rev-2020-04-27

Residential DucTester

Operation Manual

Model 350x & 350 DucTester Systems

Made by Retrotec Inc.
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Manual for:
Models 350x with DM32 and Model 350 with DM32 WiFi

Retrotec test fans, blower door systems, duct testing systems and gauges have been calibrated in our laboratory which is accredited by the ANSI-ASQ National Accreditation Board to meet requirements of international standard ISO/IEC 17025:2005. All pressure and flow devices used in the calibration are traceable to the National Institute of Standards and Technology and themselves have ISO 17025 accreditation.

Retrotec equipment and software complies with the following standards:
ASTM E779-10, ASTM E-1554, ATTMA TSL1, ATTMA TSL2, CGSB 149.10, DW/143, Energy Star, EN12237, EN13829, EN15004, FD E51-767, ISO 9972-2015, ISO 14520-2006, NEN2686, NFPA 2001-2015, RESNET, SMACNA-2002, All USA State Energy Codes, Title 24 and USACE Protocol.

Custom calibration available upon request

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Important equipment-related safeguards

When using electrical appliances, basic safety precautions should always be followed. If Retrotec equipment is used in a manner that does not follow the information provided in this manual, safety to the operator and equipment performance may be impaired.

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. Why measure Duct Leakage?

1.1 Energy loss

Leaky ducts pose health, safety and comfort problems and account for a portion of the total energy lost in a typical house.

1.2 Duct sealing saves money

A study ...

1.3 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.

2. How much duct leakage is acceptable under existing Codes?

How much duct leakage is acceptable? The table primarily shows standards for new buildings. Changes occur as countries adopt the new codes.

The leakage factor (f) shall be lower than the air leakage limit (f_{max}), corresponding to the required air tightness class, specified below, for any test pressure (p_{test}) lower than or equal to the design operating pressure (p_{design}).

The requirements shall be satisfied for positive and negative pressures.

<u>air leakage factor</u>, *f*, is the leakage flow rate per unit surface area of the duct (f = q / A) in units $m^3/s/m2$ or l/s/m2

Table 1: Duct Leakage Compliance Values according to existing Codes

<table>
<tr><th>Program/Region</th><th>Units/Test Pressure</th><th>Leakage requirement</th></tr>
<tr><td>EN12237 (Europe)</td><td>Airtightness limit, $m^3/s/m^2$</td><td>
<table>
<tr><th rowspan="2">Airtightness Class</th><th colspan="2">Static pressure limit (p_s), Pa</th><th rowspan="2">Airtightness limit, f_{max}, $m^3/s/m^2$</th></tr>
<tr><th>Positive</th><th>Negative</th></tr>
<tr><td>A</td><td>500</td><td>500</td><td>$0.027 \times P_t^{0.65} \cdot 10^{-3}$</td></tr>
<tr><td>B</td><td>1000</td><td>750</td><td>$0.009 \times P_t^{0.65} \cdot 10^{-3}$</td></tr>
<tr><td>C</td><td>2000</td><td>750</td><td>$0.003 \times P_t^{0.65} \cdot 10^{-3}$</td></tr>
<tr><td>D*</td><td>2000</td><td>750</td><td>$0.001 \times P_t^{0.65} \cdot 10^{-3}$</td></tr>
</table>
P in pascals
*ductwork for special applications
</td></tr>
<tr><td>DW/143 (UK)</td><td>Air Leakage Limit, $l/s/m^2$</td><td>
<table>
<tr><th rowspan="2">Duct Pressure Class</th><th colspan="2">Static pressure limit</th><th rowspan="2">Max Air Velocity, m/s</th><th rowspan="2">Airtightness limit, $l/s/m^2$</th></tr>
<tr><th>Positive</th><th>Negative</th></tr>
<tr><td>A – Low pressure</td><td>500</td><td>500</td><td>10</td><td>$0.027 \times P^{0.65} \cdot 10^{-3}$</td></tr>
<tr><td>B – Medium pressure</td><td>1000</td><td>750</td><td>20</td><td>$0.009 \times P^{0.65} \cdot 10^{-3}$</td></tr>
<tr><td>C – High pressure</td><td>2000</td><td>750</td><td>40</td><td>$0.003 \times P^{0.65} \cdot 10^{-3}$</td></tr>
</table>
P in pascals
</td></tr>
<tr><td>FD E51-767 (France)</td><td>Airtightness limit, $m^3/s/m^2$</td><td>
<table>
<tr><th>Air Sealing Class</th><th>Airtightness limit, f_{max}, $m^3/s/m^2$</th></tr>
<tr><td>A</td><td>$0.027 \times P_{test}^{0.65} \cdot 10^{-3}$</td></tr>
<tr><td>B</td><td>$0.009 \times P_{test}^{0.65} \cdot 10^{-3}$</td></tr>
<tr><td>C</td><td>$0.003 \times P_{test}^{0.65} \cdot 10^{-3}$</td></tr>
<tr><td>D</td><td>$0.001 \times P_{test}^{0.65} \cdot 10^{-3}$</td></tr>
</table>
P in pascals
</td></tr>
</table>

3. Model 300 / 400 System Types:

The Model 350 shares its body and inlet nozzles and Flow Plates with several other models as shown below. Each one is specialized for a certain application. The Model 340 is used primarily in the US for relatively leaky US made ducts. The Model 350 is for tighter European ducts that often have to be 100 times tighter than US ducts. The Model 301 is simply the same fan but attached to a door panel for testing tight houses, apartment, rooms or enclosures. The Model 450 is meant exclusively for testing commercial ducts at 10 to 100 times the test pressure used for US residential duct that are tested at 25 Pa normally and sometimes 50 Pa. the Model 450 has 10 times the power and is much heavier than the 450 but still a fraction of the old fashioned Commercial duct testers in common use.

This manual focuