Choose metric or imperial units for results.....	46
7.2.1.	Imperial units .....	46
7.2.2.	Metric units .....	46
7.3	Choose Duct Test type .....	47
7.4	Enter the Target test pressure.....	47
7.5	Enter date the test was carried out .....	47
7.6	Enter specific parameters for the conditions of this test .....	47
7.6.1.	Conditioned Floor Area .....	47
7.6.2.	Air Handler Flow .....	47
7.6.3.	Leakage Exponent, n .....	48
7.6.4.	Baseline pressure .....	48
7.6.5.	Enter whether pressurizing or depressurizing (Test direction) .....	48
7.7	Enter readings from this test.....	49
7.7.1.	Duct Pressure .....	49
7.7.2.	Enter “Flow” directly or enter Range Configuration and Fan Pressure.....	49
7.7.3.	Convert “Flow/Area” data so it can be entered into spreadsheet.....	50
7.8	Spreadsheet will calculate Cost of Duct Leakage.....	50
7.8.1.	% of Duct Leakage to Outdoors .....	51
7.8.2.	Annual Cooling Cost .....	51
7.8.3.	Annual Heating Cost .....	51
7.8.4.	Average Duct Operating Pressure.....	51
7.8.5.	Leakage Split .....	51
7.8.6.	Supply Leakage Penalty .....	51
7.8.7.	Return Leakage Penalty .....	52

7.9	Save the Duct Leakage Test Report as a PDF file .....	52
7.9.1.	With Office 2007: .....	52
7.9.2.	With Office 2010 .....	52
8.	Find air leaks in the ducts .....	53
8.1	Using a smoke puffer .....	53
8.2	Using theatrical smoke .....	53
8.3	Using an infrared camera .....	53
8.4	Using a wet hand .....	53
8.5	Using a Pressure Pan.....	53
9.	Measure the Air Handler system flow .....	55
9.1	For Code compliance .....	55
9.2	Why measure the Air Handler system flow? .....	55
9.3	Measure with a DucTester as a powered flow hood on the return .....	55
9.4	Measure with a DucTester on the air handler cabinet .....	56
9.5	Measure with a gauge and a flow grid.....	56
9.6	Measure using air handler blower curves.....	57
9.7	Measure using Hole Flow on the gauge .....	57
9.8	Measure with a Blower Door attached to the return or cabinet.....	57
9.9	Other methods .....	58
10.	Estimate HVAC system energy loss from ducts .....	59
10.1	Duct Air Leakage Measurements.....	59
10.2	Methodology.....	59
11.	Field Check the DucTester to find out what is not working .....	63
11.1	Field Check the gauge .....	63
11.2	Field Check the tubes.....	63
11.3	Field Check the DucTester as a system .....	64
12.	Avoid common mistakes .....	66
13.	Create a Blower Door with a DucTester fan .....	67
13.1	Use a DucTester to test tight enclosures.....	67
13.2	Blower Door System (tight enclosures) details .....	68
	Appendix A: Calculate Air Flow based on Pressure readings.....	69
	Appendix B: Flow Conversion Tables.....	71

Flow Conversion Table for Duct Test Pressure of 25 Pa .....	71
Flow Conversion Table for Duct Test Pressure of 50 Pa .....	72
Flow Conversion Table for Duct Test Pressures greater than 50 Pa .....	73
<b>Appendix C: Calculate flow if required test pressure cannot be reached .....</b>	<b>74</b>
Extrapolation Error for Flow if gauge “ <i>n</i> ” doesn’t match actual <i>n</i> .....	75
Cannot Reach 25 Pa Factors .....	76
Cannot Reach 50 Pa Factors .....	77
<b>Appendix D: Troubleshooting.....</b>	<b>79</b>
“TOO LOW” appears on display:.....	79
Gauge “Flow” reading does not change? Turn off [@ Pressure] .....	79
Fan does not run.....	79
Checking the DucTester flows .....	79
Fixing the Fan Top (for Model 200).....	79
Model 210 and 220 – obsolete models no longer in production .....	83
Adjusting DucTester Motor Mount (for Model 220).....	84
<b>Appendix E: Using a generator for power.....</b>	<b>85</b>
Generators .....	86
Honda Generator EU2000 (120V, 2000W, 67 lbs).....	86
GENYX G3000HI (230V, 3000W) generator .....	86
Portable Power Supplies .....	86
Black and Decker Electromate 400 Model VEC026BD.....	86
<b>Appendix F: Duct-Test Recording Forms .....</b>	<b>87</b>
Total Duct Leakage Test Form           Test date: _____/20____ .....	87
Total Duct Leakage Test Form (CA)       Test date: _____/20____ .....	88
<b>Glossary.....</b>	<b>90</b>

## **Important equipment-related safeguards**

When using electrical appliances, basic safety precautions should always be followed.

*Please read the following carefully before using your DucTester:*

- Avoid contact with moving parts.
- Special attention should be made to keep children and pets away from the fan when it is operating.
- Do not insert anything into the fan casing while the fan is moving.
- Ensure that no debris is inside the fan casing before operating the fan.
- Keep hands, hair and clothing away from fan at all times.
- The fan can cause damage or injury if it were to fall on someone/something.
- Do not use equipment for other than its intended use.
- Do not stand on the fan, or use the fan to support the weight of another object.
- To protect against risk of electric shock, do not place this equipment or power cord in water or other liquid.
- Press the power plug firmly into the power receptacle on the fan. Failure to do so can cause over-heating of the power cord and damage the fan.
- Do not use ungrounded outlets or adapter plugs. Never remove or modify the grounding prong.
- Do not operate any device with a damaged electrical cord, or after an equipment malfunction.
- Use only the included power plug to operate the fan.
- Turn the unit off and unplug from any electrical outlet before moving and when not in use, or when making any adjustments to the fan motor or electrical components.
- For use under indoor conditions only.
- For use where there is no exposure to water or dusty substances or explosive materials or flammable materials.
- Ensure proper cooling of the fan motor.
- Equipment is intended for diagnostic testing and to be operated for brief periods under supervision by a qualified operator. Not to be used in a role as a household appliance for the purpose of moving air.
- Failure to follow these instructions carefully may result in bodily injury, damage to property and/or equipment failure. Failing to operate equipment as intended may void warranty and compliance with CE mark and other listings.

## **Important occupant safeguards during testing**

*Please read the following carefully before carrying out tests:*

- If dust, pollen, mold spores, chemicals or other undesirable substances can get blown into living spaces, keep those susceptible to these substances away from the test area, and wear dust masks.
- Do not pressurize a duct system with air that is polluted or exposed to any toxic substances. For example, blowing air from a car-port into a house or duct system while a motor vehicle is running can quickly fill a house with toxic carbon monoxide.
- If combustion safety problems are found, tenants and building owners should be notified immediately and steps taken to correct the problem including notifying a professional heating contractor if basic remedial actions are not available.
- Air sealing duct work may change the pressure balance in a house and cause back drafting where it did not occur before. For example, a return leaking to outdoors may have pressurized a

house but when corrected, leaky supplies may reverse that and cause depressurization which could result in back drafting hot water heaters, furnaces or fireplaces.

- Be aware of all possible sources of combustion. Ensure any appliances do not turn on during the test. Turn off power to the appliance, or set the appliance to the "Pilot" setting. It is possible for flames to be sucked out of a combustion air inlet (flame rollout) during a test, which is a fire hazard and can result in high carbon monoxide levels.
- If combustion safety problems are found, tenants and building owners should be notified immediately and steps taken to correct the problem (including notifying a professional heating contractor if basic remedial actions are not available). Remember, the presence of elevated levels of carbon monoxide in ambient building air or in combustion products is a potentially life threatening situation. Air sealing work should not be undertaken until existing combustion safety problems are resolved, or unless air sealing is itself being used as a remedial action.

# 1. DucTester System Equipment

## Duct testing systems (US240, EU240, UK240)

A complete DucTester includes a calibrated fan, a digital dual-channel pressure gauge, and a Flex Duct with flange to attach the fan to a register. Systems also include a hard-sided fan case, an AC adaptor for the gauge, and a roll of Grill Mask. All pressure tubing and Control Cables are bundled together securely in one easy to use Umbilical cable (included), and the included tubing accessory kit contains T connectors and tube lengths.



Figure 1: A complete duct testing system.

### 1.1 The calibrated DucTester fan

Retrotec's DucTester was specifically designed for testing ducts and tight enclosures. It has more than three times the power necessary to test the leakiest duct system to current standards. The backward curved centrifugal impeller is perfect for creating high test pressures. The elliptical nozzle is extremely stable in both the pressurization and depressurization test directions, where it offers equivalent accuracy in both directions.

A Flow Conditioner is not needed with Retrotec fans for depressurization testing. Some duct testing fans require a flow conditioner when depressurizing a duct system, in order to get correct readings. The Retrotec DucTester does not require a flow conditioner because it uses a flow nozzle, which is intrinsically stable in either direction because the flow gets compressed as it goes through the nozzle.

All Retrotec models comply with ASTM E1554-07, ANSI/ASHRAE 152, ASTM E779-10, EN 13829, ATTMA TS-1, CGSB 149.10 and RESNET standards.

The DucTester Fan can be used as part of a Blower Door system for testing tight enclosures, as shown in section 13. For procedures on how to test an enclosure using a Blower Door system, see *Blower Door and Gauge Testing Manual*.

### 1.1.1. Range Configurations

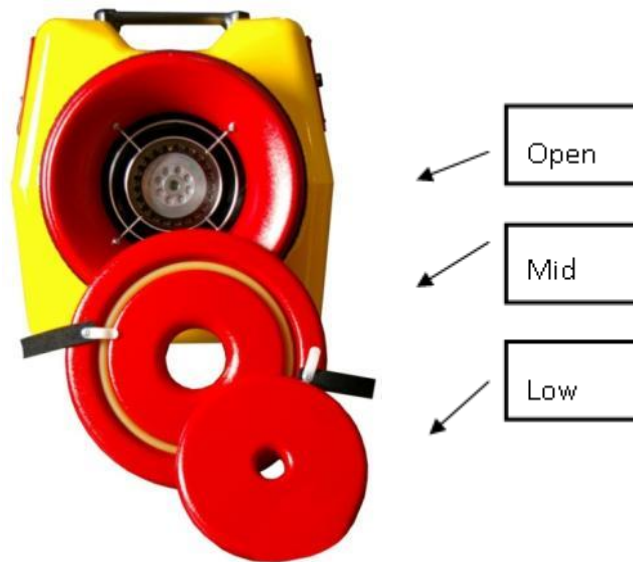


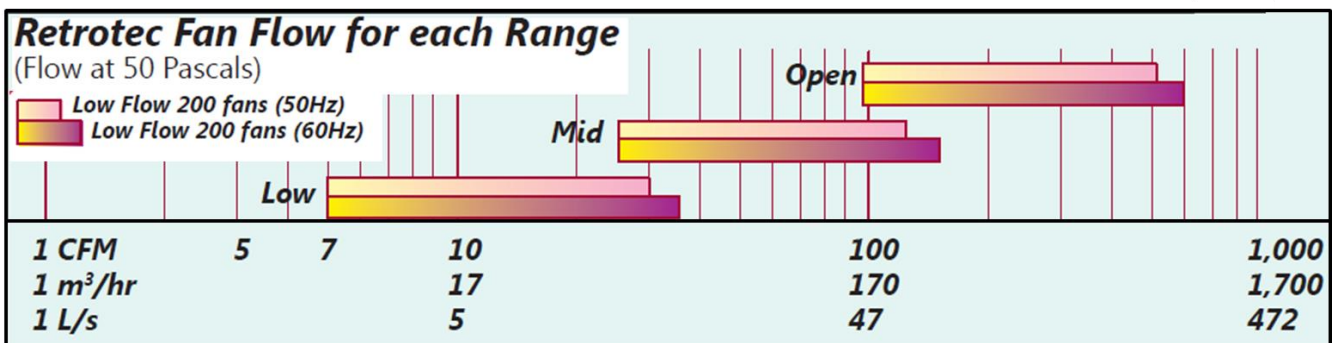
Figure 2: Three flow rings: Low, Mid and Open, restrict flow through the fan inlet.

All Retrotec calibrated fans have multiple Range Configurations in order to measure a wider range of air leakage flows. During testing, it is necessary to select the correct Range Configuration to achieve measurable and accurate results.

A calibrated fan measures flow by measuring the pressure developed inside the fan, which is often called Fan Pressure. As the fan speeds up, a suction pressure develops at the inlet of the fan that causes air to flow. By measuring this Fan Pressure, airflow can be calculated using pre-determined flow curves or tables, or the Retrotec gauge, which applies the same calculations automatically and displays the Flow directly.

When the fan slows down, the Fan Pressure can become too small to accurately measure. To increase the Fan Pressure, a restriction plate is placed in front of the fan. The fan, consequently, has to turn faster to maintain the same room or duct pressure, which creates a larger, more accurate Fan Pressure. By providing a set of flow restricting plates with calibrated holes, Retrotec DucTester fans can measure flows from 7 CFM to 725 CFM.

The Model 200 has three Range Configurations: Low, Mid, and Open. When adding restriction plates, it is important that they always be installed on the fan inlet. In order to work correctly, the plates must restrict the airflow as it enters the fan. Restricting the outflow has no effect on the inlet pressure. When depressurizing, the Flex Duct must be removed in order to change the plates.



### 1.1.2. Retrotec calibrated fan: Model 200

The Model 200 fan is included in the DU200, DE200, and DK200 duct testing systems; and included in the US200, EU200, and UK200 Blower Door systems for testing tight enclosures. This 0.25 hp fan is designed for use with the Retrotec digital gauge, which will control the fan to any desired Set Pressure or Set Speed. Alternatively, it can be controlled via a manual Speed Control Knob, allowing the gauge to be used for other tests while the fan continues to run. The Model 200 Fan has a Fan Top that includes a built in speed control knob, an on/off switch, and the ability to chain multiple fans together which allows control of multiple fans using a single gauge.



Figure 3: Retrotec Model 200 has a speed control knob and two Ethernet style Speed Control Ports for daisy chaining speed controls.

The Model 200 has two Fan Pressure sensors (located inside the fan inlet), and two self-referencing pickups (located just above and below the fan inlet) which are connected to the single green and yellow ports.

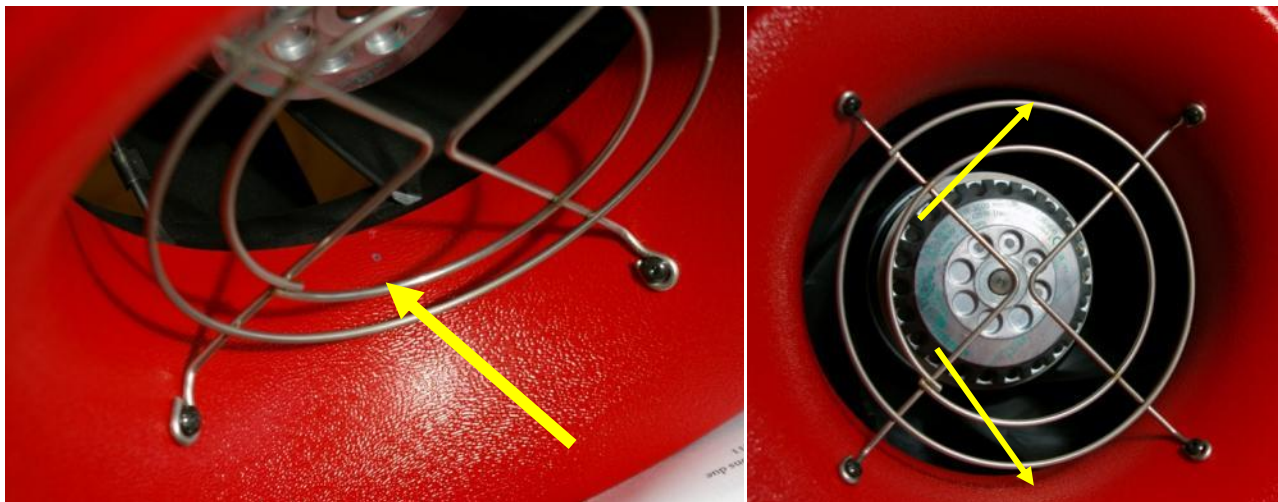


Figure 4: Fan Pressure sensors are located in the fan inlet.

The two Fan Pressure sensors are located just inside the fan inlet, behind the protective grill. Together, they measure the Fan Pressure, from which the fan airflow is calculated in the gauge. If the sensors become blocked, it is possible to clear them by attaching a pressure tube to the yellow Ref B port, and blowing air through the tube gently. A whistling sound should be heard, indicating air is flowing through the sensors.

The exterior of the inlet has the two self-referencing pressure pickups. They are connected to the green Input B port, and are used as the reference for the Fan Pressure Sensors. Self-referencing ensures that the measured pressure difference is always accurate, no matter what the direction of flow is with respect to the location of the gauge and operator.

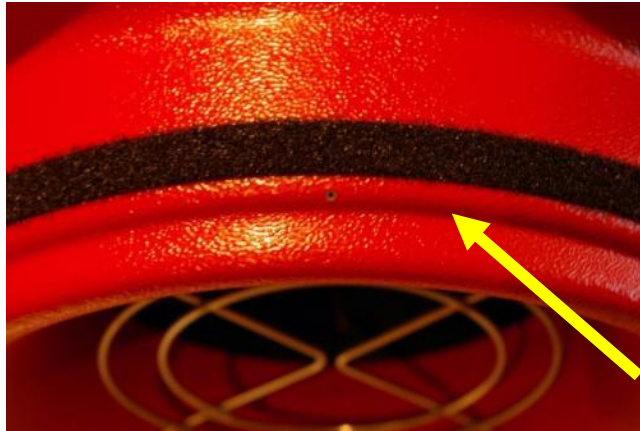


Figure 5: Self-referencing pressure pickup.

## 1.2 Digital Gauge



Figure 6: DM32 or DM-2 digital gauge.

The latest Retrotec Digital Gauge is included with all Retrotec DucTester systems. The gauge can be combined with the Model 200 fan for automatic control to Set Pressure or Set Speed. The gauge is a dual-channel manometer, which can automatically convert the measured Fan Pressure into a range of useful results that meet every major testing standard in the world.

The gauge is also capable of taking a Baseline pressure reading, and automatically recalculating results, in order to reflect this bias pressure. It can auto zero itself to ensure pressure readings do not drift away from the true pressure value during a test. It is also capable of displaying results that are extrapolated to any pressure.

The DM32 can be controlled from a computer over a Wired or WiFi network. The DM-2 requires a USB connection for computer control.

For more information on configuring and using the DM32, see the *DM32 Operation Manual*.

For more information on configuring and using the DM-2, see the *DM-2 Operation Manual*.

## 1.3 Flex Duct

Retrotec's duct testing systems (DU200, DE200, DK200) include a 10" diameter, 12' long flexible duct to connect the fan to a register, or duct system. A durable plastic Flange on one end is taped to a register or air handler, and connected to the Flex Duct to ensure a strong and simple seal. Velcro straps on either end securely attach the Flex Duct to the Flange and fan inlet or outlet.



Figure 7: Flex Duct for duct testing system with Flange and strap.

## 1.4 Additional included duct testing equipment

In addition to the calibrated fan and digital dual-channel pressure gauge, a Retrotec DucTester system includes a few additional items.

### 1.4.1. Grill Mask for sealing registers

Grill Mask is used to seal over registers and vents. Grill Mask comes in a 12" wide roll. It is perforated at 12" intervals to provide easy-to-tear pieces that can seal nearly anything. Be careful applying Grill Mask to painted surfaces, as paint can be pulled off when removing it after testing. Additional Grill Mask can be ordered from Retrotec as a single roll or in three roll bundles. A handy Grill Mask dispenser is also available as an optional accessory.



Figure 8: A roll of Grill Mask

### 1.4.2. Umbilical for connecting fan and DM-2 gauge

An umbilical neatly bundles the needed pressure tubes and Control Cable, to prevent the user from being greeted by a tangled mess of tubes and cables before each test. The standard 20' long DucTester umbilical includes a yellow, green, and blue pressure tube, as well as the Control Cable used for the DM-2 to communicate with the fan. For detailed instructions on how to connect the DucTester fan and the DM-2 gauge using the Umbilical, refer to section 3.6.



Figure 9: An Umbilical

### 1.4.3. Flange for connecting flex to ductwork at register

The Flange is the intermediate part used to secure the Flex Duct onto a return register by using masking tape or Grill Mask. For instructions on how the Flange is connected, refer to section 3.7.



Figure 10: A Flange

#### **1.4.4. Toolbag keeps all testing components in one place**

The Deluxe Condura Toolbag provides enough volume to hold all the system components of a DucTester System. It includes a shoulder strap for easy carrying. The vented exterior pocket is an important feature, useful for storing your smoke puffer which will destroy your gauge and laptop if stored together.



#### **1.4.5. Tubing Accessory Kit**

The Tubing Accessory Kit comes with blue, red, yellow and green pressure tubes (approximately 37 ft each, 1/8" inner diameter), four short male-to-male pressure tube connectors, two T-connectors for pressure tubes, a Static Pressure Probe, and a copper wire. Attaching a Static Pressure Probe to the pressure tube can prevent pressure reading interferences from wind or other air flows blowing on the pressure tube. The copper wire can be inserted into a pressure tube to prevent it from bending, and affecting the pressure reading.



**Figure 11: A Tubing Accessories Kit**

#### **1.4.6. Power Cord**

The power cord is used to power your Model 200 fan. Once it is connected to a wall outlet, the Mains Power status light turns green, indicating power is connected.



**Figure 12: A power cord for Model 200 fan**

#### **1.4.7. 9v Power Supply adapter for charging DM-2 gauge**

The 9V Power Supply adapter is used to charge the DM-2 gauge's batteries. For instructions on charging the DM-2 batteries with the 9V Power Supply Adapter, refer to section 3.6.














**Figure 13: Power supply adaptor for the DM-2**








### 1.4.8. Additional accessories for the DucTester

The following is a table containing DucTester system components with part numbers, and additional accessories that can be used with a DucTester fan. For more information on these parts, contact [sales@retrotec.com](mailto:sales@retrotec.com).

Part Number	Description	Image
DE200	DucTester (240V/50Hz)	
DK200	DucTester (110V/50Hz)	
CU230	Manual Speed Control (Includes DM205 – Control Cable)	
DM205	Control Cable – 20 ft (7 m)	
DU154	Mid-Range Ring for Model 200 Fan	
DU155	Low-Range Ring for Model 200 Fan	
PT103	Power Cord for Model 200 fan	
TL118	Deluxe Cordura Toolbag with Shoulder Strap	
DM214	Laptop Style Case for DM-2	

Part Number	Description	Image
DM221	DM-2 Dual Channel Digital Gauge	
DM203	9V DM-2 Power Supply for DM-2	
DM204	NiMH Batteries for DM-2 (Package of 4)	
DM212	USB Cable Type A to Mini B for DM-2, 6 ft (2 m)	
DM227	Umbilical for Model 200 Fan, 20 ft (7 m)	
GR109	Grill Mask, Case of 3 (12 in x 160 ft, 12" perforations)	
GR106	Grill Mask Dispenser (13 in)	
TU101	Basic Wind Damping Kit	
TU103	Wild Wind Tamer Wind Damping Kit	
PP101	Small Pressure Pan (13 in x 15 in x 4.5 in), handle, no pole (Includes PP103 – Velcro (4 x 4" adhesive backed)	

Part Number	Description	Image
PP102	Large Pressure Pan (24.5 in x 24.5 in x 8.75 in), handle, no pole (Includes PP103 – Velcro (4 x 4" adhesive backed) x 2	
GA110	Static Pressure Probe	
TU133	Bulk Tubing - Green 1/8in ID / per ft	
TU132	Bulk Tubing - Yellow 1/8in ID / per ft	
TU131	Bulk Tubing - Red 1/8in ID / per ft	
TU130	Bulk Tubing - Blue 1/8in ID / per ft	
TU119	Tubing Accessory Kit	
DU159	Model 200 Verification Plate	
DU156	Flex Duct for DucTester 12.5 ft (3.8 m)	
DU157	Flange for DucTester	
AL214	Cloth for Model 200 Fan (Includes DU160 Soft Panel Clip Kit for Low Flow Fan) Designed for testing tight enclosures Commonly used for Passivhaus	
AL103	Case for Aluminum Frame	
AL215	Extender Kit for Aluminum Frame, Red Anodized	

Part Number	Description	Image
AL111	Aluminum Frame Crossbar #5, lower	
AL112	Aluminum Frame Crossbar #6, upper	
AL106	Aluminum Frame Cam Lever Replacement Kit	
AL107	Aluminum Frame Replacement Knob	
AL113	Aluminum Frame Replacement Channel Guide Kit (5 Units)	
AL114	Aluminum Frame Replacement Corner Block Kit (Single)	
AL115	Aluminum Frame Replacement Expander Block Kit (Single)	

## 2. Why measure Duct Leakage?

### 2.1 Energy loss

Leaky ducts pose health, safety and comfort problems and account for about 25% of the total energy lost in a typical house. Because it's *"by far the most cost effective way to save energy"* (EPA quote), building codes now demand higher performance. Although visual duct inspections may be allowed in some states, duct testing provides an easier, faster, verifiable pass /fail test result. In many instances, it has a greater impact on energy use than air leaks anywhere else in the house or building enclosure. The single largest cause of performance problems in small commercial buildings is often duct leakage.

The Duct Leakage Test Report software (in Excel) available from Retrotec can be used to estimate the energy loss from duct leakage, as described in section 7.8.

### 2.2 Duct sealing saves money

A study completed in Florida examined 46 homes. They found that sealing the duct leakage reduced air conditioner use by an average of 17%. This lead to savings of \$110 per year, and the repairs were a onetime cost of \$200. Repeatedly, studies show that sealing leaky duct systems is one of the most cost-effective measures that a home owner can take. Heating or cooling, the same holds true in all climates. Another study in Arkansas noticed an average savings of 22% on heating bills when duct leakage sealing was performed.

### 2.3 Problems from duct leakage:

- Leaky return ducts pull unconditioned air into the duct system, and reduce the efficiency and capacity of the HVAC system.
- Conditioned (and expensive) air is lost directly to the outside, a crawlspace, or an attic.
- If moist air is pulled into return leaks, the dehumidification system is overwhelmed and the building will be uncomfortable.
- An inefficient duct system will result in people seeking alternative sources of heating or cooling, including increased use of electric heaters and fans.
- Dangerous gases, mold spores, insulations fibers, dust, and other contaminants can be drawn into the duct system and are blown into conditioned spaces.

### 3. Locating Duct Leaks

Air leakage from a duct system can be very hard to identify. Most duct systems are predominantly behind walls, in attics, crawlspaces, or other unconditioned and hard to access areas. Consequently, most duct leaks are hard to find, and tend to go unnoticed by owners and contractors alike.

Unfortunately, the harder a leak is to find, the more crucial it tends to be, as these leaks are often found in hot, humid, damp, and moldy environments. For more details on methods of finding air leaks in the ducts, refer to section 7.

#### 3.1 Types of duct leakage tests

There are two types of duct leakage tests: a Total Duct Leakage test, and a Duct Leakage to the Outdoors test.

**Total Duct Leakage** test is used to determine the total amount of air leakage from a duct system (to outdoors and indoors)

- only a DucTester system is needed to create a pressure in the duct system
- see section 5.1 for test procedure

**Duct Leakage to Outdoors** test is used to determine the air leakage from a duct system to the outdoors only

- Both a DucTester system and a Blower Door system are needed in to create a pressure in the duct system and the house
- see section 0 for test procedure

#### 3.2 What is duct leakage to the outdoors?

Duct systems can be either within the conditioned space (i.e., entirely enclosed in the building), or outside of the building envelope (i.e., in crawl spaces and/or attics). When ducts are contained in the conditioned space, air leaking from ducts will end up inside the home. When the ducts are outside of the conditioned space, duct air leaks go directly to the outdoors; this causes conditioned supply air to escape, and allows outdoor air to be sucked in through the return. If duct systems run within building cavities, leaked air can go to both the outdoors and inside the house.

For Duct Leakage to Outdoors tests, the DucTester fan and Blower Door create the same pressure in the house and the duct system. This neutralizes the pressure between the house and duct system, which effectively means that there would be no airflow between the duct and inside the house, resulting in the DucTester system only measuring duct leakage to the outdoors.

The studies discussed in section 2.2 mostly reference homes with duct systems outside of the conditioned space. Duct leakage to the outdoors has the most impact on HVAC performance. However, even when all ductwork is located within the building there can be significant loss to the outdoors.

#### 3.3 What is duct leakage to the indoors?

Less is understood about the impacts of duct leakage to the indoors. One of the major concerns is that leaky return systems can cause basements to depressurize, which can in turn cause combustion gases (from the furnace) to spill into the home. This can cause serious health problems for the occupants, especially if the gas mixture is high in carbon monoxide, an odorless, invisible gas and deadly gas. Along with this problem, negative pressures can also cause increased moisture in the building, and possibly allow radon gas to infiltrate as well.

### 3.4 How much duct leakage is acceptable under existing Codes?

How much duct leakage is acceptable? The table primarily shows standards for new buildings; only California has a listing for existing buildings. Changes occur as states adopt the new codes. Check at the [Online Code Environment and Advocacy Network](#) website for up to date details on energy code adoption. ENERGY STAR programs are listed even though they are voluntary programs rather than Codes.

**Table 1: Duct Leakage Compliance Values (Residential) according to existing Codes**

Program/Region	Units/Test Pressure	Leakage requirement
Abu Dhabi Building Code	CFM <sub>25</sub> /100 sq ft at + 25 Pa	Total Duct Leakage: <=12 CFM <sub>25</sub> /100 sq ft Duct Leakage to Outdoors: <=8 CFM <sub>25</sub> /100 sq ft
CA: USA Title 24 –new building (residential)	CFM <sub>25</sub> at + 25 Pa	Total Duct Leakage: <=6% of system air handler flow (actual measured airflow or airflow can be calculated by using the maximum of 400 CFM <sub>25</sub> per Ton and 21.7 CFM <sub>25</sub> per 1000 BTUh).  Maximum nominal duct leakage is 24CFM <sub>25</sub> /Ton or 1.302 CFM <sub>25</sub> /1000 BTUh for design purposes.
CA: USA Title 24–new building (residential)	CFM <sub>25</sub> at + 25 Pa	If testing at Rough-in without AHU Total Duct Leakage: <= 4% of system air handler flow (actual measured airflow or airflow can be calculated by using the maximum of 400 CFM <sub>25</sub> per Ton and 21.7 CFM <sub>25</sub> per 1000 BTUh).
CA: USA Title 24–existing building (residential)	CFM <sub>25</sub> at + 25 Pa	Total Duct Leakage: <= 15% of system air handler flow (use actual measured airflow or airflow can be calculated by using the maximum of 400 CFM <sub>25</sub> per Ton and 21.7 CFM <sub>25</sub> per 1000 BTUh). OR Duct Leakage to Outdoors <= 10% of system air handler flow (use actual measured airflow or airflow can be calculated by using the maximum of 400 CFM <sub>25</sub> per Ton and 21.7 CFM <sub>25</sub> per 1000 BTUh). OR if fail both, show a 60% reduction in leakage
CA: USA Title 24–Ducts in conditioned space (residential)	CFM <sub>25</sub> at + 25 Pa	If Ducts are in conditioned space Duct Leakage to Outdoors: <= 25 CFM <sub>25</sub>
ENERGY STAR Homes USA Version 3 (Rev 05)	CFM <sub>25</sub> /100 sq ft at + or - 25 Pa	Total Duct Leakage: <= 8.0 CFM <sub>25</sub> /100 sq ft of conditioned floor area AND Duct Leakage to Outdoors: <= 4.0 CFM <sub>25</sub> /100 sq ft of conditioned floor area.
Florida State Energy Code FL: USA		
2009 IECC International Energy Conservation Code  Global	CFM <sub>25</sub> /100 sq ft at + or - 25 Pa	Post Construction Test: Total Duct Leakage: <= 12 CFM <sub>25</sub> /100 sq ft conditioned floor area. OR Duct Leakage to Outdoors: <= 8 CFM <sub>25</sub> /100 sq ft conditioned floor area. OR Rough-in Test with air handler Total Duct Leakage: <= 6 CFM <sub>25</sub> /100 sq ft OR Rough-in Test with no air handler: Total Duct Leakage: <= 4 CFM <sub>25</sub> /100 sq ft  Required: -Where ducts are located outside the conditioned space -In existing houses where more than 50% of the ducts are replaced  Not Required: - If all ducts are located in the conditioned space

Program/Region	Units/Test Pressure	Leakage requirement
2012 IECC International Energy Conservation Code  Global	CFM <sub>25</sub> /100 sq ft at + or - 25 Pa	<p>Post Construction Test: Total Duct Leakage: <math>\leq 4</math> CFM<sub>25</sub>/100 sq ft conditioned floor area. OR Rough-in Test with air handler Total Duct Leakage: <math>\leq 4</math> CFM<sub>25</sub>/100 sq ft OR Rough-in Test with no air handler: Total Duct Leakage: <math>\leq 3</math> CFM<sub>25</sub>/100 sq ft</p> <p>Required: -Where ducts are located outside the conditioned space -In existing houses where more than 50% of the ducts are replaced</p> <p>Not Required: - If all ducts are located in the conditioned space</p>
New York State Energy Code NY: USA	CFM <sub>25</sub> /100 sq ft Total leakage at + or - 25 Pa	<p>Total Duct Leakage: <math>\leq 8.0</math> CFM<sub>25</sub>/100 sq ft of conditioned floor area or 6% of air handler flow. Measured at supply closest to air handler. Test equipment must be certified by manufacturer that it complies with ASTM E1554-07 and ASHRAE Standard 152. Duct leakage to outdoors acceptable under Method A of ASTM E1554-07.</p>
North Carolina Energy Conservation Code NC: USA	CFM <sub>25</sub> /100 sq ft Total leakage at - 25 Pa	<p>Total Duct Leakage: <math>\leq 6.0</math> CFM<sub>25</sub>/100 sq ft of conditioned floor area. Depressurize to -25 Pa measured at supply closest to air handler. Test equipment must be certified by manufacturer that it complies with ASTM E1554-07.</p>
Northwest ENERGY STAR Homes ID, MO, OR, WA: USA	CFM <sub>50</sub> /sq ft CFM <sub>50</sub> + 50 Pa	<p>Total Duct Leakage, air handler in un-conditioned space CFM<sub>50</sub> <math>\leq</math> floor area (sq ft) X 0.04 (which is same as CFM<sub>50</sub>/ sq ft <math>\leq 0.04</math>) OR CFM<sub>50</sub> <math>\leq 50</math> (when house &lt; 1250 sq ft) OR Total Duct Leakage, air handler in conditioned space CFM<sub>50</sub> <math>\leq</math> floor area (sq ft) X 0.06 (which is same as CFM<sub>50</sub>/ sq ft <math>\leq 0.06</math>) OR CFM<sub>50</sub> = 75 (when house &lt; 1250 sq ft)</p> <p>Not Required: If both the ducts and air handler are located within the conditioned space</p>
Oregon State Energy Code OR: USA		
Washington State Energy Code WA: USA	CFM <sub>25</sub> /sq ft Total leakage at + 25 Pa	<p>Total Duct Leakage with air handler NOT installed <math>\leq</math> floor area (sq ft) X 0.04 CFM<sub>25</sub> with air handler installed <math>\leq</math> floor area (sq ft) X 0.08 CFM<sub>25</sub> OR Duct Leakage to Outdoors (recommended where possible) <math>\leq</math> floor area (sq ft) X 0.06 CFM<sub>25</sub></p>

**Table 2: Maximum allowable duct leakage (Residential) according to existing Codes**

Code:	Based on 2009 IECC	GA State Code	WA State Code	VT Residential Building Energy Std	ENERGY STAR Homes V3 Rev5	Northwest ENERGY STAR Homes	CA Title- 24 Code – Altered ducts	CA Title-24 Code – New ducts	Based on 2012 IECC
Region:	AL CT DC DE FL IA ID IN KY MA MI MT NC NE NH NJ NM NV NY OH OR RI SC VA	GA	WA	VT	USA	ID OR MO WA	CA	CA	MD
Test Pressure	+ or – 25 Pa	+ or – 25 Pa	+ 25 Pa	+ or – 25 Pa	+ or – 25 Pa	+ 50 Pa	+ 25 Pa	+ 25 Pa	+ or – 25 Pa
Units	CFM /100 sq ft	CFM /100 sq ft	CFM / sq ft	CFM /100 sq ft	CFM /100 sq ft	CFM / sq ft	CFM	CFM	CFM /100 sq ft
Max Total Duct Leakage, at rough in, NO air handler	4	N/A	0.04	4	N/A	N/A	N/A	4% of system airflow	3
Max Total Duct Leakage, at rough in, with air handler	6	6	0.08	3	N/A	N/A	N/A	6% of system airflow	4
Max Total Duct Leakage, post construction with air handler	12	12	0.08	N/A	8	0.06 CFM/ sq ft or 75 CFM	15% of system airflow	6% of system airflow	4
Max Duct Leakage to Outdoors, post construction with air handler	8	8	0.06	6	4	N/A	10% of system airflow	N/A	N/A

**Tighter ducts required**

The table is listed from left to right in order of loosest to tightest “Total Duct Leakage” requirements.

*Disclaimer: This information is not guaranteed. As Codes are being updated continually, this table represents the most up to date information available at the time of publishing. Please refer to “rev” date on cover page of this document to determine date of publishing.*

### 3.5 Set up your DucTester for duct leakage testing

A step by step guide to the Duct Testing Procedures can be found in Retrotec's *DucTester 200 QuickGuide*.

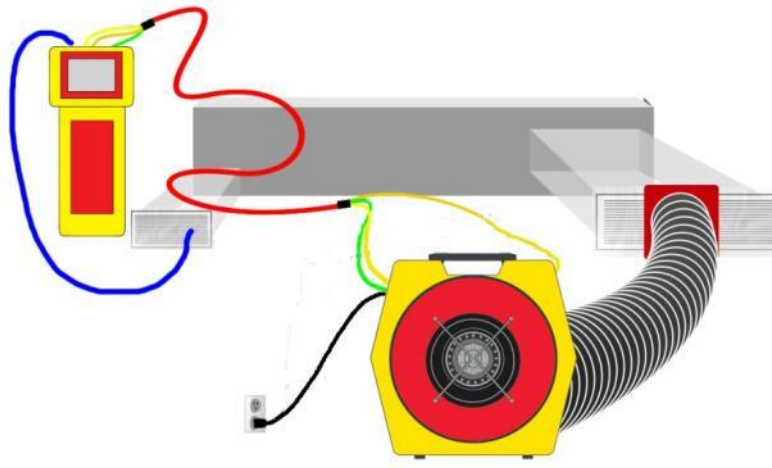


Figure 14: DucTester setup, including tubing locations and necessary connections.

### 3.6 Unpack, connect the gauge to the DucTester

Prior to beginning any test, it is important to verify that the system is functioning properly. Check that the batteries have enough power, and that the fan can be controlled either automatically or manually.

#### 3.6.1. Charge the gauge



Figure 15: 4 NiMH AA batteries type in the battery compartment of the DM-2

The nickel-metal hydride (NiMH) batteries should save you about \$200 per year on batteries, so it's worth spending some time to get familiar with them. You can change them to non-rechargeable batteries but ensure the **[Setup]** key is used to change the "Battery Type" because trying to charge non-rechargeable batteries will damage your gauge.

1. If they're not already installed, install the 4 NiMH AA batteries into the battery compartment of the DM-2 gauge. Always use four batteries that are exactly the same and that have been charged for the same amount of time. Never use mismatched batteries.
2. The batteries will need to be charged for a minimum of 18 hours if this is the first time they're being used.

3. Press **[On]** and then **[Exit]** to view the battery indicator in the top left corner of the screen.
4. If the batteries are less than one quarter full, connect the battery charger for approximately 12 hours.
5. The batteries will charge more quickly if the DM-2 is turned off. A large battery icon will be displayed on the screen, as shown in Figure 20.



Figure 16: The screen and back view of the DM-2 while the batteries are being charged.

### 3.6.2. Make all connections on the gauge and fan

6. Often, the yellow, green and blue tubes and the Control Cable are left permanently connected to the gauge but if not, make those connections.



Figure 17: Pressure ports on the back of the gauge are color-coded to match the tubing.



Figure 18: Electrical connections on the back of the gauge include Control Cable that goes to the DM-2 (shown connected), USB cable for a PC, reset switch and DC power connection.

7. Connect the power cord to a wall outlet and to the fan. Turn on the power switch. The Mains Power status light turns green, indicating power is connected. Before connecting the Control Cable, the manual speed control knob can be used to test run the fan. If the Control Cable is connected it must be disconnected to use the Manual Speed Control Knob. The Manual Speed Control Knob must be turned to zero and back on again to re-activate it.



Figure 19: Model 200 Fan Top with power cord, color-coded tubing connections (green and yellow) and Control Cable.

8. Connect the Control Cable to the fan, unless you wish to use the Manual Speed Control Knob. When the Control Status light is illuminated solid green, this means the fan is connected to the gauge and is ready to perform automated testing. Having the Speed Control Cable connected disables the manual Speed Control Knob. To enable the manual Speed Control Knob, disconnect the yellow Speed Control Cable and turn the knob on, off and on again.
9. Connect the yellow and green tubes on the fan.
10. Insert the blue tube into the duct system, typically through a supply register closest to the air handler or into the supply plenum itself. Attaching a Static Pressure Probe to the blue tube is mandatory when connecting to the plenum to avoid the effects of the moving air (velocities) to be found there. While not necessary when connecting to registers since there is almost no velocity there, it makes a handy method to pierce the tape and hold the blue tube in place.



Figure 20: Insert the blue tube into a supply register closest to the air handler

11. If the rechargeable batteries in the DM-2 are below one quarter power, the battery charger should be connected to the "DC Power" port on the DM-2. Charge them fully overnight.
12. To test control of the fan, press **[Set Speed] [20] [Enter]** on the DM-2. This sets the fan to 20% speed. The preferred method is using **[Set Pressure] [25] [Enter]**. (Some standards require 50 Pa).
13. Press **[Exit]** to stop the fan.

### 3.7 Blue Tube location matters when testing leaky ducts

When measuring extremely leaky duct systems (where the leakage is over 500 CFM), the location of the test measurement point has a significant influence on the measured results because the test pressure induced in the duct system will vary throughout the system.

The highest leakage results will likely be measured when the blue tube is put into the supply register that is furthest from the air handler. Conversely, putting the blue tube into the main supply trunk line, or supply plenum, will measure lower leakage results. Measuring with the blue tube at the return ducting, where the DucTester is normally attached, will show the lowest possible leakage results.



Figure 21: A Static Pressure Probe attached to a pressure tube allows the measurement of pressure without flow interference (e.g: inside a supply register)

Some programs require test results from two test measurement locations. The two results are averaged, which helps eliminate error due to the location of the test measurement point.

In duct systems that are relatively tight (200 CFM or less), the induced test pressure in the system is more uniform, and all locations will provide similar results. Essentially, if a duct system passes an energy code requirement of 100 CFM or less, the test point location will not affect results in any significant way.

New home testing is typically done using the register closest to the supply plenum which is just fine most of the time. If the system is too leaky to pass, try placing the blue tube in the return plenum; if the reading is about the same, the leaks are in the return, if the leaks are a lot less, they are in the supply.

If you have a Blower Door and a pressure pan, pressurize the house to 50 Pascals and then take pressure readings on the pressure pan, with the pressure pan closing off one register at a time. The leakiest ducts will be found behind those registers with the highest pressures.

### **3.8 Connect the DucTester to the Duct System**

The DucTester has a 10 inch by 12 foot Flex Duct with a Flange on one end which is normally connected to a return grill, but which can also be connected to the air handler cabinet. When considering where to connect the DucTester to the duct system, it is important to think about airflow restriction and accessibility.

#### **3.8.1. Connect the Flex Duct to return register**

For most duct tests, the DucTester should be connected to the central return (if there is one) or to the air handler cabinet itself. If there are multiple returns in a duct system, the return duct work is typically smaller in size and can cause restrictions in airflow that can create backpressures and contribute to poor and inaccurate test results. If the air handler is in a difficult location for access (i.e., in the attic or crawl space), find the closest, largest return grill to the air handler and use that.

1. Choose the main return with the most direct connection to the air handler. Remove filters behind the return grill.
2. Attach the Flange to the return grill using Grill Mask or high quality masking tape. Seal the remaining openings with Grill Mask.
3. Attach the open end of the Flex Duct to the Flange (which is attached to the return grill); use the Velcro strap to secure it to the Flange.
4. Place the DucTester in such a position as to minimize any major bends in the Flex Duct.



**Figure 23: Flange taped onto a return register before attaching the Flex Duct**



**Figure 22: Flex Duct connected to the Flange.**

### 3.8.2. OR Connect the Flex Duct to the air handler cabinet

Alternatively, connect a Flex Duct to the air-handler cabinet. Normally this will give the same results as connecting to a return. In cases where there is no return ducting installed, or where leaks in the return system are excessive, connecting to the air-handler might be the only option to measure the supply section of the ducts.

1. Cut a piece of cardboard the same size as the access panel to the blower compartment of the air handler unit. Cut a hole in the middle of the piece of cardboard that is slightly smaller than the square Flange.
2. Put the cardboard piece with the attached Flange onto the opening of the blower compartment access. Tape the cardboard in place and seal all four sides of the cardboard panel.
3. Attach the Flex Duct to the Flange and secure it with the Velcro strap. Ensure that the DucTester has been placed in such a position as to minimize any major bends in the Flex Duct.
4. Select a location to measure the test pressure that is induced by the DucTester. This induced pressure will be measured on Channel A of the gauge.



**Figure 24: Preparing to connect to ducts via air handler**

### 3.8.3. OR Connect the Flex Duct to a ceiling level return using a Flow Hood

The optional Flow Hood is a faster way to connect to a ceiling register. Here the system is being pressurized from a ceiling level return. It is a Pressure Pan with a hole in it, pre-cut to fit the Flex Duct and a Flange. The blue tube goes into the supply register closest to the air handler just as before.

When pressing the Flow Hood over the ceiling register, precautions must be taken to prevent the black rubber weather-strip from marking light colored walls. Either cover the rubber with clear tape, or avoid scraping over the painted surface.

Before the registers are covered, and while the air handler is running, the system's air handler flow rate can also be measured up to the capacity of the DucTester. For detailed instructions on how to use a powered Flow Hood to measure system air handler flow, refer to section 9.3.

Higher air flow rates can also be measured when connected to the air handler itself because then the exclusive @Pressure feature on the Retrotec gauge can be used to establish an exact flow rate at any required pressure.



## 3.9 Prepare the Duct System for a test

Preparing for a duct leakage test requires preparing both the duct system and the building. The following setup procedures are recommended by Retrotec. If the test is being conducted according to a specific program guideline, you may be required to set up the duct system and building differently than what is described below.

### 3.9.1. Before beginning the duct leakage test

1. Adjust the HVAC system controls to ensure that the air handler does not turn on during the test.
2. Remove all filters inside the ductwork including any filter that is behind the return grill (that the DucTester will be connected to).
3. Seal off all remaining supply and return registers using Grill Mask. A roll is provided with all DucTester systems.



**Figure 27: Turn off the air handler**



**Figure 25: Seal all supply and return registers with Grill Mask**



**Figure 26: Remove all air filters**

While it would be ideal to seal between the register and the wall using Grill Mask, caution must be used to prevent pulling paint off the wall.

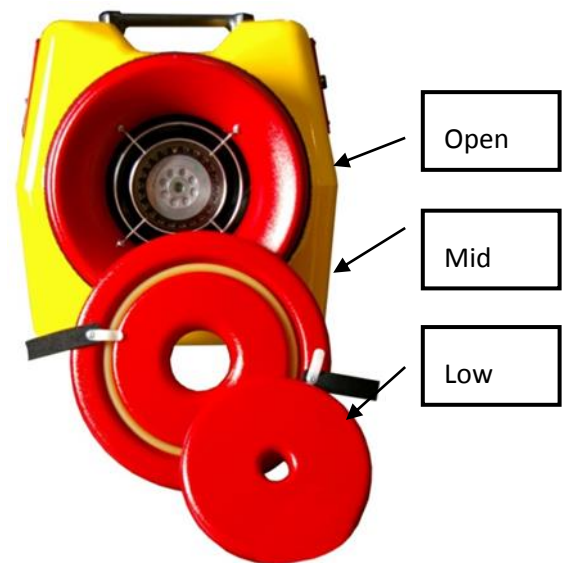
4. Seal combustion air and ventilation inlets directly connected to the duct system. This can be done by sealing the opening on the outside of the building, but can also be done by removing the inlet from the duct work and taping off the opening.
5. Turn off all exhaust fans, dryers, and room conditioners.
6. Turn off vented combustion appliances, if there is a possibility that the area containing the appliance will become depressurized during the testing procedure.
7. Open all interior doors leading to rooms containing a supply or return register (and open an exterior door or window for a Total Duct Leakage test – see section 5.1). When ducts run through an unconditioned space, that space must also be opened to the outdoors, to relieve any pressure that may build up in that space during the test.

### 3.10 Install Range Ring on fan

Each Retrotec DucTester includes three Range Configurations to maximize accuracy and versatility: Low, Mid, and Open. The selected Range Configuration will determine the range of air flow that the DucTester can measure. While it is easy to change the Range Configuration when pressurizing, it is better to make your best guess at the correct Range Configuration when testing in the depressurization direction since the Flex Duct must be removed to change Range Configurations. Do NOT try to forcefully attach the Range Rings to the exhaust; they must always go on the inlet of the fan, where the Velcro holds them in place.

Remove a Range Ring for leakier ducts or add a Range Ring for tighter ducts. Testing should always be done at the highest possible fan speed, which means using the most restrictive Range Configuration possible (the one with the smallest hole possible). Higher fan speeds lead to the highest degree of accuracy. If the fan is running too slowly “TOO LOW” or “-----” will appear on the gauge display indicating you must change to a more restrictive range.

Generally, the “Mid” range will work for most duct systems.



**Figure 28: Range Plates for the Model 200.**

### 3.11 Select a test direction

Duct leakage can be measured by blowing air into the ducts to pressurize the ducts, or by pulling air out of the ducts to depressurize the ducts. Program guidelines may specify a particular test direction. Both test directions provide similar results, however depressurization testing is faster and more consistent because the negative pressure will pull the Grill Mask (or other sealing means) onto the registers ensuring a tighter seal. In the absence of any other requirement, Retrotec recommends depressurization. Some standards require pressurization.

#### 3.11.1. Setting up for depressurization

1. Install the “Mid” Range Ring, since most systems can be tested on this Range Configuration. For more information about selecting and changing Range Configurations, refer to section 3.10.
2. Install the Flex Duct over the fan inlet, covering the Range Rings and tighten the strap.



Figure 29: Install Flex Duct over the fan inlet, covering the Range Rings, for depressurization.

#### 3.11.2. Setting up for pressurization

The only advantage of pressurizing is that it makes changing Range Rings on the fan easier. If a pressurization test is needed, simply install the Flex Duct on the outlet side of the fan.



Figure 30: Install Flex Duct over the fan exhaust, for pressurization.

## 4. Set up the gauge to display Duct Leakage Results

Read the Total Duct Leakage results directly from the gauge. On the DM-2 this is the results display "Mode". In order to compare duct systems in different homes/buildings, it is necessary to normalize the leakage results for the size of the HVAC system and the size of the building. The two most common variables used to normalize duct leakage are total HVAC flow rate and the floor area of the building.

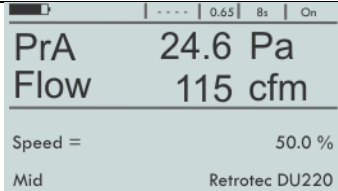
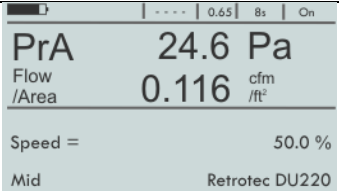
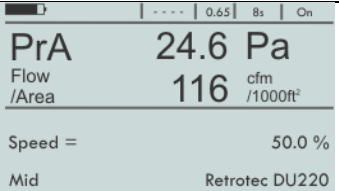
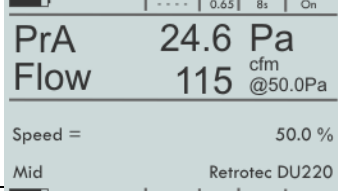
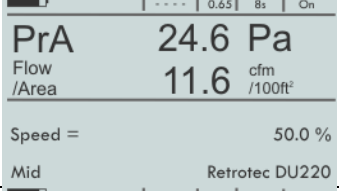
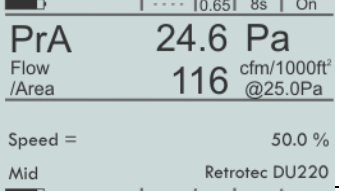
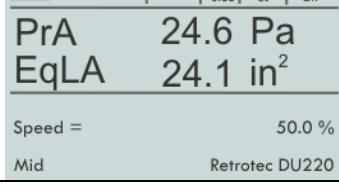
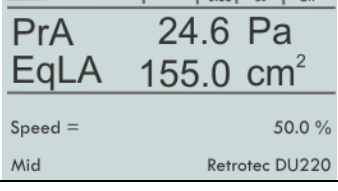
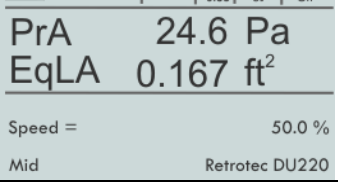
		
		
		

Figure 31: Some of the most common results that can be read directly off the gauge.

### 4.1 Mode setup for duct testing in the US

Table 3 shows what settings will directly calculate the results required for testing compliance with the codes adopted in the various states.

Table 3: Gauge Mode Setup for US state Codes and programs for Duct Testing

Code	2009 IECC	ENERGY STAR	Northwest ENERGY STAR Homes	Title-24 Code	WA State Code
Region:	VT GA CT DE GA ID IL IO MA NC NH NJ NY OH TX MD	USA	ID MO OR WA	CA	WA
Pressure	Pa	Pa	Pa	Pa	Pa
Flow	CFM	CFM	CFM	CFM	CFM
(Flow) @ Pressure	@25 Pa	@25 Pa	@50 Pa	@25 Pa	@25 Pa
EqLA	Off	Off	Off	Off	Off
(EqLA) @ Pressure	n/a	n/a	n/a	n/a	n/a
EfLA, Effective Leakage Area	Off	Off	Off	Off	Off

<b>(EflA) @ Pressure</b>	n/a	n/a	n/a	n/a	n/a
<b>Air Changes</b>	Off	Off	Off	Off	Off
<b>(Air Changes) @ Pressure</b>	n/a	n/a	n/a	n/a	n/a
<b>Flow per Area of Conditioned floor area</b>	CFM/100 ft <sup>2</sup>	CFM/100 ft <sup>2</sup>	CFM/ft <sup>2</sup>	Off	CFM/100 ft <sup>2</sup>
<b>(Flow per Area) @ Pressure</b>	@25 Pa	@25 Pa	@50 Pa	Off	@25 Pa
<b>EqLA per Area</b>	Off	Off	Off	Off	Off
<b>(EqLA per Area) @ Pressure</b>	n/a	n/a	n/a	n/a	n/a
<b>EfLA per Area</b>	Off	Off	Off	Off	Off
<b>(EfLA per Area) @ Pressure</b>	n/a	n/a	n/a	n/a	n/a

Grey areas in the table indicate those results are not needed for those programs but can be turned on or off any time they may be needed. The “@ Pressure” value for Flow measurement is set at the value required for duct testing.

## 4.2 Mode Setup for various standards around the world

Table 4: Gauge Mode Setup for various standards around the world

<b>Standard:</b>			
<b>Region:</b>	<b>France Res</b>	<b>France Apt</b>	<b>France Comm</b>
<b>Pressure</b>	Pa	Pa	Pa
<b>Flow</b>	m <sup>3</sup> /hr	m <sup>3</sup> /hr	m <sup>3</sup> /hr
<b>(Flow) @ Pressure</b>	80 Pa	160 Pa	240 Pa
<b>EqLA</b>	Off	Off	Off
<b>(EqLA) @ Pressure</b>	Off	Off	Off
<b>EfLA, Effective Leakage Area</b>	Off	Off	Off
<b>(EfLA) @ Pressure</b>	Off	Off	Off
<b>Air Changes</b>	Off	Off	Off
<b>(Air Changes) @ Pressure</b>	Off	Off	Off
<b>Flow per Area</b>	Off	Off	Off

(Flow per Area) @ Pressure	Off	Off	Off
EqLA per Area	Off	Off	Off
(EqLA per Area) @ Pressure	Off	Off	Off
EfLA per Area	Off	Off	Off
(EfLA per Area) @ Pressure	Off	Off	Off

### 4.3 Setting up the DM32 gauge for Duct Testing

When the 200 fan is used for Duct testing, it is called the 240 on the DM32. Be sure to choose this Device so that the correct n value will be used to calculate the @ pressure, and the correct fan flow coefficients will be used to calculate flow.

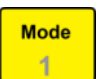
### 4.4 Setting up and using the DM-2 gauge for Duct testing

1. Set up the gauge to show the results you require

Press **[Mode]** to cycle through available results. Typically, choose between Flow, and Flow/Area.

Units for flow are typically CFM, and units for Flow/Area are typically CFM/ft<sup>2</sup>, CFM/100 ft<sup>2</sup>, or CFM/1000 ft<sup>2</sup>.

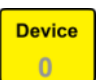
If a desired results mode such as Flow/Area does not appear as a choice, press **[Setup]**, scroll to "Mode Setup", press **[Enter]**, scroll down to "Flow/Area", and choose the desired units by pressing **[▶]** or **[◀]**. When required units are displayed, Press **[Exit]** twice, and the Flow/Area in the chosen units will be one of the choices when the **[Mode]** key is pressed.



2. Set up the gauge to show only the fans and ranges you need, and set the ones currently in use

Press **[Device]** to get "Retrotec DU220". Devices can be disabled or enabled by pressing **[Setup]** and going into the "Device Setup" menu

Press **[Range Config]** to get "Mid". If Range Ring installed on fan is not Mid-Range, adjust the setting on the gauge to match what is installed. Range Configurations can be disabled or enabled by pressing **[Setup]**, going into the "Device Setup" menu, and selecting individual Devices and the choosing from the available Range Configurations.



3. Set up the gauge for proper time averaging and ensure that it will be Auto Zeroed.

Press **[Time Avg]** to get "4s", or go to 8 seconds if it's fluctuating.

Press **[Auto Zero]** to get "On".



Use [Set Pressure] on gauge. Press **[Set Pressure] [25] [Enter]**. The fan will automatically accelerate and maintain a pressure of 25 Pa in the duct system. Press **[@ Pressure]** until “@ 25 Pa” is displayed to view the result at exactly 25 Pa. If your standard requires 50 Pa, substitute 50 for 25.

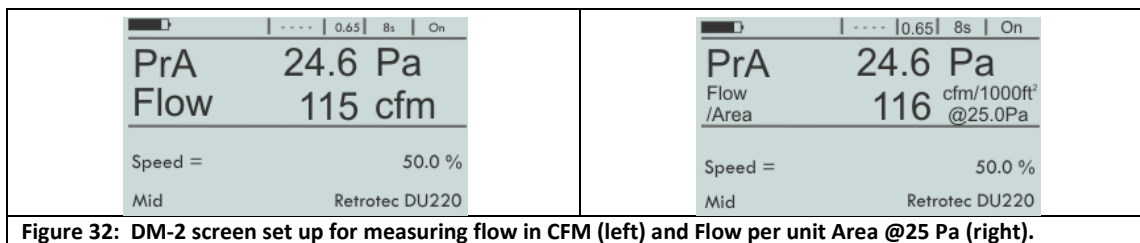
OR

Use [Set Speed] on gauge. Press **[Set Speed] [50] [Enter]** to set the fan speed to 50%. Press **[Jog/Hold]** until "Jog" appears. Use **[▲]** or **[▼]** to adjust the speed until “Pr A” displays close to 25 Pa. Press **[@ Pressure]** until “@ 25 Pa” is displayed to view the result estimated at exactly 25 Pa. If your standard requires 50 Pa, substitute 50 for 25.

OR

Use the manual Speed Control Knob on the Fan Top. Increase the fan speed until a stable pressure of 25 Pa (or -25 Pa) is displayed on “Pr A”. Press **[@ Pressure]** to display the results is displayed at the “Mode” at exactly 25 Pa. If your standard requires 50 Pa, substitute 50 for 25.

5. If "TOO LOW" appears as the flow result, or the desired test pressure cannot be reached, change the Range Configuration on the fan and on the gauge to match (see section 3.10).



## 5. Conduct the Duct Leakage tests

### 5.1 Total Duct Leakage

A Total Duct Leakage test measures the total amount of air leakage from a duct system. This includes leaks to both conditioned spaces, and leaks to unconditioned spaces. Total Duct Leakage is thus the sum of duct-to-outdoor and duct-to-house leaks. The procedure described in Section 3.5 gets you through the Total Duct Leakage test, using either pressurization or depressurization. Note that an Exterior door or window must be open in order to ensure that the pressure inside the building is the same as the pressure outdoors. The unconditioned space must also be vented (open a window or door from that space if possible, or ensure there are open roof/crawl space vents).

Pressurization and depressurization tests have the same tubing configurations, shown in Figure 33 for Total Duct Leakage under depressurization and Figure 34 for Total Duct Leakage under pressurization. The only difference between the two tests is that for a Depressurization test, the Flex Duct is connected to the Fan inlet, over top of the Range Rings. The tubing setup is the same for both tests, as illustrated in the figures, except the Flex Duct is connected to one side or the other of the fan.

Depressurization tests work better since the seal over the register is improved by the negative pressure in the ducts – the negative pressure sucks the seal tight to the register, whereas under duct Pressurization, the positive pressure in the ducts tends to push the seals off the registers.

The test diagrams display testing at 25 Pa. For results at 50 Pa, substitute “50” wherever “25” appears.

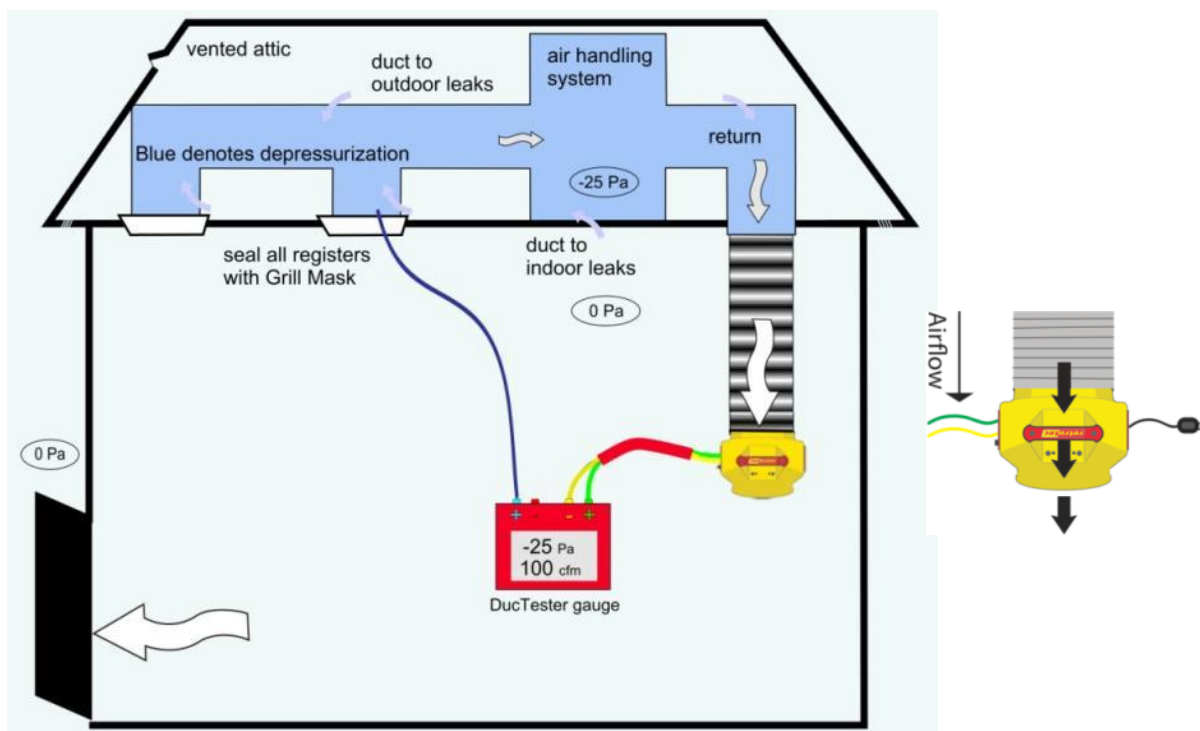


Figure 33: Total Duct Leakage under depressurization - DucTester and tubing setup.

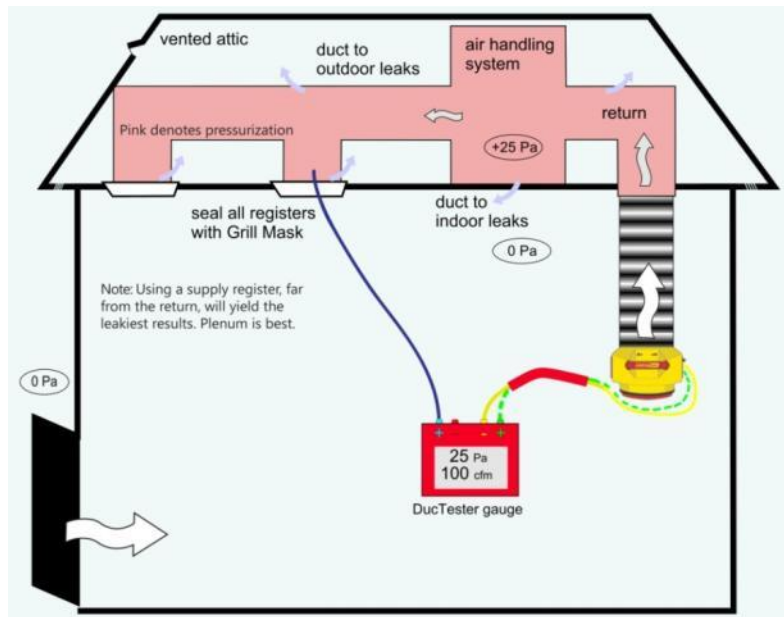


Figure 34: Total Duct Leakage under pressurization - DucTester and tubing setup.

## 5.2 Duct Leakage to Outdoors with 2 gauges and 2 fans

A Duct Leakage to Outdoors Test neutralizes the duct leakage to the house (or conditioned spaces) by pressurizing the house to the same pressure as the ducts. The measured duct leakage thus only reflects the leaks to outdoors.

If a green, self-referencing, pressure port is available on the Blower Door fan, use the green pressure tube to connect it to the Blower Door gauge, and ensure the Device chosen on the gauge is "Retrotec 3000SR".

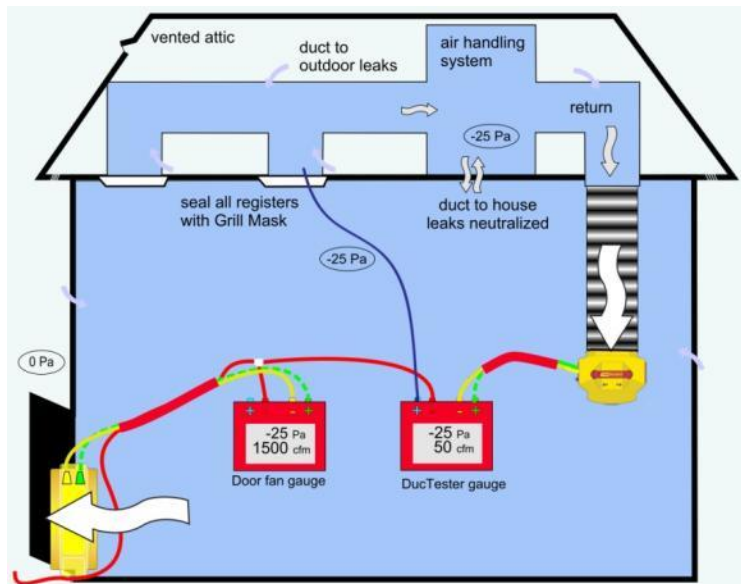
### 5.2.1. Method #1: Set both duct and house to -25 Pa (or 25 Pa)

Method 1 allows the [**@Pressure**] extrapolation function to be used, increasing accuracy and allowing the test to be carried out with a single setting for the DucTester and Blower Door gauge. No changes need to be made on the DucTester gauge from the Total Duct Leakage Test, which is convenient if you have to carry out both tests.

1. Complete the previous Total Duct Leakage test.
2. Ensure all doors and windows are closed and exhaust fans are still off (except any doors/windows required to vent the unconditioned space).
3. Connect the Blower Door as displayed in Figure 36 (depressurization) or Figure 37 (pressurization).
4. Connect the red ports together with one red tube, and run the end outdoors as shown in Figure 36. This makes the duct and house pressure measurements use the same reference (outdoors).
5. Set the DucTester to 25 Pa (or -25 Pa) by pressing [**Set Pressure**] [**25**] [**Enter**] on the DucTester gauge.
6. Repeat step 5 on the Blower Door gauge.



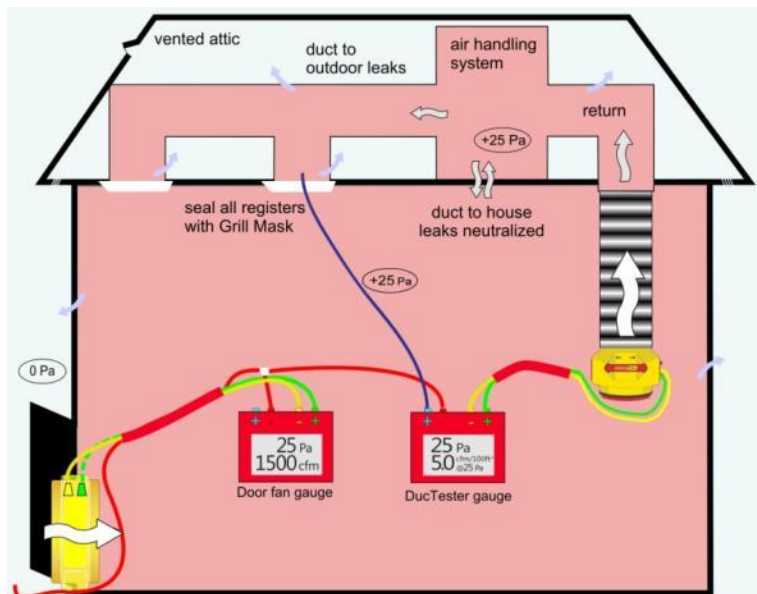
Figure 35: Connecting the red tubes of 2 gauges together with a T-connector



**Figure 36: Method #1 Duct Leakage to Outdoors, under depressurization**

7. If the Blower Door pressure reading fluctuates more than 2 Pa, press **[Time Avg]** and increase the time averaging to reduce it. If still above 2 Pa, use the Baseline feature as outlined in the *DM-2 QuickGuide* or *DM-2 Operations Manual*.
8. Press **[@ Pressure]** on the DucTester gauge to display the duct leakage result "@25Pa".
9. Record "Flow" on the DucTester gauge which represents Duct Leakage to Outdoors

If your test requires 50 Pa, substitute 50 for 25 in all instructions.



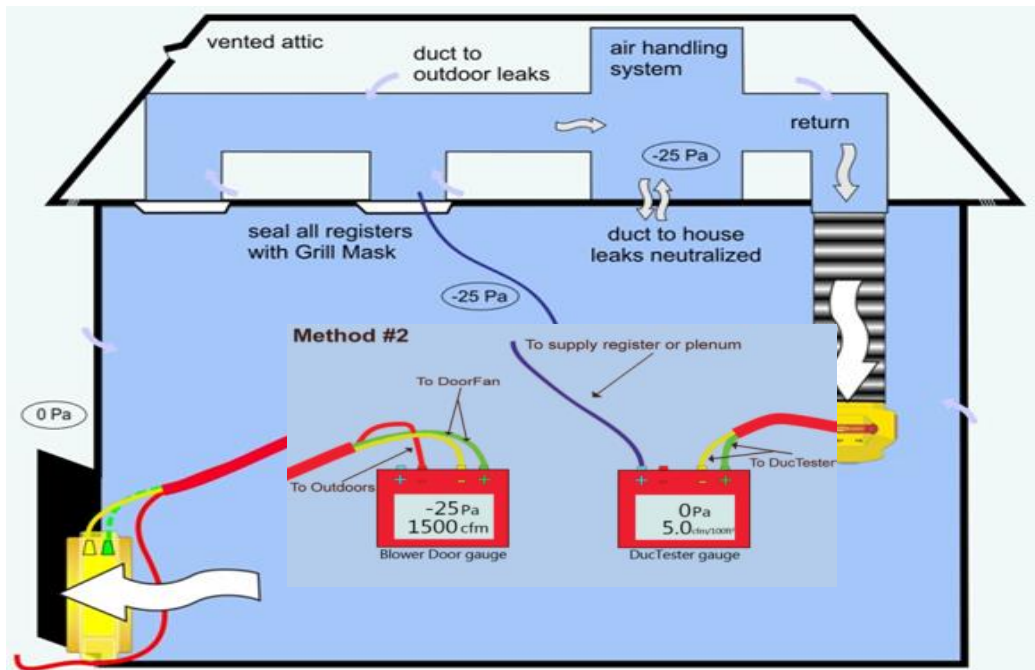
**Figure 37: Method #1 Duct Leakage to Outdoors, under pressurization**

### **5.2.2. Method #2: Set duct to house pressure to 0 Pa (using DucTester gauge)**

Method 2 does not require connecting a red tube from the DucTester gauge to outdoors, but will result in huge errors if **[@ Pressure]** is turned on. If your standard requires 50 Pa, substitute 50 for 25 in all instructions.

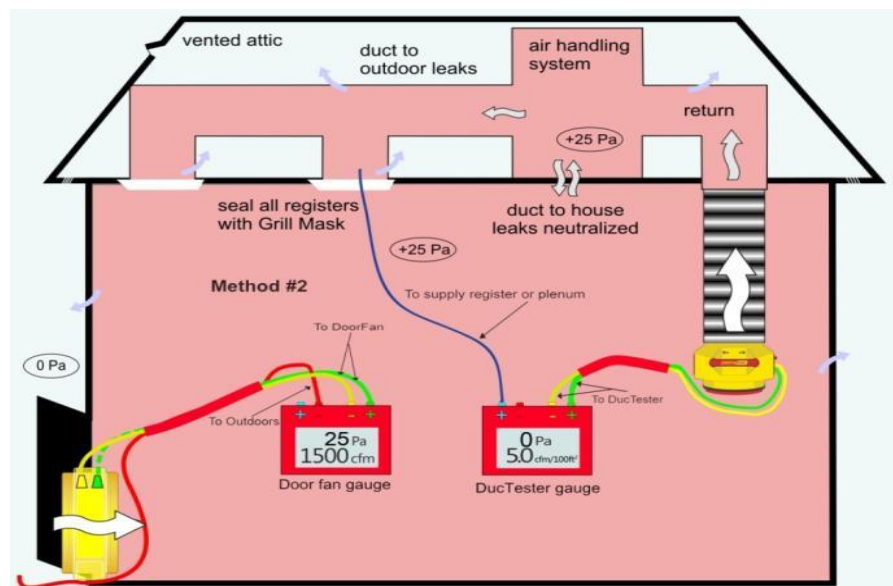
1. Complete the previous Total Duct Leakage test.
2. Ensure all doors and windows are still closed and exhaust fans are still off.
3. Connect the Blower Door per diagram in Figure 38 (depressurization) or Figure 39 (pressurization).

4. With DucTester fan off, set the Blower Door to 25 Pa by pressing **[Set Pressure] [25] [Enter]** on the Blower Door gauge.



**Figure 38: Method #2: Duct Leakage to Outdoors, under depressurization**

5. Press **[@ Pressure]** if required to remove “@” from the display on the DucTester gauge.
6. Set the DucTester to 0 Pa by pressing **[Set Pressure] [0] [Enter]** on DucTester gauge.
7. When 0 Pa +/- 1 is achieved on the DucTester gauge, record “Flow” from the DucTester gauge, which is Duct Leakage to Outdoors.



**Figure 39: Method #2 Duct Leakage to Outdoors, under pressurization**

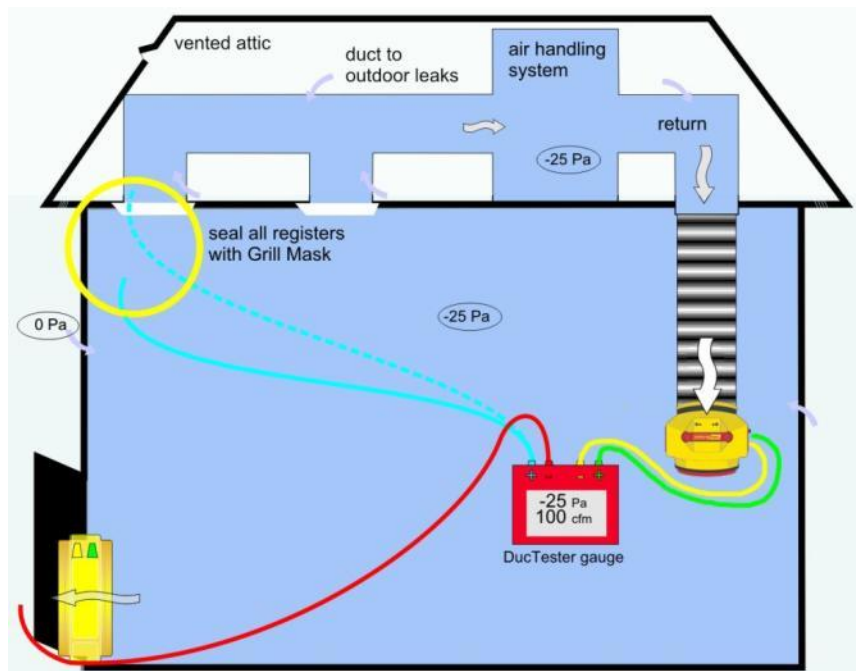
### 5.3 Duct Leakage to Outdoors with 1 gauge and 2 fans

Duct Leakage to Outdoors may be measured using only one gauge to alternatively measure the house to outdoor pressure then the duct to outdoor pressure, until the house and ducts are at the same pressure

with respect to the outdoors. The method requires connecting and disconnecting the blue tube, alternately measuring the house and duct pressure and adjusting the fans separately until the house and ducts are at the same pressure.

When the house and ducts are at the same pressure, “Flow” on the DucTester gauge displays the result for Duct Leakage to Outdoors.

For depressurization, set the Blower Door to pull air out of the building and the DucTester to pull air out of the duct system. If your standard requires 50 Pa, substitute 50 for 25.



**Figure 40: 1 Gauge Duct Leakage to Outdoors under depressurization, setting the building pressure**

1. Ensure that the Device is DU200 and the correct DucTester Range is selected on the gauge.
2. Close all doors and windows and shut off any exhaust fans in the building.
3. Connect the blue tube from the duct register to the gauge, run the red tube from the gauge to the outdoors, and run the yellow and green tubes to the DucTester.
4. Manually adjust the DucTester speed (with the Speed Control Knob on the DucTester) to reach -25 Pa in the ducts. Wait 60 seconds.
5. With the DucTester still running, disconnect the blue tube from the gauge so the blue port on the gauge is open to the house.
6. Manually adjust the Blower Door speed (with the Speed Control Knob on the Blower Door fan) to change the building pressure until -25 Pa appears on “PrA” of the gauge.
7. With the Blower Door still running, connect the blue tube to the gauge and re-adjust the DucTester speed to again set the duct pressure to -25 Pa.
8. Record duct leakage, “Flow” on the gauge, when you’re confident the building and duct pressures have both been stabilized at -25Pa.

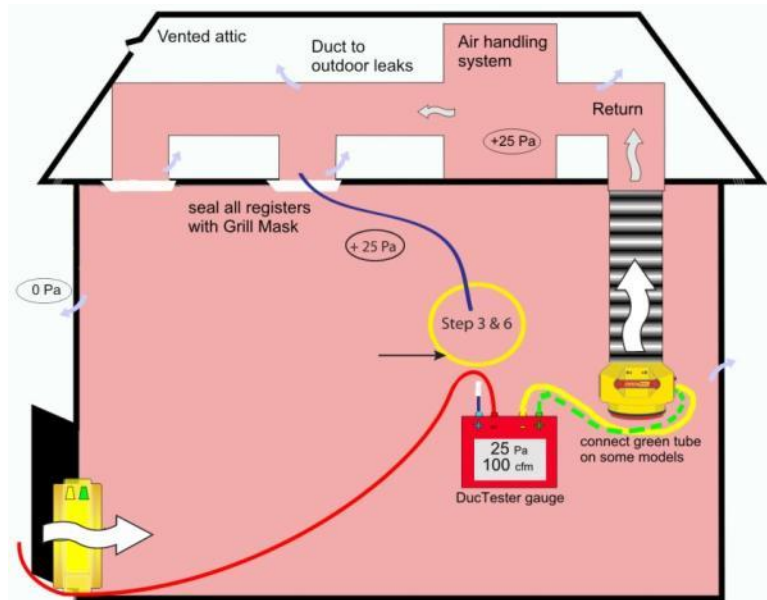


**Figure 41: 1 Gauge Duct Leakage to Outdoors under depressurization, setting the duct pressure**



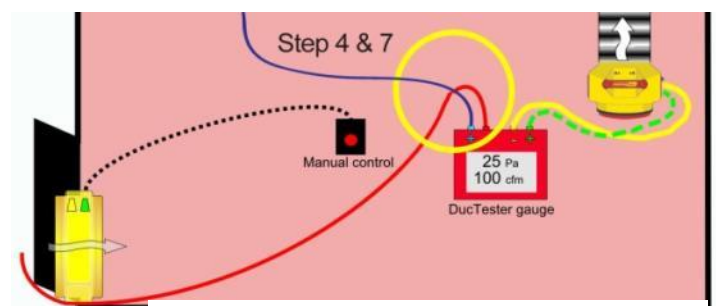
**Figure 42: Disconnecting and re-connecting the blue pressure tube is easier using a male-to-male connector**

For pressurization, set the Blower Door to blow into the building and the DucTester to blow into the duct system. If your standard requires 50 Pa, substitute 50 for 25.



**Figure 43: 1 Gauge Duct Leakage to Outdoors under pressurization, setting the building pressure**

1. Ensure that the Device is DU200 and the correct DucTester Range is selected on the gauge.
2. Close all doors and windows and shut off any exhaust fans in the building.
3. Keep the blue port on the gauge open to the house, run the red tube from the gauge to the outdoors, and run the yellow and green tubes to the DucTester. Manually adjust the Blower Door speed (with the Speed Control Knob on the Blower Door fan) to change the building pressure until 25 Pa appears on "PrA" of the gauge.
4. Connect the blue tube from the duct register to the gauge.
5. Manually adjust the DucTester speed (with the Speed Control Knob on the DucTester) to reach 25 Pa in the ducts. Wait 60 seconds.
6. With the DucTester still running, disconnect the blue tube from the gauge and re-adjust the Blower Door speed to again set the building pressure to 25 Pa.
7. Connect the blue tube to the gauge and re-adjust the DucTester fan speed to achieve 25 Pa.
8. Record duct leakage, "Flow" on the gauge, when you're confident the building and duct pressures have both been stabilized at 25Pa.

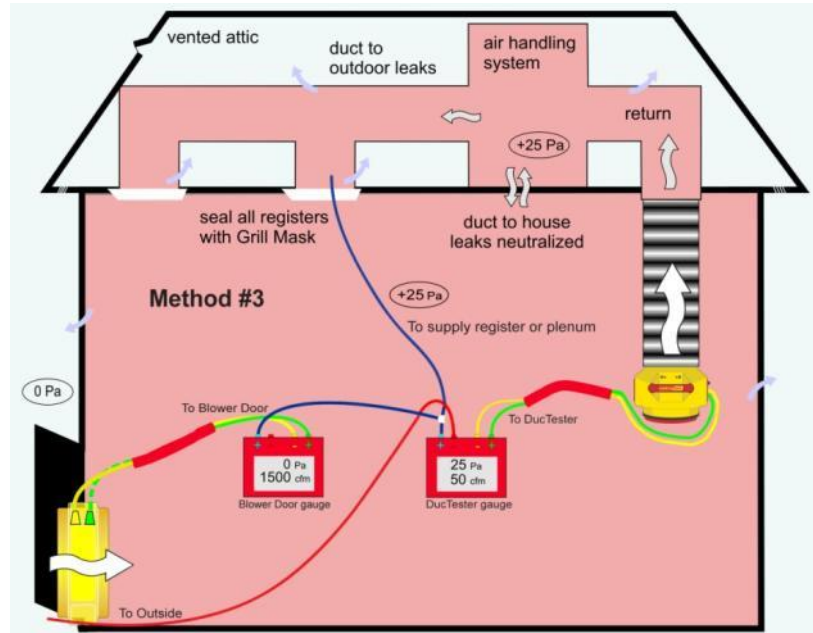


**Figure 44: 1 Gauge Duct Leakage to Outdoors under pressurization, setting the duct pressure**

#### 5.4 Combined Total Duct Leakage and Duct Leakage to Outdoors Method

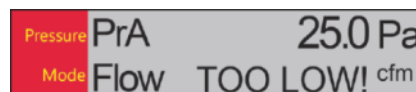
This combined method measures both Total Duct Leakage and Duct Leakage to the Outdoors with 2 fans and 2 gauges by setting the duct to house pressure to 0 Pa using the Blower Door gauge. This method is good for repeat testing because both measurements can be made with no changes to the gauge or the tubing between tests. Another advantage is that the **[@ Pressure]** function can still be used. Because you pressurize the house first, there will not be the usual problem with blowing seals off registers when the ducts are pressurized. If your standard requires 50 Pa, substitute 50 for 25.

1. Close all exterior doors and windows and shut off exhaust fans.
2. Connect the Blower Door and DucTester as shown in Figure 45.
3. To measure Total Duct Leakage
4. Press **[Set Pressure] [25] [Enter]** on the DucTester gauge.
5. Press **[@ Pressure]** to display the duct leakage result "@25Pa" on the DucTester gauge.
6. To measure Duct Leakage to Outdoors,
7. Turn off "@25Pa" on the Blower Door gauge by pressing **[@ Pressure]**.
8. Set the Blower Door gauge to 0 Pa by pressing **[Set Pressure] [0] [Enter]** on the Blower Door gauge.
9. When 0 Pa +/- 1 is achieved on the Blower Door gauge, record the result from "Flow" on the DucTester gauge which is Duct Leakage to Outdoors.



**Figure 45: Combined Total Duct Leakage and Duct Leakage to Outdoors Method, under pressurization**

### 5.5 If no Results are displayed (TOO LOW or ---)



If the target pressure has been reached, but “TOO LOW” or “---” appears as a flow reading, the fan is running too slowly to measure flow. Perform the following to get a duct leakage result:

1. Add the next smaller Range Ring.
2. Change **[Range Config]** on the gauge to match the Range Ring installed on the fan.

3. Re-adjust DucTester fan speed.

If the Range Ring installed is “Low”, (the one with the smallest hole), there are no more Range Rings to install, and “TOO LOW” or “---” still appears:

1. Make sure “Range Config” on the gauge is “Low” to match the installed Range Ring.
2. Check that the blue tube is connected to the gauge and then check that it is reading pressure – put a finger on the open end of the blue tube and ensure that the “PrA” reading changes. If it does not, then the tube is blocked or pinched.
3. Check that there is no blockage in the ducts between the DucTester and the register containing the blue tube. To do this, move the blue tube to a different register and compare the reading on “PrA” to the original reading. If the pressures in the two locations are not similar, there may be blockage in the duct system that needs to be removed.
4. Check that the DucTester is actually reading properly on Channel B. To do this, open up a taped register to provide enough leakage to get a reading, and then increase the pressure to 25 Pa or 50 Pa on “PrA”. If the flow still reads “TOO LOW” then the yellow or green tubes could be blocked or disconnected.

If you are sure that the blue tube is reading pressure, there is no blockage in the ducts or tubes, and that the DucTester is actually reading flow, and “TOO LOW” or “---” still appears, the ducts must be extremely tight; less than 7 CFM. To get a rough result, cover half the inlet ring with tape which will quadruple the fan pressure signal. Read the CFM, but divide the answer by two (since half the hole is open). If still reading “TOO LOW”, cover three quarters of the inlet with tape, read the CFM and divide the answer by four (since only one quarter of the hole is open).

Instead of doing the calculations, an alternative is to set the gauge “Mode” to “PrB”, (Pressure on Channel B), using the **[Mode]** key and look up the associated flow in Table 10 (for 25 Pa induced duct pressure) or Table 11 (for 50 Pa induced duct pressure).

## 5.6 Cannot achieve test pressure



If the DucTester fan reaches 100% speed on the “Mid” or “Low” Range Ring before reaching the target pressure, the fan is not providing enough air flow to reach the target pressure. Perform the following to reach the target pressure:

1. Remove a Range Ring.
2. Change **[Range Config]** on the gauge to match the fan.
3. Re-adjust DucTester fan speed.

If the no Range Ring installed (i.e., “Open” with no more Range Rings to remove), and the desired test pressure cannot be reached at maximum speed:

1. If the duct pressure is close to the required test pressure (within 5 Pa), use the **[@ Pressure]** key to extrapolate to what the flow would be at the desired pressure.
2. Try the Duct Leakage to Outdoors test, which will neutralize duct leakage to the house.
3. Look for large disconnects in the duct system by pressurizing the house with the Blower Door and putting smoke in front of the registers. Registers with high velocity smoke movement are a good indication of a potential disconnect behind that register. Fixing the disconnect in the ducts may reduce the leakage enough to continue testing the duct system.

## **6. Restore the house to pre-test conditions after testing is complete**

Notice the conditions in the building upon arrival and be sure to restore it to that condition before leaving.

### *Before leaving the house*

1. Remove all Grill Mask from registers.
14. Replace all filters from the return(s) and air handler.
15. Turn the furnace, air conditioning, HVAC system back on.
16. Ensure any combustible appliances that were turned off are turned back on, and that they are properly vented again.
17. Unseal any closed ventilation, or reconnect the ducts if it was disconnected.
18. Close any exterior doors or windows that were opened during total duct leakage test.

## 7. Create a Duct Leakage Test Report with Potential Energy Savings

The Retrotec *Duct Leakage Test Reporting* software was developed so users have a way to automatically create professional reports that display duct leakage results as well as potential energy savings. Reports serve as simple documentation of the results of your test and can be used to compare the results of a tested duct system with regulated code or voluntary energy efficiency program requirements (see section 3.4). These reports can be printed directly or saved and stored as a PDF file.

The latest version of the software can be downloaded from Retrotec's website. Microsoft Excel 2007 or higher must be installed on the computer to run the software. Click on one of the following links to download:

[For Excel 2007](#)

[For Excel 2010 or higher](#)

The image shows a screenshot of the Retrotec Duct Leakage Test Reporting software interface. The interface is divided into two main sections: the input form on the left and the generated report on the right.

**Input Form (Left):**

- Instructions:** 1. Macros must be enabled. 2. Fill out the green cells only. 3. To save the Duct Leakage Test Report as a PDF file, click "Save As" → "PDF or XPS" → "Publish".
- Inputs:** Includes fields for Client (John Smith's House), Tester (Duct Testing Company), Equipment (Retrotec DU200), and Test data (Conditioned Floor Area: 300.0 sq ft, Air Handler Flow: 1250 CFM, Leakage Exponent: 0.60).
- Test data:** Includes fields for Duct Pressure (-25.2 Pa), Fan Pressure (597.0 Pa), and Flow (188 CFM).
- Cost of Duct Leakage:** Includes fields for % of Duct Leakage to Outdoors (80%), Annual Cooling Cost (\$1,199), and Annual Heating Cost (\$1,200).

**Report (Right):**

**retrotec** Test Date: 2012-05-29

**Duct Leakage Test Report**

**Client:** John Smith's House  
Building Address: 12345 Broadway Street  
Address: 12345 Broadway Street  
City: Everson, WA 98427  
Contact: Deborah Smith  
Phone: (360) 123-4567

**Tester:** Duct Testing Company  
Company: Duct Testing Company  
Address: 12345 Main Street  
City: Everson, WA 98427  
Technician: Colin Genge  
Phone: (360) 738-9835

**Test Type:** Total Duct Leakage  
**Test Equipment:** Retrotec DU200

**Gauge S/N:** 203460  
**Fan S/N:** FN1002509

**Building and Duct Details**

Conditioned Floor Area	300.0 sq ft
Air Handler Flow	1250 CFM
Percentage of Duct Leakage to Outdoors	75% (estimated)

	Supply	Return
Average Duct Operating Pressure	25.0 Pa	25.0 Pa
Leakage Split	50%	50%
Leakage Penalty	100%	50%

**Leakage Data**

Baseline Pressure	0.3 Pa
<b>Depressurization</b>	
Duct Test Pressure	-25.5 Pa
Fan Test Pressure	597.0 Pa
Range Configuration	Mid
Duct Leakage	188 CFM
Leakage Area	34.7 sq in
Leakage constant, C	26.99
Leakage Exponent	0.60 (assumed)

**Leakage Results**

Total Duct Leakage	188 CFM at 25 Pa
Duct Leakage as % of Air Handler Flow	15.1%
Duct Leakage to Outdoors (estimated)	141 CFM at 25 Pa
Leakage/Conditioned Floor Area	0.628 CFM/sq ft at 25 Pa
	62.8 CFM/100 sq ft at 25 Pa
	628 CFM/1,000 sq ft at 25 Pa

**Duct System Losses**

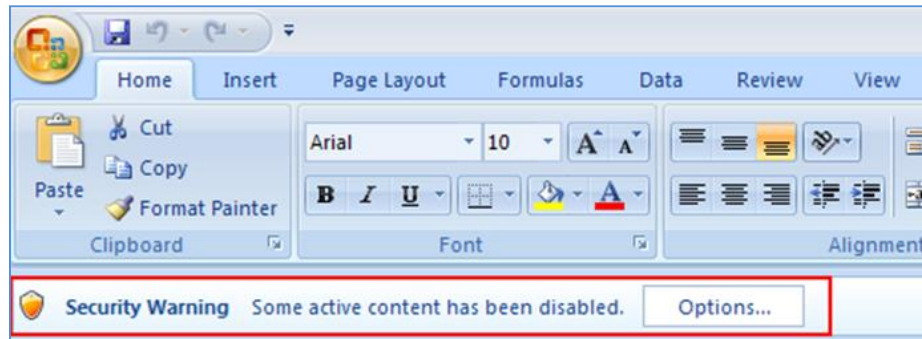
HVAC System Efficiency Loss	8.5%
Annual Cooling Loss	\$93
Annual Heating Loss	\$127

## 7.1 Get the Excel spreadsheet based software to run on your system

### 7.1.1. Enable Macros (with Office 2007)

For the software to run properly, macros must be enabled. To enable macros:

Click the "Options..." button (by the Security Warning, on the toolbar shown below)



Select "Enable this content"

Click "OK"

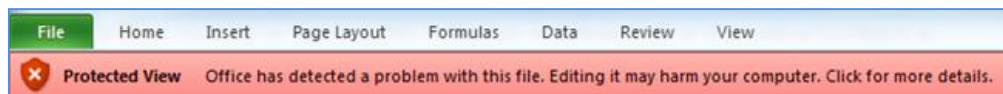
Occasionally, you may get this popup prompt when you open Excel:



In this case, click "Enable Macros" and you will not have to perform the procedure above.

### 7.1.2. Enable Macros (with Office 2010)

For the software to run properly, macros must be enabled. Before Office 2010 allows you to enable macros, depending on which version of the Duct Leakage Test Report software you have, there may be a warning you have to bypass, before enabling macros. You may see the following "Protected View" warning (red bar):



If so, click on it, and you will see the following Protected View option:



Click “Edit Anyway.” Now go back to the main screen and you will see the option to enable macros:



Click the “Enable Content” button.

### 7.1.3. Showing/Hiding the Ribbon

When Macros are enabled, the software automatically hides the MS Excel “Ribbon” since it is not used.

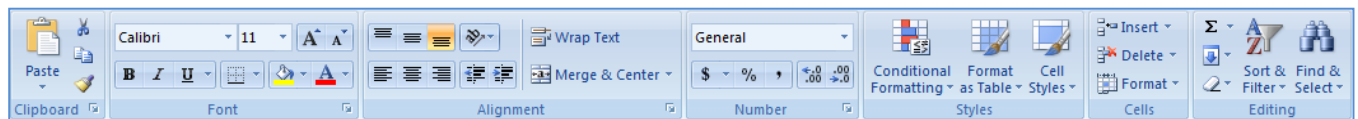


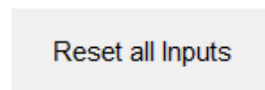
Figure 46: The MS Excel “Ribbon”

After closing the software however, the Ribbon remains hidden when a new Excel spreadsheet is opened. If it’s desired to have the Ribbon shown again, press Ctrl + F1 at any time. Pressing Ctrl + F1 again will hide the Ribbon.

### 7.1.4. Enter test information and results into green cells

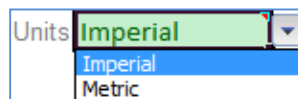
Only enter test data or details into the green cells.

To reset all inputs, click the “Reset all Inputs” button at any time:



## 7.2 Choose metric or imperial units for results

Use the dropdown menu to select the desired units for data entry and results.



### 7.2.1. Imperial units

“Flow” and “Duct Leakage”: cubic feet per minute, or CFM

“Conditioned Flow Area”: square feet, or sq ft

“Leakage Area”: square inches, or sq in

### 7.2.2. Metric units

“Flow” and “Duct Leakage”: cubic metres per hour, or m<sup>3</sup>/h

“Conditioned Flow Area”: square meters, or m<sup>2</sup>

“Leakage Area”: square centimeters, or cm<sup>2</sup>

### 7.3 Choose Duct Test type

Click to select the type of test you are performing: a Total Duct Leakage test or a Duct Leakage to Outdoors test.

Test type

☒ Total Duct Leakage

☐ Duct Leakage to Outdoors

The differences between a Total Duct Leakage test and a Duct Leakage to Outdoors test are described in section 3.1. For the setup of these tests, refer to the illustrations and descriptions in section 5.

### 7.4 Enter the Target test pressure

Use the dropdown menu to select the pressure at which the duct system was tested, and the pressure at which the results will be displayed.

Target test pressure 25 Pa

25 Pa

50 Pa

Codes or programs usually require this pressure to be 25 Pa, however it may be 50 Pa. See section 3.4 for these requirements.

**Leakage Results**

Total Duct Leakage **188 CFM at 25 Pa**

Duct Leakage as % of Air Handler Flow **15.1%**

Duct Leakage to Outdoors (estimated) **113 CFM at 25 Pa**

Leakage/Conditioned Floor Area **0.628 CFM/sq ft at 25 Pa**

**62.8 CFM/100 sq ft at 25 Pa**

**628 CFM/1,000 sq ft at 25 Pa**

### 7.5 Enter date the test was carried out

Enter the test date in the format of YYYY-MM-DD, where YYYY is the year displayed in four digits, MM is the month displayed in two digits, and DD is the day displayed in two digits.

Test Date 2012-05-29

### 7.6 Enter specific parameters for the conditions of this test

#### 7.6.1. Conditioned Floor Area

The Conditioned Floor Area is the area that is normally air-conditioned or heated (i.e., inside the building envelope). Even though supply ducts may not discharge directly into all these spaces, they are considered “conditioned” if their temperature follows indoor temperature closer than outdoor temperature. Likewise, if the area is not air-conditioned or heated, it is not considered to be part of the Conditioned Floor Area.

The area entered is used to calculate the result for “Flow/Area” that will be displayed on the report. The Duct Leakage Test Report calls this result the “Leakage/Conditioned Floor Area”.

#### 7.6.2. Air Handler Flow

This is the total air flow through the duct system provided by the system air handler.

Air Handler Flow 1250 CFM

This input is optional, and is only needed if you want the report to display the “Duct Leakage as a % of Air Handler Flow”.

Duct Leakage as % of Air Handler Flow 8.6%

If this value cannot be found under the Air Handler’s design specifications, it can be measured using methods described in section 9. It can also be calculated using the forms in Appendix F.

### 7.6.3. Leakage Exponent, n

The Leakage Exponent is the "n" value, as read from the top bar of the DM-2 gauge.



It is used to extrapolate results, if you cannot reach your Target test pressure (see section 5.6). This value is relative to how leaky the ducts are.

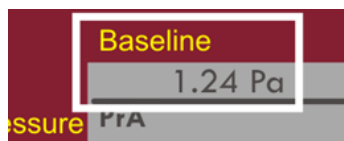
If you are unsure of which value to use, enter 0.60 (the default value), which is typical for most duct systems.

### 7.6.4. Baseline pressure

The Baseline pressure is the pressure between the enclosure and the outdoors due to stack, wind, and flues (with the DucTester fan turned off). Baseline pressure is also called “static pressure”, “bias pressure,” or “zero Fan Pressure difference”. These terms are used interchangeably with each other in documents/standards used in the industry.

It is optional to enter a Baseline pressure, since its values are usually very insignificant for duct leakage test results. This is because not a huge portion of the ducts (as opposed to buildings) are directly connected to the outdoors.

A method for determining Baseline pressure is by having a digital gauge accumulate readings over an adjustable time period. The [Baseline] key on the gauge allows for this measurement to be taken. For more information, refer to Retrotec’s *Manual-DM-2 Operation*.



### 7.6.5. Enter whether pressurizing or depressurizing (Test direction)

Click to select whether the DucTester fan is setup to depressurize or pressurize the duct system (see section 3.11).

Test direction

☒ Depressurization

☐ Pressurization

## 7.7 Enter readings from this test

### 7.7.1. Duct Pressure

Enter the Duct Pressure during the test, which is the "PrA" reading on the DucTester gauge. The Duct Pressure in the software are always assumed to be the pressure of the ducts relative to the pressure of the outdoors.

The Duct Pressure should be a positive number for pressurization, and negative number, with a "-" sign, for depressurization. This is important if you have entered a Baseline pressure since the calculated Duct Test Pressure will then be different depending on the sign.

There are two important points to remember for recording Duct Pressures:

If the **[Baseline]** function on the gauge was used, you must ensure the Baseline was cleared before starting the fan. The Baseline value in the gauge is cleared by pressing **[Exit]** on the gauge before starting the fan. If this is done properly, the "Baseline" reading on the screen is blank.



Clearing the Baseline value on the gauge ensures that the "PrA" pressure on the gauge does not subtract the Baseline pressure, since the software will subtract this once it is entered. In order to avoid subtracting Baseline pressure twice – once on the gauge, and again in software, ensure the gauge is not using a Baseline value.

If you are using the Method 2 or Combined Method to do the Duct Testing, described in section 5.2.2 and 5.4 respectively, where you are setting the pressure between the duct system and the house to 0 Pa, enter 25 or -25 Pa (Duct Pressure relative to outdoors), NOT 0 Pa.

### 7.7.2. Enter "Flow" directly or enter Range Configuration and Fan Pressure

The dropdown menu is used to select whether you want to enter data as:

"Flow" from the gauge, or

"Range Config" and Fan Pressure ("PrB") from the gauge

It does not matter which of the two methods you choose, since either one will calculate the same results. If you decide to enter "Flow" directly, only one value needs to be recorded from the gauge, rather than two values if Range Configuration ("Open," "Mid," or "Low") and "PrB" method is selected.

The following screenshots shown below in each section are: the dropdown selection, the inputs that will appear as a result of that selection, and the Leakage Data that appears on the generated report as a result of that selection. The inputs highlighted in red are what would be copied from the gauge.

"(Enter Flow directly)":

Depressurization	
Duct Pressure	-25.0 Pa
Range Configuration, or Enter "Flow" directly	(Enter Flow directly)
Flow (from gauge)	Low Mid Open (Enter Flow directly)

Depressurization	
Duct Pressure	-25.0 Pa
Range Configuration, or Enter "Flow" directly	(Enter Flow directly)
Flow (from gauge)	103 CFM

Pressurization	
Duct Test Pressure	25.0 Pa
Duct Leakage	103 CFM

“Open,” “Mid,” or “Low” (200 series fan); “Open”:

Depressurization		Depressurization
Duct Pressure	-25.0 Pa	-25.0 Pa
Range Configuration, or Enter "Flow" directly	Mid	Mid
Fan Pressure	Low	197.0 Pa
Flow (calculated)	Mid	103 CFM
	Open (Enter Flow directly)	

Pressurization	
Duct Test Pressure	25.0 Pa
Fan Test Pressure	197.0 Pa
Range Configuration	Mid
Duct Leakage	103 CFM

To clear the test data shown in this section, click the “Clear Test Data” button.

Clear Test Data

### 7.7.3. Convert “Flow/Area” data so it can be entered into spreadsheet

Before obtaining the Duct Leakage Test Reporting software, you may have previously only recorded the “Flow/Area” data directly from your gauge, but no “Flow” data. Now you might like to print a report based on this Flow/Area. You will soon realize that you cannot enter Flow/Area data directly into the software to obtain results. Instead, you must enter “Flow” to calculate results; therefore, you must calculate a “Flow” to enter.

Example:

You live in North Carolina, and your state code requires that you report your results in the units of CFM/100 sq ft. During a prior test of your client’s duct system, you measured and recorded a Flow/Area of 26.3 CFM/100 sq ft at 25.0 Pa on your gauge. The conditioned flow area of the house is 1500 sq ft. What do you enter into the software as your “Flow”?

$$\text{Flow} = \frac{\text{Flow}}{\text{Area}} * \text{conditioned floor area}$$

$$\text{Flow} = \frac{26.3 \text{ CFM}}{100 \text{ sq ft}} * 1500 \text{ sq ft}$$

$$\text{Flow} = 395 \text{ CFM}$$

You would enter a “Flow” of 395 CFM, at a “Duct Pressure” of 25 Pa, with a “Conditioned Floor Area” of 1500 sq ft into the software.

### 7.8 Spreadsheet will calculate Cost of Duct Leakage

Values for parameters can be entered into the “Cost of Duct Leakage” section so that estimates of the Annual Cooling Loss and Annual Heating Loss (i.e., potential energy losses due to duct leakage) can be reported. These inputs are optional. If nothing is entered into this section, the “Cost of Duct Leakage” section of the report will not appear in the output.

## Cost of Duct Leakage

HVAC System Efficiency Loss **12.3%**

Annual Cooling Loss **\$136**

Annual Heating Loss **\$185**

For further detail on Duct system loss parameter calculations, refer to section 10.

If you are unsure of what the values are, simply assume the default values by clicking the "Use Default Values" button:

Use Default Values

Note: The "Annual Cooling Loss" and "Annual Heating Loss" in the Duct Leakage Report are for estimation purposes only.

### 7.8.1. % of Duct Leakage to Outdoors

Enter the estimated percentage of the Total Duct leakage that leads to outdoors in order to estimate Cost of Duct Leakage. (Input is only required when performing a Total Duct Leakage test)

### 7.8.2. Annual Cooling Cost

Enter the cooling cost per year from the utility bill. This entry is used to estimate the cost of Duct Leakage to Outdoors included in the cooling bill.

### 7.8.3. Annual Heating Cost

Enter heating cost per year from the utility bill. This entry is used to estimate the cost of Duct Leakage to Outdoors included in the heating bill.

### 7.8.4. Average Duct Operating Pressure

Measure the pressure in the supply duct closest to the plenum and enter that pressure to get an accurate calculation of duct losses. Do the same for the return. Using the test pressure (default value) here will not be accurate.

### 7.8.5. Leakage Split

Enter the estimated fraction of the Total Duct Leakage that is on the supply side and the return side. The default values are 0.5, meaning the leakage of the HVAC system is split evenly between the supply and return. Adding the Leakage Split for the supply side and the return side together should always come out to 1.0.

### 7.8.6. Supply Leakage Penalty

This is the estimated fraction of energy loss of the supply side. The default value is 1.0. This means that of the supply air leakage, all of its energy is lost to the outdoors (i.e., none of its energy is returned back into the house). This number can be lowered if some of the energy from duct leakage leads back into the house. For example, if supply leaks are going into a wall cavity, some of the energy will be go back into the house, so a lower leakage penalty would provide a better estimate of annual HVAC losses.

### **7.8.7. Return Leakage Penalty**

This is the estimated fraction of energy loss of the return side. The default value is 0.5, which assumes that of the return air leakage, about half of its energy is lost to outdoors (i.e., the other half of its energy stays inside the house). This number can be raised if you suspect that there is actually more energy loss to the outdoors from the return side. For example, if the return goes through a very cold crawl space, the return leakage would pull in cold air and have a greater effect on the annual HVAC losses.

## **7.9 Save the Duct Leakage Test Report as a PDF file**

### **7.9.1. With Office 2007:**



Click the MS Office icon at the top left corner of the window:

Mouseover "Save As" on the menu → Click "PDF or XPS"

Select the directory to save the PDF file to → Enter a proper file name for the PDF file to as

Click "Publish"

### **7.9.2. With Office 2010**

Click "File" → "Save As" → Change the "Save as type" to "PDF "

Select the directory to save the PDF file to → Enter a proper file name for the PDF file to as Click "Save"

## 8. Find air leaks in the ducts

Locating leaks in the ducts can be a tricky process, and there are a number of methods that are used.

### 8.1 Using a smoke puffer

Smoke puffers work similarly to theatrical smoke for finding leaks, but on a much smaller scale. The chemical smoke of Retrotec's Air Current Tester is the same density as air, and therefore does not move unless there is air movement. Puff out a small amount of smoke near suspected leaks, (for example, near joints, or in front of registers), while the DucTester is connected to the ducts and running, and notice the smoke either being blown away or being sucked in, depending on the direction of the test.

### 8.2 Using theatrical smoke

The use of theatrical smoke can be a very effective way to find leaks in a duct system. A theatrical smoke machine is used to inject non-toxic chemical smoke through the DucTester fan, and into the duct system. Walking around to check the duct systems will point out obvious leak locations where smoke appears. This can help find hard-to-detect leaks in attics and crawlspaces. Using this type of detection is called theatrical for a reason – it is quite a sight to see for homeowners and builders.

Caution: Make sure not to inject the smoke directly into the fan motor, but instead into the edge of the fan housing. Also, make sure to clean any residue away from the flow sensors, motor and fan housing when the show is over. The particles can block the sensors needed for measurements.

### 8.3 Using an infrared camera

An infrared camera can graphically display areas where cold air is infiltrating into a house or building, or show from the outside, where hot air is exfiltrating. The camera can also show zones that are poorly insulated, and would otherwise be invisible without opening up wall sections.

### 8.4 Using a wet hand

Sometimes, a damp hand is more than enough to feel the movement of air around a leak. Wet skin will feel cool or cold in the path of moving air.

### 8.5 Using a Pressure Pan

If a Blower Door system is available, checking all the registers with a Pressure Pan, prior to doing a duct leakage test, can be useful for finding the leakiest part of the system, and for determining the most conservative location for the DucTester system pressure pickup. A pressure pan test can also locate large disconnects in the duct system, which may prevent the acquisition of a useful result in a full duct leakage test. Set the Building Pressure to 25 Pa, and cover the register with the Pressure Pan connected to the blue port of the DM-2; readings over 1 Pa indicate some leakage, readings over 5 Pa is severe leakage at that register and 25 Pa indicates a complete disconnect.



Figure 47: Pressure Pans, large and small shown

**Table 5: Retrotec Pressure Pans**

Pressure Pan	Dimensions (in)	Part number
Large	24.5 x 24.5 x 8.75	PP101
Small	13 x 15 x 4.5	PP102

For more information about conducting a Pressure Pan test, see the Retrotec *Blower Door and Gauge Testing Manual*

## 9. Measure the Air Handler system flow

### 9.1 For Code compliance

For Code compliance testing, the air handler flow rate is seldom measured because it takes too much time. Typically air handler flow is calculated by using 400 CFM per Ton or 21.7 CFM per 1000 BTU. Other Codes require results expressed as CFM of duct leakage per square foot of conditioned floor area.

Small (around 2 Ton) systems with a single return can have their air flow measured at the return. Measuring from the air handler cabinet is preferred, especially for systems greater than 2 Tons.

### 9.2 Why measure the Air Handler system flow?

Air handler system flow rates are required to evaluate system performance. Reduced flow rate is one of the prime reasons that HVAC systems underperform. For air conditioners, insufficient flow leads to excessively cold coils that will ice up and reduce performance in that way. For heating systems, insufficient airflow will cause too great a temperature rise that will cause an over-temperature condition that will cause the furnace to short cycle, reducing its efficiency.

In both cases, insufficient air flow will affect comfort and decrease the system's ability to maintain the desired room temperature. This may cause homeowners to mistakenly assume that their system is too small and replace their unit with a larger one that will make matters even worse.

Variable speed systems are less prone to short cycling due to insufficient airflow unless the load becomes great enough to cause the unit to operate near its upper limit of capacity at which point it will short cycle.

### 9.3 Measure with a DucTester as a powered flow hood on the return

The Retrotec DucTester and Flow Hood can be used to measure air flows through supply registers, exhaust fans and other airflow devices, without affecting their flow rate, by neutralizing the pressure that would create a resistance to flow. By using the DucTester to create a Powered Flow Hood, a vent area can be "set to zero", eliminating any pressure difference. This is unlike using a traditional flow hood, where the flow hood itself creates a resistance to flow, altering what is being measured.

Ensure the "n" value on the gauge is set to 0.5. A unique feature of the Retrotec gauge is that it will allow accurate calculations of air handler flow rates even if the DucTester is not capable of achieving exactly the same flow as the air handler is putting out.

On the DM-2 gauge, press the **[Setup]** key and scroll to "N=" and set it to 0.5.

The Flow Hood looks similar to the Retrotec Pressure Pan, except it has a ten inch diameter hole in the center and an array of pressure pickup tubes inside. The hole makes the Flow Hood ready to attach the Flex Duct. Pass the Flange through the 10 inch hole in the Flow Hood and attach the Flex Duct.

For measuring supply flows, attach the Flex Duct to the inlet (suction) side of the fan over top of the Range Rings. For measuring return flows; attach the Flex Duct to the outlet (discharge) side of the fan.



**Figure 48: Measuring air flow with a Powered Flow Hood**

Attach the blue Tube to the connector on the Flow Hood. Connect the other end to the “Input A” port (blue) on the gauge. The “Ref A” (red) port on the gauge should be left open.

Connect the green and yellow tubing to the “Input B” (green) and “Ref B” (yellow) ports on the gauge respectively. Connect the other ends to the same color ports on the DucTester.

Adjust the **[Set Speed]** until “PrA” reads a pressure of 0 Pa. Record the flow in CFM. To have the DucTester automatically acquire and maintain a 0 pressure, press **[Set Pressure] [0]** and the gauge will cause the DucTester to increase in speed to eliminate whatever pressure it sees at the time that the keys are pressed.

Ensure the pressure that is to be set to 0 actually exists before the keys are pressed because it uses the direction of the pressure to set the direction of control. This means that the fan speed up to eliminate the pressure it first sees regardless of sign. Make sure the “@ Pressure” feature is turned off, otherwise erroneous results will occur due to the result being divided by whatever tiny pressure occurs above or below zero.

## **9.4 Measure with a DucTester on the air handler cabinet**

Ensure the “n” value on the gauge is set to 0.5. A unique feature on the Retrotec gauge will allow the gauge to accurately calculate the air handler flow rate even if the DucTester is not capable of achieving exactly the same flow rate as the air handler is putting out.

On the DM-2 gauge, press the **[Setup]** key and scroll to “N=” and set it to 0.5.

Measure the supply plenum pressure using the Static Pressure Probe supplied with each DucTester. Put the end of the blue tube with the probe into the supply plenum, connect the other end of the blue tube to the “Input A” (blue) port and read the pressure from “PrA” on the gauge.

Attach the DucTester to the cabinet using cardboard and tape so it is blowing into the air handler on the Open range. Set Pressure to the previously measured value. Press **[Set Pressure]** and enter the previously measured supply plenum pressure. Press the **[@ Pressure]** key until the supply plenum pressure appears as “CFM@”. Read the “CFM@” result on the gauge.

For example, if the pressure in the supply plenum is 70 Pa, Press **[Set Pressure], [70], [Enter]** to get the DucTester to recreate the original pressure in the plenum. Press the **[@ Pressure]** key until “CFM @ 70 Pa” appears on the display. The CFM result displayed will be corrected for what the airflow will be during normal operation (the supply pressure in the plenum measured at the start of the test).

If “TOO LOW” or “----” appears the pressure in the plenum is too high to get an accurate reading. Repeat the procedure but move the Static Pressure Probe to measure the pressure farther away from the air handler.

## **9.5 Measure with a gauge and a flow grid**

A unique Retrotec feature allows the gauge to be used with flow grids from other manufacturers.

Press the **[Setup]** key and scroll to “N=” and set it to 0.5.

Set the gauge to the flow grid using the **[Setup]** key. Use the “Mode Setup” menu as necessary to enable the flow grid as a choice of Device on the gauge.

Measure the supply plenum pressure using the Static Pressure Probe supplied with each DucTester. Put the end of the blue tube with the probe into the supply plenum, connect the other end of the blue tube to the “Input A” (blue) port and read the pressure from “PrA” on the gauge.

Install the flow grid into the filter slot per manufacturer instructions, which includes connecting the green and yellow tubes to the gauge. Press **[Set Pressure]** and enter the just measured supply plenum

pressure, even though the gauge is not controlling anything. Press the **[@ Pressure]** key until the supply plenum pressure appears as “CFM@”. Read the “CFM@” result on the gauge.

For example, if the pressure in the supply plenum is 70 Pa, Press **[Set Pressure]**, **[70]**, **[Enter]** to get the DucTester to recreate the original pressure in the plenum. Press the **[@ Pressure]** key until “CFM @ 70 Pa” appears on the display. The CFM result displayed will be corrected for what the airflow will be during normal operation (the supply pressure in the plenum measured at the start of the test).

If “TOO LOW” or “----” appears on the display as the result, the pressure in the plenum is too high to get an accurate reading. Remove the probe from the plenum, read the CFM on Channel B and use the table that came with the flow grid to correct the flow to match the pressure measured in the supply.

## **9.6 Measure using air handler blower curves**

If air handler blower curves are available, they will show system flow versus pressure across the air handler, from supply to return. To determine the pressure across the air handler, measure the pressure between the air handler cabinet on the return side and the supply plenum.

You may need the results in units other than Pascals, often inches WC, depending on what pressure units are used on the air handler blower curves. Do this by changing the units on the display using **[Setup]>>”Mode Setup”>>”Pressure”** and choosing the units required such as inches of Water Column (in wc).

You could manually convert Pascal readings by dividing the pressure in Pascals by 250 for inches Water Column.

## **9.7 Measure using Hole Flow on the gauge**

Because flow through a known size hole depends on pressure across the hole, and air flow into an enclosed space will cause pressure and flow through the hole, we can use a box with a hole in it to measure the system air flow.

Cut the flaps off one side of a medium-sized cardboard box. Cut a 2" x 2" square hole in the center of another side where the cardboard is only one layer thick. Punch a 0.25 inch diameter hole in the box near the opening and insert a tube into this hole. Connect the other end of the tube to the yellow port of the gauge (so Channel B is reading the pressure inside the box instead of from the fan). The gauge should show Pressure on Channel B in Pascals.

Observe the pressure in the box. Increase the size of the hole in the box until the pressure is about 5 Pa. Box pressure of 8 Pa or less are recommended because higher pressures mean the air handler is increasingly blocked and the test method itself is affecting the performance.

On the Retrotec gauge, set the result display “Mode” to “Hole Flow”. Enter the area of the hole into the gauge using the **[Area]** key, ensuring that the units you use for area match what the gauge is expecting for area. Units for area when calculating Hole Flow default to square inches. Read the CFM directly from the gauge to get the air handler flow.

Because this method partially blocks the flow from the air handler, readings are not exact, especially if pressures in the box are above 8 Pa.

## **9.8 Measure with a Blower Door attached to the return or cabinet**

Measure the supply plenum pressure using the Static Pressure Probe supplied with each Blower Door. Put the end of the blue tube with the probe into the supply plenum, connect the other end of the blue tube to the “Input A” (blue) port and read the pressure from “PrA” on the gauge.

Attach a 24 inch Flex Duct (optional accessory to Retrotec Blower Doors) to the outlet side of the Blower Door fan and the Flex Duct flange to a return or the air handler cabinet so it is blowing into the ducts on

the Open Range. Set the pressure to the just measured supply plenum pressure. Press **[Set Pressure]** and enter the previously measured supply plenum pressure. Read the CFM result directly from the gauge after waiting for at least one minute to let the measurement settle down.

For example, if the pressure in the supply plenum is 70 Pa, press **[Set Pressure]**, **[70]**, **[Enter]** to get the Blower Door to recreate the original pressure in the plenum. Read the CFM result directly from the gauge

If “TOO LOW” or “----” appears the pressure in the plenum is too high to get an accurate reading. Repeat the procedure but move the Static Pressure Probe to measure the pressure farther away from the air handler.

## **9.9 Other methods**

Temperature rise and other standard HVAC methods exist but are not covered here.

## 10. Estimate HVAC system energy loss from ducts

### 10.1 Duct Air Leakage Measurements

In this section, you will learn a simple method for estimating HVAC system losses through field measurements of duct air leakage. Assumptions must be made about the HVAC and duct systems (including system airflow, operating pressure in the ductwork, supply and return breakdown of leakage, and energy loss penalty from supply and return leaks) to estimate the annual energy loss for heating or cooling in the climate in question.

This estimation technique must be used with caution, as duct leakage loss calculations are extremely complex, and many assumptions are being made in order for the estimation to work. The leakage rate determined using the following air leakage procedure may differ from actual operating conditions. This simple model should not be used for research purposes, program design or impact evaluations, as more sophisticated duct leakage loss models are available and more accurate.

To use software to perform the simple methodology below, refer to section 7.

### 10.2 Methodology

Complete a “Duct leakage to outside” test

Record the leakage rate in CFM at 25 Pa (CFM25).

Determine the CFM25 multiplier for average operating pressure

It has been assumed that 25 Pa is a representative pressure for leaks in the duct system under normal operating conditions. However, if you have evidence to suggest that another pressure would better represent leaks under normal conditions, this can be modified. Use the following table to adjust CFM25 for different average operating pressures.

During normal (average) operating conditions, duct pressures can vary greatly. They are much more stable during a duct leakage test. Use separate multipliers for the return and supply ducts, respectively (as necessary).

Definitions:

Average Operating Pressure: 25 Pa is a representative pressure for leaks in the duct system under normal operating conditions. However, if you have evidence to suggest that another pressure would better represent leaks under normal conditions, this can be modified.

Pressure Multiplier is a factor applied to calculate the Loss Factor, based on the normal Average Operating Pressure.

**Table 6: CFM25 multipliers for average operating pressures. Multiplier for CFM25 = (Avg. Operating Pressure/25)<sup>0.60</sup>**

Average Operating Pressure (Pa)	Multiplier for CFM25
5	0.38
10	0.58
15	0.74
20	0.87
25	1.00
30	1.12
35	1.22
40	1.33

Average Operating Pressure (Pa)	Multiplier for CFM25
45	1.42
50	1.52
55	1.60
60	1.69
65	1.77
70	1.85
75	1.93
80	2.01
85	2.08
90	2.16
95	2.23
100	2.30
105	2.37
110	2.43
115	2.50
120	2.56
125	2.63
130	2.69
135	2.75
140	2.81
145	2.87
150	2.93
155	2.99
160	3.05
165	3.10
170	3.16
175	3.21
180	3.27
185	3.32
190	3.38
195	3.43
200	3.48

When possible, use actual operating conditions to determine the best multiplier to use from the table above.

Calculate a loss factor for supply and return leaks

Supply Loss Factor = (SLS x SLP x SPM)

Where: SLS is Supply Leakage Split (default 0.5)

SLP is Supply Leakage Penalty (default 1.0)

SPM is Supply Pressure Multiplier (default 1.0)

Supply Loss Factor =  $0.5 * 1.0 * 1.0$

= 0.5

Return Loss Factor = (RLS x RLP x RPM)

Where: RLS is Return Leakage Split (default 0.5)

RLP is Return Leakage Penalty (default 0.5)

RPM is Return Pressure Multiplier (default 1.0)

$$\begin{aligned}\text{Return Loss Factor} &= 0.5 * 0.5 * 1.0 \\ &= 0.25\end{aligned}$$

Definitions:

Leakage Split is the estimated fraction of total measured leakage, either on the supply side or the return side of the duct system

Supply Leakage Penalty: The default value is 1.0. This means that of the supply air leakage, all of its energy leads to the outdoors (i.e., none of its energy is regained back into the house). This number can be lowered if some of the energy from duct leakage leads back into the house.

Return Leakage Penalty: The default value is 0.5. This assumes that of the return air leakage, about half of its energy is lost to outdoors. (i.e., the other half of its energy is regained back into the house). This number can be raised if you suspect that there's actually more energy loss to the outdoors from the return side.

Estimate HVAC system airflow

Estimate the total airflow from the system documentation, measured through static pressure/fan curve, or by measuring system airflow using flow measuring techniques.

Calculate HVAC system loss (%)

$$\% \text{ HVAC System Loss} = \frac{\text{CFM}_{25} \text{ Leakage to outside} \times (\text{Supply Loss Factor} + \text{Return Loss Factor})}{\text{Estimated System Airflow in CFM}}$$

*Example 1:*

*We conduct a Duct Leakage to Outdoors Test on a 3 ton, 11 SEER heat pump system (supplies located in the attic and returns in the crawlspace). The owners report a \$1300/yr cooling bill and a \$700/yr heating bill. Using 25 Pa as our duct testing pressure, we measure 270 CFM<sub>25</sub> of duct leakage to the outside. We measure a total system airflow of 1425 CFM using a total flow measurement method. We will use the default values for Supply/Return Loss Factors.*

$$\% \text{ HVAC System Loss} = \frac{270 \text{ CFM} \times (0.5 + 0.25)}{1425 \text{ CFM}}$$

$$\% \text{ HVAC System Loss} = 14\%$$

$$\text{Annual cooling loss} = 14\% \times \$1300 = \$182$$

$$\text{Annual heating loss} = 14\% \times \$500 = \$70$$

$$\text{Annual capacity loss} = 14\% \times 3 \text{ ton} = 0.42 \text{ tons}$$

$$\text{Annual operating SEER} = (1 - 14\%) \times 11 \text{ SEER} = 9.5 \text{ SEER}$$

*Example 2:*

*For the same house measured above, the correct leakage split is determined with the majority of leakage on the return side at 200 CFM. Assume the average operating pressure for the return side is closer to 35 Pa because it is close to the plenum takeoff.*

CFM<sub>25</sub> multiplier for return = 1.22

CFM<sub>25</sub> multiplier for supply = 1.0 (default)

Leakage splits:

$$SLS = 200 \text{ CFM}_{25} / 270 \text{ CFM}_{25} = 0.74$$

$$RLS = 70 \text{ CFM}_{25} / 270 \text{ CFM}_{25} = 0.26$$

Loss Factors:

$$SLF = (0.74 \times 1.0 \times 1.22) = 0.9$$

$$RLF = (0.26 \times 0.5 \times 1.0) = 0.13$$

$$\begin{aligned} \% \text{ HVAC System Loss} &= \frac{270 \text{ CFM} \times (0.9+0.13)}{1425 \text{ CFM}} \\ &= 20\% \end{aligned}$$

$$\text{Annual cooling loss} = 20\% \times \$1300 = \$260$$

$$\text{Annual heating loss} = 20\% \times \$500 = \$100$$

$$\text{Annual capacity loss} = 20\% \times 3 \text{ ton} = 0.6 \text{ tons}$$

$$\text{Annual operating SEER} = (1 - 20\%) \times 11 \text{ SEER} = 8.8 \text{ SEER}$$

## 11. Field Check the DucTester to find out what is not working

Standard procedure says you calibrate your gauges every year or two, but does this really make sense? The gauge can be calibrated regularly but when did the gauge go out of calibration? Last week or last year?

There is a quick way to field-check your gauge regularly or before an important test. Gauge calibration, where errors are typically a few %, is not as frequent a cause of problems when compared to blocked, leaking or pinched tubes that happen more often and can yield errors of 10 or 90%. Sending your gauge in for calibration does not address those problems but doing a field check will.

### 11.1 Field Check the gauge

To verify the calibration of a gauge, the easiest method is to compare the readings of one channel with respect to the other channel. If the pressures are equal, then it is likely the gauge is accurate, because the chance of both channels being out of calibration by the same amount is very small.

*To perform a cross port check*

1. Press **[Exit]** to ensure there is no “Baseline” and then press **[Time Average]** repeatedly until “4s” appears.
2. Press **[Mode]** until both channels display pressure (in Pascals, Pa).
3. Connect the Input port of Channel A to the Input port of Channel B using a small piece of tubing that is known not to be blocked or pinched. The measured pressure on both channels should be within 2% of each other.
4. Disconnect the tubing, and then connect the Reference ports of both channels using the same piece of tubing. The measured pressure on both channels should be within 2% of each other.
5. Use a longer piece of tube to check the gauge at lower pressures.
6. Turn off **[AutoZero]** to stop the pressure from dropping.

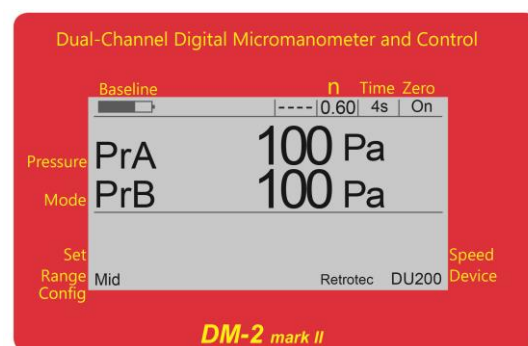


Figure 49: Gauge field check configurations (cross-channel checks (left), cross-gauge checks (right)).

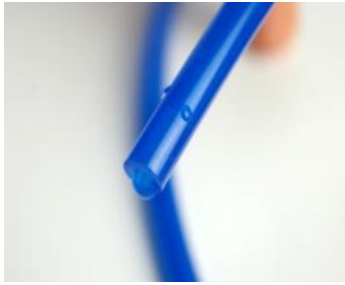
The same procedure can be followed to compare two gauges by setting up as shown on the right of Figure 49. The reading for “PrA” and “PrB” on both gauges should be the same.

Gauge calibration has now been checked, removing that major source of error.

### 11.2 Field Check the tubes

A problem that is a lot more common than gauge calibration is pinched or blocked tubes. They can be pinched inside the gauge where you'll never see it or even inside the fan. Tubes often get temporarily

blocked with a drop of water which still allows the gauge to work but the readings are only a fraction of what they should be. This test will identify those problems and takes only minutes.



**Water in tube**



**Pinched tube**

1. Press **[Exit]** and then **[Time Average]** until "4s" appears.
2. Press **[Mode]** until both channels display pressure (in Pascals).
3. Connect the yellow tube between the red and yellow ports on the gauge.
4. If the readings are within 2% and don't drop rapidly, the yellow tube is not blocked or leaking and the gauge is accurate.
5. Disconnect the yellow tube and connect the Blue tube from Blue to Green ports to check that tube and the negative side of the gauge.
6. Disconnect the Blue tube and connect the Green tube from the Green port to the Red Port to check that tube and the negative versus positive calibration of the gauge.



If both channels don't display the same pressure or the pressure drops rapidly the tubes are blocked or leaking. Water can be whipped or blown out of tubes and crimped tubes can be adjusted.

If the readings are different, either one tube is blocked or the gauge is faulty. Try another tube to see if it's the tube or the gauge. Check each tube separately. If differences on the gauge persist with different tubes connected, repeat the test against another gauge. Only then should a gauge return be considered.

Pressure dropping to zero in 10 seconds or less indicates a leak somewhere; try another tube and try the same tube on a different port to see which piece is faulty, the tube or the gauge. If the tube end is damaged, slice 1/8 inch off the tube and try again.

The tubes have now all been checked, removing that major source of error.

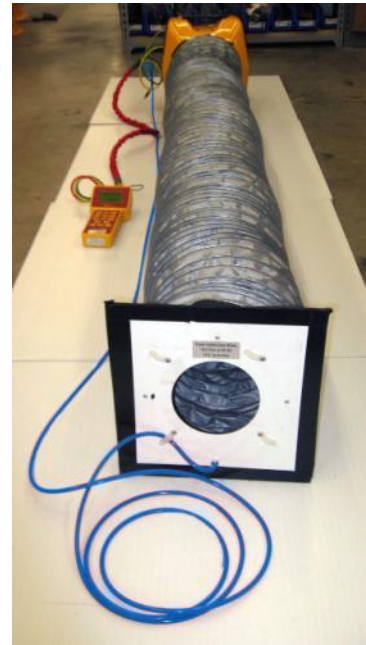
### **11.3 Field Check the DucTester as a system**

This check will ensure that the DucTester is connected properly, and will ensure that the measured results for flow are within 10% of the true value when using the DucTester as a system with Flex Duct. The flow verification plate is optional equipment, since a temporary one can be easily manufactured using thin, solid, cardboard with a 4" x 4 5/8" square hole (18.6 sq in) cut in the center. If making your own, a 1/4 inch diameter hole should be made in one corner of the plate, as far away from the larger hole as possible, into which the blue tube can be inserted.

### *To field check the DucTester calibration*

1. Tape the Field Calibration Plate to the Flex Duct Flange, and attach the blue tube to the pressure pickup or into the small cut hole (if using a homemade one).
2. Set that DucTester in the Mid-Range configuration
3. Attach the Flex Duct to the outlet side of the fan to pressurize the Flex Duct. If depressurizing ducts normally, you can also check the DucTester in that direction by attaching the flex to the inlet of the fan where you must connect the green reference tube.
4. Stretch the Flex Duct to its full length. Set the “Mode” to “Flow”.
5. Press **[Set Pressure] [25] [Enter]** and the fan will automatically control to 25 Pa. Press **[@ Pressure]** to display “CFM @25 Pa”.
6. Compare the measured results with the flow marked on the calibration plate. A homemade plate with the specified size hole should read within 5% of 105 CFM.

The calibrated fan and flex duct has now been checked as a system, removing that major source of error.



**Figure 50: DucTester field calibration check setup.**

## 12. Avoid common mistakes

The following mistakes are commonly made when performing a duct test, and can significantly affect the results.

- Wrong Range Configuration and or wrong Device selected on gauge
- Water in tube, pinched tube
- No green reference tube attached while depressurizing ducts
- Having @ Pressure set to the wrong pressure
- Having @ Pressure on when setting the pressure on the DucTester to zero when measuring duct leakage to outdoors using method #2.
- Not covering all registers
- Not locating and sealing ducts running to outdoors such as fresh air supply ducts
- Tape sealing registers being blown off, usually happens in pressurization
- Furnace coming on during a test
- Too leaky to test accurately, although this is usually not an issue because tests can be performed accurately at twice the allowable duct leakage.
- Be aware of ducts with no leaks:

In some cases, especially in new construction, it is possible to find ducts that have no leaks. Some indications would be if even a very low fan speed results in a very high duct pressure, or if no flow can be measured with even the most restrictive Range Configuration. One way to verify that the test is correct, and that the ducts are not leaky, is to unseal a single register. This introduces a leak to the duct system, which is measured by the equipment. If this test results in a measure leak of the approximate size of the opened register, the previous test is valid, and the system is too tight to measure any duct leakage.

- Method 2 duct leakage to outdoors or combined method has erratic readings:

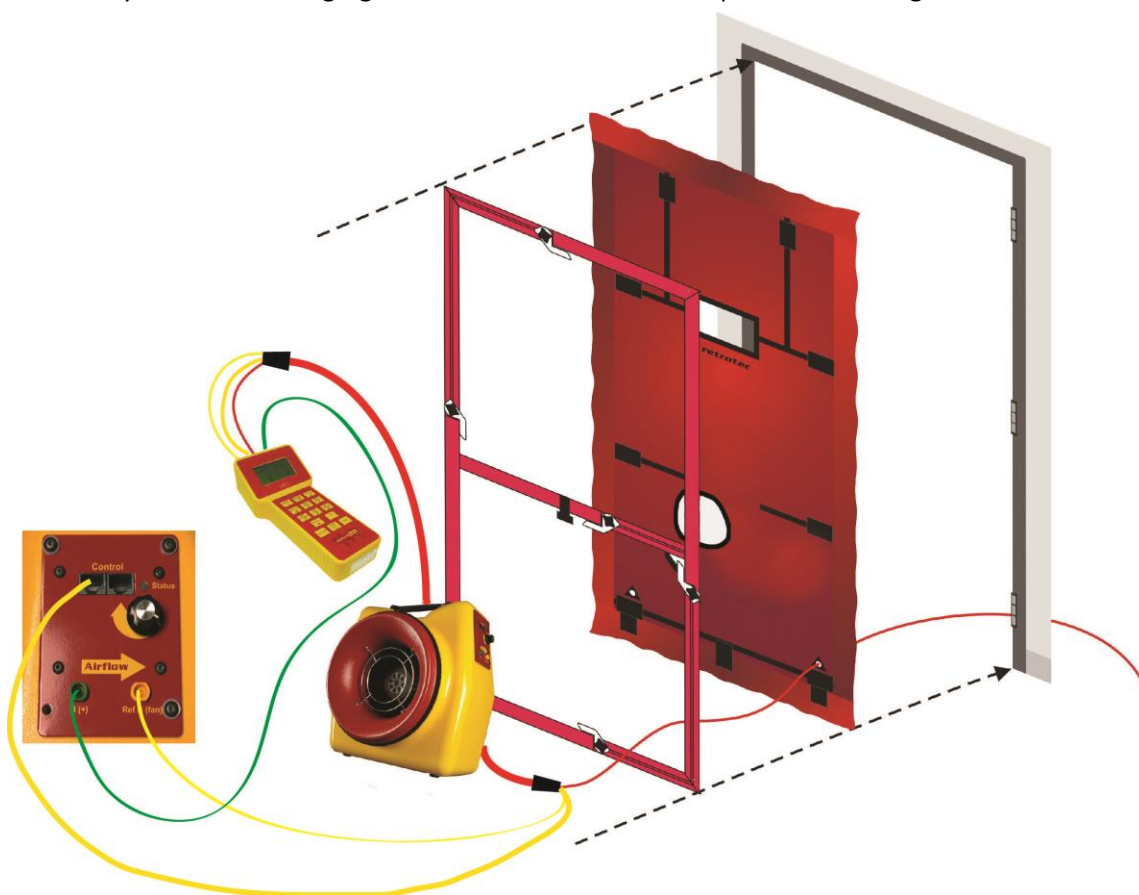
Huge errors will result if [**@ Pressure**] is turned on during this test because it creates a divide by zero error. Press [**@ Pressure**] to remove “@” from the display. This method relies on the DucTester gauge measuring the pressure between the house and ducts which is set to zero by the DucTester but the extrapolation to zero that is attempted by the gauge will not work.

## 13. Create a Blower Door with a DucTester fan

### 13.1 Use a DucTester to test tight enclosures

To turn a duct testing system into a Blower Door system for testing tight enclosures, you only need to add an Aluminum Frame and a Low-Flow Cloth Door Panel. If you have a DucTester system, your Umbilical will have blue, yellow and green tubes. In this case, the blue tube will be connected to the red port on the gauge and passed through the panel. The graphic in Figure 51 shows the umbilical that comes with a Blower Door system, with a red, yellow and green tube, and the red tube connected to the red gauge port and going through the panel to the outdoors. It is not necessary to change your Umbilical just for this color change.

Blower Door systems for testing tight enclosures should be set up as shown in Figure 51 below:



**Figure 51: Blower Door setup using a Model 200 fan to test tight enclosures. The left image shows the Fan Top from a side view of the Model 200 fan with tubing and Control Cable connections. Same configuration for the 300 fan.**

The green tube is always recommended and **MUST** be connected if the flow is towards the operator (i.e., air is blowing towards where the operator is standing). The Speed Control Cable can be plugged into either one of the two Control ports.

To measure building envelope leakage with Blower Door testing, please refer to procedures outlined in Retrotec's *Manual-Blower Door Operation* and *QuickGuide-Blower Door*.

## 13.2 Blower Door System (tight enclosures) details

The blower door systems (US200, EU200, UK200) include all of the parts listed above for a typical duct testing system, except instead of a Flex Duct, the Blower Door systems include an Aluminum Frame and Cloth Door Panel to tightly fit the Model 200 fan into a doorway. A similar system is available with the 300 fan.

Also included is a hard-sided case for the Aluminum Frame. The gauge can be placed securely into the included gauge holder that holds it upright on the Aluminum Frame for easy access during a Blower Door test.



Figure 52: Blower Door system for testing tight enclosures.



To expand your DucTester into a Blower Door system for testing tight enclosures, you only need to add a Low-Flow Cloth Door Panel with Aluminum Frame.

Table 7: Aluminum Frame Door Panel dimensions

Dimensions		With Extender Kit
Panel width	24.5 - 41.5 in (62.2 - 105.4 cm)	30 - 48 in (76 - 122 cm)
Panel height	51.5 - 95 in (131 - 241 cm)	60 - 110 in (152 - 280 cm)
Frame thickness	1.75 in (5.3 cm)	
Frame case	53 x 10 x 4 in (134 x 25 x 10 cm)	
Frame weight	14.2 lbs (6.4 kg)	

## Appendix A: Calculate Air Flow based on Pressure readings

The air flow being produced by the calibrated fan is a value that can be calculated based on the pressure developed by the air moving across the inlet side of the fan towards the exhaust. Because the fan is calibrated, there are known values describing the mathematical relationship between the fan pressure, which is measured across the fan inlet, and the resulting air flow through the fan.

The Fan Pressure needed to calculate the fan flow is the difference between the pressure at the pickup and the pressure in the vicinity of the inlet side of the fan. The fan pressure pickup is located inside the fan near the inlet side of the fan. Self-referencing fans such as the DU200 have the reference port built in, and it is placed to measure the ambient pressure in the vicinity of the inlet side of the fan. It is important to set the Device on the gauge to DU200 because that tells the gauge not to adjust the “PrB” value before calculating flow. Such an adjustment is required in the case of flow toward the operator when the fan is not self-referenced.

Each fan and range combination has a different flow equation. For each fan and range combination available, the variables needed to calculate flow are listed in the table below.  $N$  and  $K$  values depend on the type of fan and the Range Plate/Ring being used.

Since both the fan pressure pickup and the reference for the fan pressure (yellow and green ports on the fan connected to the gauge) are on the inlet side of the fan, “PrB”, will always show the correctly referenced fan pressure and can be used directly as the fan pressure,  $FP$ , value in the flow equation.

To determine the fan flow for a particular Fan Pressure, insert the values measured for  $FP$  and  $DP$ , and the  $N$  and  $K$  values from the table into the following equation:

$$\text{Flow CFM} = (FP - DP \times K1)^N \times (K + K3 \times FP)$$

Where:

$FP$  is the fan pressure from Channel B displayed as “PrB”

$DP$  is the duct pressure from Channel A displayed as “PrA”

There are two conditions for  $FP$  that must be met before the calculated flow can be considered valid. The absolute value of  $FP$  must be greater than the minimum fan pressure,  $MF$ , from the table and greater than a factor calculated from the duct pressure,  $DP$ , and  $K2$  from the table:

So before calculating flow ensure that:  $|FP| > MF$

And:  $|FP| \geq |DP| \times K2$

**Table 8: N and K coefficients for all supported fans in the gauge.**

	Range	n	K	K1	K2	K3	MF
<b>Model 200 / DU220</b>	Open	0.5115	30.7774	0.000	0.2	0.0000	10
	Mid	0.5415	5.9146	0.000	0.5	0.0000	25
	Low	0.6125	1.0056	0.024	0.5	-0.0002	25
<b>Mn DuctBlaster</b>	Open	0.5032	108.7000	0.000	1.0	0.0000	25
	Ring 1	0.5038	40.5000	0.000	1.0	0.0000	25
	Ring 2	0.5064	15.2700	0.000	1.0	0.0000	25
	Ring 3	0.5140	5.8400	0.000	1.0	0.0000	4
<b>Mn Exhaust Fan</b>	E1	0.5000	43.7300	0.000	1.0	0.0000	1.0
	E3	0.5000	20.7200	0.000	1.0	0.0000	1.0

	Range	n	K	K1	K2	K3	MF
	E3	0.5000	10.0700	0.000	1.0	0.0000	1.0
Mn True Flow	#14	0.5000	115.0000	0.000	1.0	0.0000	10
	#20	0.5000	154.0000	0.000	1.0	0.0000	10

Table 9: N and K coefficients for all supported fans in the gauge, Obsolete.

	Range	n	K	K1	K2	K3	MF
100	Open	0.4910	39.4840	0.000	1.0	0.0000	10
	2.75	0.5110	3.0110	0.000	1.0	0.0000	10
	1.23	0.5110	1.1290	0.000	1.0	0.0000	10

## Appendix B: Flow Conversion Tables

### Flow Conversion Table for Duct Test Pressure of 25 Pa

Table 10: Flow in CFM for various fan pressures, Retrotec Model 200 Fans, Duct Test Pressure: 25 Pa (relative to outdoors)

Flow AWAY or TOWARDS operator, both green and yellow tubes connected.

Fan Pressure (Pa)	Open	Mid	Low		Fan Pressure (Pa)	Open	Mid	Low
10	100		4.2		96	318	70	16
12	110		4.7		98	321	71	16
14	119	25	5.1		100	324	72	17
16	127	27	5.6		105	333	74	17
18	135	28	6.0		110	341	75	18
20	142	30	6.3		115	349	77	18
22	150	32	6.7		120	356	79	18
24	156	33	7.1		125	364	81	19
26	163	35	7.4		130	371	83	19
28	169	36	7.8		135	378	84	20
30	175	37	8.1		140	385	86	20
32	181	39	8.4		145	392	88	21
34	187	40	8.7		150	399	89	21
36	192	41	9.0		155	406	91	21
38	198	42	9.3		160	413	92	22
40	203	44	10		165	419	94	22
42	208	45	10		170	426	95	23
44	213	46	10		175	432	97	23
46	218	47	10		180	438	98	23
48	223	48	11		185	444	100	24
50	228	49	11		190	451	101	24
52	232	50	11		195	457	103	24
54	237	51	12		200	463	104	25
56	241	52	12		205	468	106	25
58	246	53	12		210	474	107	26
60	250	54	12		215	480	108	26
62	254	55	13		220	486	110	26
64	258	56	13		225	491	111	27
66	262	57	13		230	497	112	27
68	266	58	13		235	502	114	27
70	270	59	13		240	508	115	28
72	274	60	14		245	513	116	28
74	278	61	14		250	518	118	28
76	282	62	14		255	524	119	28
78	286	63	14		260	529	120	29
80	289	63	15		265	534	121	29
82	293	64	15		270	539	123	29
84	297	65	15		275	544	124	30
86	300	66	15		280	549	125	30
88	304	67	15		285	554	126	30
90	307	68	16		290	559	127	31
92	311	68	16		295	564	129	31
94	314	69	16		300	569	130	31

## Flow Conversion Table for Duct Test Pressure of 50 Pa

**Table 11: Flow in CFM for various fan pressures, Retrotec Model 200 Fans, Duct Test Pressure: 50 Pa (relative to outdoors)**

Flow AWAY or TOWARDS operator, both green and yellow tubes connected.

Fan Pressure (Pa)	Open	Mid	Low	Fan Pressure (Pa)	Open	Mid	Low
10	100		4.3	96	318	70	16
12	110		4.8	98	321	71	16
14	119	25	5.2	100	325	72	17
16	127	27	5.6	105	333	74	17
18	135	28	6.0	110	341	75	18
20	142	30	6.4	115	349	77	18
22	150	32	6.8	120	356	79	18
24	156	33	7.1	125	364	81	19
26	163	35	7.5	130	371	83	19
28	169	36	7.8	135	378	84	20
30	175	37	8.1	140	385	86	20
32	181	39	8.5	145	392	88	21
34	187	40	8.8	150	399	89	21
36	192	41	9.1	155	406	91	21
38	198	42	9.4	160	413	92	22
40	203	44	10	165	419	94	22
42	208	45	10	170	426	95	23
44	213	46	10	175	432	97	23
46	218	47	10	180	438	98	23
48	223	48	11	185	445	100	24
50	228	49	11	190	451	101	24
52	232	50	11	195	457	103	24
54	237	51	12	200	463	104	25
56	241	52	12	205	468	106	25
58	246	53	12	210	474	107	26
60	250	54	12	215	480	108	26
62	254	55	13	220	486	110	26
64	258	56	13	225	491	111	27
66	262	57	13	230	497	112	27
68	266	58	13	235	502	114	27
70	270	59	13	240	508	115	28
72	274	60	14	245	513	116	28
74	278	61	14	250	519	118	28
76	282	62	14	255	524	119	28
78	286	63	14	260	529	120	29
80	290	63	15	265	534	121	29
82	293	64	15	270	539	123	29
84	297	65	15	275	544	124	30
86	300	66	15	280	549	125	30
88	304	67	15	285	554	126	30
90	307	68	16	290	559	127	31
92	311	68	16	295	564	129	31
94	314	69	16	300	569	130	31

## Flow Conversion Table for Duct Test Pressures greater than 50 Pa

The preceding tables can be used for much higher back pressures. The fan pressure must be at least 50% of the back pressure or 25 Pa, whichever is greater. When using the gauge, this is taken care of automatically. If you are taking manual readings you must control this yourself or use the calculation spreadsheet that Retrotec can provide.

*Example: your Model 200 is blowing into 200 Pa on Mid Range which has a K2 value of 0.5 meaning the Fan Pressure must be at least  $0.5 \times 200 = 100$  Pa. Simply read directly off the chart as long as your Fan Pressure is greater than 100 Pa.*

For the Low Range for example, there is back pressure compensation in the flow formula that makes these readings more difficult but if this is ignored, the results will still be within 6%. Use the gauge or calculation spreadsheet or formulae to get the correct result.

When testing at high back pressures, over 200 Pa, this limitation on the minimum fan pressure will reduce the width of each flow range meaning for some flow rates, you will not be able to get a reading. These gaps between ranges are a limitation of the Model 200 which is not as apparent in the Model 300 that has many more ranges.

Whenever testing over 250 Pa, we recommend using the new Model 451 that will test up to 2500 Pa with up to 260 CFM of flow, or even 5000 Pa at 100 CFM of flow.

## Appendix C: Calculate flow if required test pressure cannot be reached

### “n” setting for estimating flow @ pressure during house and duct leakage test

Houses and ducts have leaks through holes that will have both turbulent and laminar flow going through them. The relationship between pressure and flow is as follows:

$$\text{flow} = \text{Pressure}^n \times C$$

The actual flow exponent  $n$  for an enclosure can be calculated by measuring enclosure leakage at multiple pressure differences, from 10 to 50 Pa, and determining the slope of the line when graphing log of flow versus log of pressure. The graph of pressure versus flow will be linear if graphed on a log-log scale, and the slope will be  $n$ . The constant  $C$  is a value depending on the flow characteristics of the opening through which the air is moving, and can be thought of as the flow at 1 Pa. Once  $n$  is known, flow at 1 Pa can be found using the graph.

A wide open hole has an  $n$  of 0.5, meaning that when the pressure is quadrupled, the flow doubles. That is due to completely turbulent flow going through that hole (flow = square root of pressure, a constant for that particular hole).

$$\text{flow} = \text{Pressure}^n$$

$$\text{flow} = \text{Pressure}^{0.5}$$

An  $n$  value of 1.0 represents tiny little holes, so small that the air would not be turbulent but rather would go through the holes as laminar flow. This means that when pressure is quadrupled, the flow will also be quadrupled.

$$\text{flow} = \text{Pressure}^1$$

$$\text{flow} = \text{Pressure}$$

$$4 * \text{flow} = 4 * \text{Pressure}$$

Duct holes tend to be slightly larger so tend towards more laminar with less turbulent flow and larger  $n$  values, whereas houses have more prevalent long tiny cracks, and therefore tend to have lower  $n$  values.

The  $n$  value is saved in the gauge. Set it to 0.65 for houses, and 0.60 for ductwork. Set to 0.5 for tests on the Retrotec house simulator, while measuring air handler flow and for any large hole that is not composed of long thin cracks.

The gauge uses the  $n$  value to extrapolate for flows at other pressures using the following formula:

$$\text{Flow at desired test pressure} = (\text{Flow at measured pressure}) * \left( \frac{\text{desired test pressure}}{\text{measured pressure}} \right)^n$$

Note that because the formula is using a ratio of the two pressures, and both pressures will have the same  $C$ , the  $C$  value is not required for the extrapolation.

For example: If we guess at the  $n$  value of a duct as being 0.6 and measure 100 CFM at 20 Pa (by accident or by design), then the gauge will complete the following calculation to estimate the flow at 25 Pa:

$$\text{flow@25 Pa} = \text{flow@20 Pa} \times \frac{25^{0.6}}{20^{0.6}}$$

If the test pressure (20 in this case) is close to the desired reference pressure (25 Pa in this case), then the correction is small and the value of  $n$  does not play as large a role. However, if the test pressure is much higher or lower than the reference pressure, the error can be greater.

The @ Pressure extrapolation feature is very useful for ensuring that results taken for flow reflect the flow at the desired test pressure, even when the pressure was not adjusted perfectly and was within 5 to 10 Pa of the desired test pressure.

### Extrapolation Error for Flow if gauge “n” doesn’t match actual n

To continue the above example: The flow at 20 Pa is 100 CFM. Assume the actual  $n$  is 0.7, but this is unknown. Instead, 0.6 will be used.

The gauge would calculate:

$$\text{Flow@25 Pa} = \frac{25^n \times \text{CFM}}{20^n}$$

$$\text{Flow@25 Pa} = \frac{25^{0.6} \times 100}{20^{0.6}}$$

$$\text{Flow@25 Pa} = 114 \text{ CFM}$$

However, if actual  $n$  was 0.7, the flow at 25 should have been:

$$\text{Flow@25 Pa} = \frac{25^{0.7} \times 100}{20^{0.7}}$$

$$\text{Flow@25 Pa} = 117 \text{ CFM}$$

This value is less than 3% off from what it should be. If the test pressure was within 1 or 2 Pa of the reference pressure of 25 Pa, the @ Pressure reading would be exact.

If a gauge has the extrapolation or flow exponent “ $n$ ” set to an assumed value but the actual exponent (the true exponent value that describes the enclosure) differs, the flow values estimated by the gauge when extrapolating will be off by a small error amount. The tables below show the percent error that can result from entering an incorrect exponent value in the gauge and using the [**@ Pressure**] function.

If the “ $n$ ” value on the gauge is set to 0.65 and the actual duct “ $n$ ” is different, a small error, as shown in Table 12 will result if the [**@ Pressure**] function is used at the Achieved Pressure to estimate a result at 50 Pa.

**Table 12: Errors in Estimated Flow at 50 Pa if gauge “ $n$ ”= 0.65 differs from actual  $n$**

Assumed $n$ = 0.65		Actual Flow Exponent ( $n$ ) of Ducts					
		0.50	0.55	0.60	0.65	0.70	0.75
Achieved Pressure (Pa)	10	-21.4%	-14.9%	-7.7%	0.0%	8.4%	17.5%
	15	-16.5%	-11.3%	-5.8%	0.0%	6.2%	12.8%
	20	-12.8%	-8.8%	-4.5%	0.0%	4.7%	9.6%
	25	-9.9%	-6.7%	-3.4%	0.0%	3.5%	7.2%
	30	-7.4%	-5.0%	-2.5%	0.0%	2.6%	5.2%
	35	-5.2%	-3.5%	-1.8%	0.0%	1.8%	3.6%
	40	-3.3%	-2.2%	-1.1%	0.0%	1.1%	2.3%
	45	-1.6%	-1.0%	-0.5%	0.0%	0.5%	1.1%
	50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	55	1.4%	1.0%	0.5%	0.0%	-0.5%	-0.9%
	60	2.8%	1.8%	0.9%	0.0%	-0.9%	-1.8%
	65	4.0%	2.7%	1.3%	0.0%	-1.3%	-2.6%
	70	5.2%	3.4%	1.7%	0.0%	-1.7%	-3.3%

If the “*n*” value on the gauge is set to 0.60 and the enclosure “*n*” is different, a small error, as shown in Table 13 will result if the **[@ Pressure]** function is used at the Achieved Pressure to estimate a result at 50 Pa.

**Table 13: Errors in Estimated Flow at 50 Pa if gauge “*n*” = 0.60 differs from actual *n***

Assumed <i>n</i> = 0.6		Actual Flow Exponent ( <i>n</i> ) of Enclosure					
		0.50	0.55	0.60	0.65	0.70	0.75
Achieved Pressure (Pa)	10	-14.9%	-7.7%	0.0%	8.4%	17.5%	27.3%
	15	-11.3%	-5.8%	0.0%	6.2%	12.8%	19.8%
	20	-8.8%	-4.5%	0.0%	4.7%	9.6%	14.7%
	25	-6.7%	-3.4%	0.0%	3.5%	7.2%	11.0%
	30	-5.0%	-2.5%	0.0%	2.6%	5.2%	8.0%
	35	-3.5%	-1.8%	0.0%	1.8%	3.6%	5.5%
	40	-2.2%	-1.1%	0.0%	1.1%	2.3%	3.4%
	45	-1.0%	-0.5%	0.0%	0.5%	1.1%	1.6%
	50	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	55	1.0%	0.5%	0.0%	-0.5%	-0.9%	-1.4%
	60	1.8%	0.9%	0.0%	-0.9%	-1.8%	-2.7%
	65	2.7%	1.3%	0.0%	-1.3%	-2.6%	-3.9%
	70	3.4%	1.7%	0.0%	-1.7%	-3.3%	-4.9%

Achieved pressure is the actual maximum pressure achieved in the enclosure (ducts in this case) during the test.

$$\text{Error} = \left( \frac{\text{Pressure of Interest}}{\text{Achieved Pressure}} \right)^{(\text{Actual } n - \text{Assumed } n)}$$

In the tables, the *Pressure of Interest* is 50Pa, and *Assumed n* is 0.65 or 0.60

The actual flow exponent *n* for an enclosure can be calculated by measuring enclosure leakage at multiple pressure differences, from 10 to 50 Pa, and determining the slope of the line on the graph of pressure versus flow which will be linear if graphed on a log-log scale, and the slope will be *n*.

### Cannot Reach 25 Pa Factors

If you have a situation where you cannot reach the required 25 Pa during the test, there is a way to estimate the flow at that pressure based on the measured pressure and flow you did achieve. This is the procedure the gauge uses for extrapolating the flow at the required pressure when you use the **[@ Pressure]** key. The following equation describes the relationship between the flow at the required pressure of 25 Pa and the actual measured flow at the measured pressure:

$$\text{Flow at 25 Pa} = (\text{Flow at measured pressure}) * \left( \frac{25 \text{ Pa}}{\text{measured pressure}} \right)^n$$

$$\text{CFM}_{25} = \text{CFM}_P * \left( \frac{25}{P} \right)^n$$

For most ducts, the  $n$  value is usually 0.60. For the flow at 50 Pa, replace “25” with “50.”

Rather than using the equation in the situation where the 25 Pa test pressure cannot be achieved, you can use tables with the factors already calculated and the following procedure.

Take a flow (CFM) reading at the pressure achieved and multiply by the "Cannot reach 25 Pa factor" from Table 14 to get an estimate of the flow that would result at 25 Pa.

For example: if you read 600 CFM at a building pressure of 19 Pa, the "Cannot reach 25 factor" from Table 14 is 1.18. To get the estimated flow at 25 Pa, make the following calculation:

$$600 \text{ CFM} \times 1.18 = 708 \text{ CFM}$$

Thus the estimated result for CFM at 25 Pa will be 708 CFM.

The factors depend on the  $n$  value chosen. Table 14 is for  $n$  of 0.60 which is typical for ducts.

**Table 14: Factors for when a duct pressure of 25 Pa cannot be reached (assumed  $n$  value of 0.6).**

Pressure achieved	Cannot reach 25 factor
25	1.00
24	1.02
23	1.05
22	1.08
21	1.11
20	1.14
19	1.18
18	1.22
17	1.26
16	1.31
15	1.36
14	1.42
13	1.48
12	1.55
11	1.64
10	1.73
9	1.85
8	1.98
7	2.15
6	2.35
5	2.63

## Cannot Reach 50 Pa Factors

Rather than using the equation in the situation where the 50 Pa test pressure cannot be achieved, you can use tables with the factors already calculated and the following procedure. Take a flow (CFM) reading at the pressure achieved and multiply by the "Cannot reach 50 Pa factor" from Table 15 to get an estimate of the flow that would result at 50 Pa.

For example, if you read 1000 CFM at a building pressure of 30 Pa, the "Cannot reach 50 factor" from Table 15 is 1.36. To get the estimated flow at 50 Pa, make the following calculation:

$$1000 \text{ CFM} \times 1.36 = 1360 \text{ CFM}$$

Thus the estimated result for CFM at 50 Pa will be 1360 CFM.

The factors depend on the “*n*” value chosen, and Table 15 is for “*n*” of 0.60 which is typical for ducts.

**Table 15: Factors for when a duct pressure of 50 Pa cannot be reached (assumed “*n*” value of 0.60).**

Pressure achieved	Cannot reach 50 factor	Pressure achieved	Cannot reach 50 factor
50	1.00	25	1.52
49	1.01	24	1.55
48	1.02	23	1.59
47	1.04	22	1.64
46	1.05	21	1.68
45	1.07	20	1.73
44	1.08	19	1.79
43	1.09	18	1.85
42	1.11	17	1.91
41	1.13	16	1.98
40	1.14	15	2.06
39	1.16	14	2.15
38	1.18	13	2.24
37	1.20	12	2.35
36	1.22	11	2.48
35	1.24	10	2.63
34	1.26	9	2.80
33	1.28	8	3.00
32	1.31	7	3.25
31	1.33	6	3.57
30	1.36	5	3.98
29	1.39		
28	1.42		
27	1.45		
26	1.48		

## Appendix D: Troubleshooting

Occasionally simple problems do occur with a DucTester system. If the problem is described in any of the following sections, follow the steps to attempt to resolve the problem. If the problem persists, contact [support@retrotec.com](mailto:support@retrotec.com).

### **“TOO LOW” appears on display:**

Backpressure refers to the pressure that the DucTester fan works against while running. Under most testing conditions, backpressure is not a concern. If the backpressure is too great, the gauge will automatically sense it and display "TOO Low" or "-----", indicating the fan pressure signal is too low compared to the pressure the fan is working against. Changing to a more restrictive Range Configuration will solve this problem.

### **Gauge “Flow” reading does not change? Turn off [ @ Pressure]**

When the measured flow or fan pressure does not increase as fan speed increases the gauge has likely been set to calculate a value for [ @ Pressure]. To have the gauge show the actual measured flow at the current “PrA”, simply press [ @ Pressure] until there is no @ symbol next to the flow reading.

If [ @ Pressure] is active, the gauge calculates a reading for flow at the test pressure, no matter what the actual “PrA” reads. Therefore, regardless of fan speed, the measured flow will appear relatively unchanging.

### **Fan does not run**

Make sure the power light is on and the power switch is set to “1”. If the yellow Speed Control Cable (Ethernet-style) has been connected previously to a gauge, the Speed Control Knob must be turned off and then on again. This is a fail-safe feature so the fan does not go on unless you want it to.

Alternatively, turning the power switch off and back on will activate the Speed Control Knob as long as the Speed Control Cable is not connected.

### **Checking the DucTester flows**

Set the gauge to Pressure on both channels using the [Mode] key.

Establish a test pressure of at least 25 Pa in a box or duct with flex duct connected to the DucTester fan and using the manual Speed Control Knob to pressurize. Disconnect the blue tube and connect it to the yellow port on the gauge. “PrB” should now read the same 25 Pa. If higher by a significant amount, then Channel A is leaking, but if lower then Channel B is leaking.

With the Flex Duct removed, set the fan to full speed. “PrB” should read about 200 Pa. If the value is a lot lower, Channel B is leaking. Connect the blue tube to “Input A” on the DM-2, and “Ref B” on the fan. (Yellow tube is disconnected.) Channel A should read about 200 Pa.

### **Fixing the Fan Top (for Model 200)**

Occasionally, it is possible for the Fan Pressure tubes, located inside the Fan Top, to become blocked, pinched, or disconnected. This will prevent the gauge from reading changes in Fan Pressure when the fan speed changes.

The Fan Top for the Model 200 refers to the two mounted red plates attached to the sides of the fan. Attached behind them are Printed Circuit Boards (PCBs). For this section, we will refer to the Control

PCB assembly as the one that has "Control" printed on the mounting plate. We will refer to the Power PCB assembly as the one with the power switch on it, and has "Mains Power" printed on it.

- Attach a one foot length of tube to the "Ref B (Fan)" port on the Fan Top. Try sucking on the tube; you should hear a whistling sound from inside the fan as air is drawn into the two pickup points (see Figure 5 and Figure 4).
- Do the same thing with the tube attached to the "B" port. If no sound is heard from the port, than the pressure tube(s) under the Fan Top are blocked. If both tubes are clear, there is no need to continue. Blowing air through the tube connector can remove a water drop if that was causing the blockage.

**Caution:** Unplug the power cable before performing the following.

*To fix a Fan Top pressure tube (on the Control PCB assembly)*

1. Remove the Control PCB assembly, by removing the four hex head screws on the corners, using the 3/32" hex (Allen) key. The Control PCB assembly is the one that says "Control" on the mounting plate.



2. Gently lift the assembly away from the fan, exposing the tubes and wires beneath.



3. If the yellow or green tubes are blocked or kinked, replace that section of tube. To replace the tubes, first snip the end off.



4. Carefully remove old tube. It is easy to damage connector when removing old tube. If removal is difficult, a small amount of heat from something like a hair dryer may be used to ease removal. If tubing connector is damaged, replace the connector.



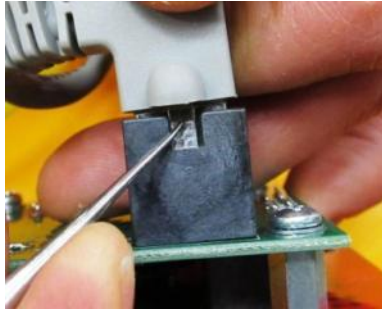
5. Carefully insert tube on connector. Again, a small amount of heat or a bit of silicon lubricant will ease installation. Make sure that the tube is fully inserted onto the connector, and that the connector is not damaged or bent.



6. Re-install the Control PCB assembly to the fan shell. Be certain not to over tighten the mounting screws as it is very easy to over tighten and thus strip out the threads in the plastic fan shell.
7. Occasionally it may be necessary to replace the Power PCB assembly. The Power PCB assembly has the power switch on it, and says "Mains Power." Remove the Power PCB assembly, by removing the four 8-32 x 5/8" button head screws that secure it to the fan shell, using the 3/32" hex (Allen) key.



8. Gently lift the Power PCB assembly away from the fan shell.
9. Disconnect the Power PCB assembly from wiring harness by carefully pulling all six of the flag connectors away from the PCB using a pair of pliers. Use a tool to depress the tab on the plug, as shown, and remove



10. Set the old assembly aside, and connect the new one
11. Connect the wires to the Power PCB assembly by attaching the flag connectors to the terminal posts on the Power PCB as indicated. Be careful to not bend the PCB.

120v/240v	
Green/Yellow	Labeled GND
Blue (Motor Wire)	J3-3 (Labeled WHT 115V)
Black	J3-7 (Labeled BLK)
Blue (Capacitor Wire)	J3-8 (Labeled BRN)

12. Ensure the Power PCB assembly sits on the fan shell cavity flush such that the wires and/or tubing are not being pinched or crushed under the Power PCB assembly.
13. Re-attach the Power PCB assembly to the fan shell with the previously removed screws.

## Model 210 and 220 – obsolete models no longer in production

The 210 and 220 model duct testing fans were sold with R31 and Q32 DucTester systems respectively. At 0.25 hp, the fans were designed specifically for duct testing. Rendered obsolete by the Model 200 fan, the Model 210 and some Model 220 fans require a manual speed control. The Model 220 offers a self-referencing port for easy testing in both directions. The main difference between the Model 210 and the 220 are the Fan Top designs for Pressure and Speed Control connectivity.



Figure 53: Obsolete Retrotec Model 210 has an audio style connection for speed control and only a single pressure connector



Figure 54: Obsolete Retrotec Model 220 has Ethernet-style connections for speed control from the gauge.

## Adjusting DucTester Motor Mount (for Model 220)

If, when rotating, the fan blade rubs on the fan casing, it may be necessary to adjust the motor mount. This can happen when the motor mount inside of the fan shifts slightly, either from being dropped or some other accident. Be very careful before attempting this procedure. Loosening the bolts too far can cause the nut to fall off inside the fan, requiring more extensive repairs. The fan can be sent back to Retrotec for adjustment, if the procedure seems too complicated or troublesome.

### *To adjust the DucTester motor mount*

Remove the ½" Velcro strip from the fan outlet	Use a Phillips Head screwdriver and 5/16" wrench to remove outlet screen.
	
Lightly loosen the four Flange nuts using 7/16" wrench and 5/32" Allen key	Adjust the motor so it overlaps the plastic cylinder.
	
Spin the motor and listen to see if it is rubbing against the plastic. Continue adjusting the motor until it ceases to rub against the plastic.	Tighten the four Flange nuts. Make sure that the motor does not shift as the nuts are tightened. Continue to spin the motor to listen for rubbing.
Once the nuts are tight, and the fan blades have stopped rubbing against the plastic, reinstall the outlet screen.	Retrotec recommends that a field calibration check be performed on the fan after attempting this procedure.
	

## Appendix E: Using a generator for power

Retrotec recommends a generator with inverter type AC power output. Size the generator capacity above the maximum power required in order to reduce distortion of the AC power waveform. The higher the rated power output, the better. Suggestions for minimum generator output sizes are 3000W for Blower Doors and 500W for DucTesters.

**Table 16: Acceptable generator power output.**

Fan	Operating Voltage	Max Operating Current (Watts)	Max Inrush Current	Minimum Generator Power Output
Model 200 Series DucTester	120VAC	2A (240W)	2.5A (300 W)	500 W
	208VAC	N/A	N/A	
Model 200 w/2350 Fan Top	120VAC	2A (240W)	3A (360W)	
	208VAC	0.9A (187W)	1.2A (250W)	



When selecting the generator, look for key words and phrases including:

- “inverter output”
- “utility-grade AC power”
- “suitable for sensitive electronics”

**Table 17: Portable generator AC power output types.**


Type of AC Power Output	Comments/Expectation	
Inverter	Best; Compatible	Recommended
AVR – Automatic Voltage Regulation	Questionable; May not perform	Not Recommended
Brushless	Worse; May not perform	Not Recommended
CycloConverter	Worst; May not perform	Not Recommended

## Generators

<p><b>Honda Generator EU2000 (120V, 2000W, 67 lbs)</b></p> <ul style="list-style-type: none"><li>• Works with all DucTester fan models.</li><li>• Works with both 2200 and 2350 series fans.</li></ul> <p>The Honda EU2000 provides 2000 watts and 120V AC power. It is equipped with an inverter, and is specially designed for sensitive electronic equipment. At 16.7 Amps, it meets the needs of most Retrotec equipment.</p>	 A red and black Honda EU2000 portable generator. It has a carrying handle on top and various outlets on the front.
<p><b>GENYX G3000HI (230V, 3000W) generator</b></p> <ul style="list-style-type: none"><li>• Works with all Retrotec Fans.</li></ul> <p>The G3000HI is equipped with an inverter, and runs at 230V and a maximum of 3000W for even the most powerful Retrotec equipment.</p>	 A yellow and black GENYX G3000HI portable generator. It has a carrying handle on top and a digital display on the front.

## Portable Power Supplies

Portable power supplies can provide enough power for Retrotec DucTester fans, but are unlikely to produce sufficient power for a Blower Door. Please ensure that the power supply meets the minimum power requirements of the fan before attempting to use one.

<p><b>Black and Decker Electromate 400 Model VEC026BD</b></p> <ul style="list-style-type: none"><li>• ONLY use with DucTesters with a 2350 Fan Top (per label).</li></ul> <p>The VEC026BD is a 110/120VAC power supply with a built in 400W inverter.</p>	 A red and black Black and Decker Electromate 400 power supply. It has a carrying handle on top and various outlets on the front.
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## Appendix F: Duct-Test Recording Forms

### Total Duct Leakage Test Form

Test date: \_\_\_\_\_/20\_\_\_\_

Fan Model \_\_\_\_\_ Fan Serial # \_\_\_\_\_ Digital Gauge Serial # \_\_\_\_\_

Address: \_\_\_\_\_ Contact: \_\_\_\_\_ Phone: \_\_\_\_\_

Technician: \_\_\_\_\_

Step	✓		More details and check off
1		Position DucTester near return	Ensure the flex will reach the return grill
2		Turn Air-handler off (if installed)	Put your car keys beside the switch so you remember to turn back on
3		Remove the furnace filter and cover filter opening	
4		Attach flex to return register or access door in the air handler	Attached to __ return register, __ access door
6		Seal all registers	
7		Insert blue tube in a supply register	__ attached to register closest to plenum
8		Open interior and one exterior door	To make indoor and outdoor pressure the same
9		Make connections to the DucTester	__ yellow tube, __ green tube, __ power cord, __ speed control
10		Connect tubes and speed control to the gauge	__ blue tube, __ yellow tube, __ green tube, __ speed control
11		Enter conditioned floor area of the house into gauge	_____ sq ft conditioned floor area
12		Create a 25 Pa pressure in the ducts	Press [Set Pressure], [25], and [Enter]. Press [@] to display “@ 25 Pa”
13		Range Configuration, usually it will be Mid	__ Low, __ Mid __ Open
14		Record Pressure (PrA) and Flow Record Flow with @ 25 Pa displayed. Record n and Time Avg displayed.	_____ Pa _____ CFM with NO @ 25 _____ CFM @ 25 _____ n and _____ seconds of Time Average displayed.
15		Record Flow Direction	__ flow into ducts, __ out of the ducts
16		Record CFM/100 sq ft	_____ CFM/100 sq ft
17		Maximum Allowable duct leakage __ Post Construction: 12 CFM/100 sq ft __ Rough in Air handler installed: 6 CFM/100 sq ft __ Rough in Air handler not installed: 4 CFM/100 sq ft	__ Pass, __ Fail.
18		Remove tape, turn HVAC equipment back ON	Return home to state you found it in

Recording form based on IECC 2009

**Total Duct Leakage Test Form (CA)**

Test date: \_\_\_\_\_/20\_\_\_\_

Fan Model \_\_\_\_\_ Fan Serial # \_\_\_\_\_ Digital gauge Serial # \_\_\_\_\_

Address: \_\_\_\_\_ Contact: \_\_\_\_\_ Phone: \_\_\_\_\_

\_\_\_\_\_  
Technician: \_\_\_\_\_

The DucTester measures the total leakage of a duct system by pressurizing all ducts to 25 Pascals with the air-handler off and the registers taped over.

Step ↓	✓		Detailed Description of the Step
1		Position DucTester near return	Ensure the flex will reach the return grill
2		Turn Air-handler off	Put your car keys beside the switch
3		Remove the furnace filter	Cover filter opening
4		Attach Flange + flex to return register	... or __ access door in the air handler
6		Insert blue tube in a supply register	
7		Seal all other registers	Do NOT seal to the wall or ceiling.
8		Open doors or windows	
9		Connect the DucTester	__ yellow tube, __ power cord, __ speed control, __ green tube.
10		Connect the DM-2	
11		Turn on and set up the DM-2	
12		Create a 25 Pa pressure in the ducts	
13		Range Configuration	__ Low 1" nozzle, __ Mid 2" nozzle, __ Open inlet.
14		Record Flow and Pressure Record Flow with @ 25 Pa displayed. Record n and Time Avg displayed.	__ CFM, __ Pa with NO @ Pressure displayed. __ CFM, __ @ 25 feature used. __ n and __ seconds of Time Average displayed.
15		Record Flow Direction	__ pressurize with flow into ducts, __ depressurize
16		Maximum Allowable duct leakage (per next page) is:	__ CFM, __ Pass, __ Fail.
17		Remove tape	Remove tape from registers.
18		Turn HVAC equipment back ON	Re-install the furnace filter and turn all HVAC equipment back ON

Recording form based on CA Title 24

**New duct systems** must leak less than 6% of the air handler's flow.

Maximum allowable duct tester measurement based on 3 different base system air handler flow is:

For A/C systems multiply the Tonnage X 24 CFM.	TONNAGE ____ X 24 = ____
Assumes 400 CFM per Ton with maximum allowable leakage of 6% = 24 CFM per Ton.	CFM
E.g. a 5 Ton system must have less than 5 X 24 = 120 CFM of leakage at a 25 Pa test pressure in the supplies.	
For Heating systems divide the BTU /1000 X 1.302 CFM.	BTU ____ /1000 X 1.302 = ____ CFM
Assumes 21.7 CFM per 1000 BTU capacity with maximum allowable leakage of 6% = 1.302 CFM per 1000 BTU.	
E.g. a 100,000 BTU furnace must less than 100,000 / 1000 X 1.302 = 132 CFM of leakage.	
Measure the fan flow divided by 100 X 6.	Measured fan flow ____ / 100 X 6 = ____ CFM
E.g. an air-handler blower flow of 2000 CFM must have less than 2000 / 100 X 6 = 120 CFM of leakage.	

**Existing duct systems** must leak less than 15% of the air handler's flow.

The Maximum allowable duct tester measurement based on 3 different base system air handler flow is:

For A/C systems multiply the Tonnage X 60 CFM.	TONNAGE ____ X 60 = ____
Assumes 400 CFM per Ton with maximum allowable leakage of 15% = 60 CFM per Ton.	CFM
E.g. a 5 Ton system must have less than 5 X 60 = 300 CFM of leakage at a 25 Pa test pressure in the supplies.	
For Heating systems divide the BTU /1000 X 3.255 CFM.	BTU ____ /1000 X 3.255 = ____ CFM
Assumes 21.7 CFM per 1000 BTU capacity with maximum allowable leakage of 15% = 3.255 CFM per 1000 BTU.	
E.g. a 100,000 BTU furnace must have less than 100,000 / 1000 X 3.255 = 326 CFM of leakage.	
Measure the fan flow divided by 100 X 15.	Measured fan flow ____ / 100 X 15 = ____ CFM
E.g. an air-handler blower flow of 2000 CFM must have less than 2000 / 100 X 15 = 300 CFM of leakage.	

## Glossary

Term	Definition
<b>ACH50 or ACH @ 50 Pa</b>	Designation for “Air Changes at 50 Pa.” Can be calculated by taking CFM50 x 60 minutes/ hour, and dividing by the house volume
<b>Aluminum Frame</b>	Describes a frame over which cloth is stretched to provide a Door Panel closure for air leakage testing in buildings
<b>Baseline pressure</b>	Pressure that exists when the enclosure has been prepared for the test, but before the fan is activated. There is always some Baseline pressure due to stack, wind, flues and active HVAC systems. There are two components of Baseline pressure. A fixed Baseline offset (usually due to stack or HVAC) and a fluctuating pressure (usually due to wind or elevator operation). A method determining Baseline pressure is by having a digital gauge accumulate readings over an adjustable time period (Note: The terms “static pressure”, “bias pressure,” and “zero Fan Pressure difference” are used interchangeably with the term Baseline Pressure in other documents/standards used in the industry.)
<b>Blower</b>	The Retrotec fan unit that induces air flow and provides a Fan Pressure signal from which flow is measured.
<b>CFM</b>	Units: Cubic feet per minute (the units of volumetric flow)
<b>CFM50 or CFM @ 50 Pa</b>	CFM @ 50 Pa is the flow rate, in cubic feet per minute, required to depressurize/pressurize the building to 50 Pascals.
<b>Conditioned Space</b>	An area or volume that is normally air-conditioned or heated (i.e., inside the thermal envelope). Even though supply ducts may not discharge directly into these spaces, they are considered “conditioned” if their temperature follows indoor temperature closer than outdoor. (e.g., Any space maintained above 50°F in winter and below 80°F in summer)
<b>Control port</b>	Ethernet port on a Retrotec fan, labeled “Control”
<b>Depressurization</b>	The process of creating a negative pressure in the enclosure by blowing air out of it. Air is drawn in from outside to replace it, showing up as “geysers” when checked with an air current tester.
<b>digital gauge</b>	A gauge with an electronic pressure sensor and digital display that is capable of reading in tenths of a Pascal.
<b>DOE</b>	U.S. Department of Energy
<b>Blower Door</b>	A test instrument that fits into an open doorway in order to pressurize or depressurize an enclosure. It includes a calibrated fan and pressure gauge capable of measuring air-flow, and is used while mounting it into a doorway. A Blower Door is often called a “Door Fan” or an “Infiltrometer™”. The term “Door Fan” is more descriptive than the common term “blower door”, since the apparatus is a “fan” in a door, and since it does not use a “blower.”
<b>Door Panel</b>	A solid or flexible panel used to temporarily seal off a door way while allowing for the installation of a fan for the purpose of blowing air into the building in order to measure the air leakage rate or to provide a pressure to assist in the location of air leaks.
<b>effective leakage area</b>	A common term used to describe air flow at a pressure by equating it to an equivalent size hole in an elliptical nozzle that would pass the same air flow at the same test pressure. It is usually referenced to 4 Pa and incorporates a 1.0 discharge coefficient. It is typically about half the size of an equivalent leakage area that describes the same air flow rate. See ASTM E779-10, eq. (5).
<b>enclosure</b>	The surface bounding a volume, which is connected to outdoors directly. For example an apartment whose only access to outdoors was through a doorway that leads directly outdoors. If a building contains a series of apartments or offices whose only access to the outdoors is through a common hallway then the enclosure would be the volume that bounds all of the apartments or offices.
<b>Envelope</b>	The surfaces composed of floor and walls and floors that separate the test volume from volume surrounding the test volume. Also see “enclosure”
<b>Equivalent Leakage Area (ELA or E<sub>q</sub>LA)</b>	In layman’s terms, the ELA is the size of hole we’d have if all the building’s cracks and holes could somehow be brought together. Also called: Whole Room Leakage and includes leaks through the ceiling and below the ceiling (BCLA). In Engineer’s terms: the equivalent size of hole required in a flat plate to give the same flow rate having a discharge coefficient of 0.61 and taken at the Reference Pressure.

Term	Definition
	<p>This ELA is sometimes called the EqLA or Canadian ELA because it was first used in the Canadian GSB air leakage standard for houses. This ELA enjoys worldwide acceptance by most testers, even in the US. This ELA should not be confused with another ELA that is often called the EFLA or Effective Leakage Area. It is very unfortunate that both these ELA's have the same acronym of ELA. The EFLA was developed for the US ASTM Standard and is smaller than the EqLA by at least a factor of 0.61 because it uses a discharge coefficient of 1.0. This EFLA is sometimes called the LBL or Lawrence Berkley Labs ELA because it was developed there and is used in the LBL natural Air Change model that enjoys wide usage. Apart from that usage, the EFLA is not used very much but the existence of both can create huge problems.</p> <p>When it is taken at a Reference Pressure of 75 Pa, it is often referred to as EqLA75. EqLA is typically about twice the size of an effective leakage area that describes the same air flow rate. See ASTM E779-10, eq. (5).</p>
<b>Fan Pressure</b>	The pressure difference between the inlet side of the fan and the interior of the fan.. This pressure can be read as "PrB" from Channel B on the gauge. It is used by the computer to calculate the air flow rate through the Blower Door.
<b>Fan Top</b>	<p>Part on the fan where the fan's tubing, Control Cable, and power connections are.</p> <p>The Fan Top for the Model 200 refers to the two mounted red plates attached to the sides of the fan. Attached behind them are Printed Circuit Boards (PCBs). In this manual, we will refer to the "Control PCB assembly" as the one that has "Control" printed on the mounting plate. We will refer to the "Power PCB assembly" as the one with the power switch on it, and has "Mains Power" printed on it.</p>
<b>HVAC</b>	Heating Ventilating and Air conditioning.
<b>Leakage</b>	A general term used to describe holes or the area of holes in in the envelope around an enclosure.
<b>Leakage Area</b>	This is the same as "Leakage" but expressed in sq ft or m <sup>2</sup> .
<b>LEED</b>	Leadership in Energy and Environmental Design
<b>Low-Flow Cloth Door Panel</b>	Cloth Door Panel used to test tight enclosures with a Model 200 fan
<b>Manual Speed Control Knob</b>	The dial that is on a Fan Top to control fan speed
<b>Open Range</b>	A Range configuration on a Retrotec Blower Door that has no Range Rings or Range Plates attached. It is sometimes referred to as Open (22) Range since it's diameter is 22 inches.
<b>outdoors</b>	Outside the building in the area around the building.
<b>Pascal (Pa)</b>	Often shown as "Pa". A very small metric unit of pressure. There are 249 Pascals in 1 inch Water Column (the pressure required to push water up 1 inch in a tube). One Pascal = 0.000145 psi.
<b>Pressurization</b>	The process of creating a positive pressure in the house by blowing air into the enclosure. Air is pushed out through all the leaks, causing the smoke to move away from the operator when checked with an air current tester.
<b>Range Plate</b>	The Range attachment on the Retrotec Door, which holds Ranges C8, C6, C4, C3, C2, C1, L4, L2, and L1. See Retrotec's <i>Range Configuration QuickGuide</i> .
<b>Range Ring</b>	The plastic Range attachments on the Retrotec Blower Door, which include Range A and Range B. See Retrotec's <i>Range Configuration QuickGuide</i> . On the DucTester, Range rings are called Mid and Low.
<b>reading</b>	A set of simultaneous Room Pressure and Fan Pressure measurements. Sometimes referred to as a data set or test point because it is plotted as one point on a graph.
<b>reference pressure</b>	The pressure at which the ELA is calculated, usually at the test pressure.
<b>room</b>	See "Enclosure".
<b>room pressure</b>	The pressure difference created by the Blower Door between inside and outside of the enclosure. This pressure is commonly measured by Channel A on the gauge.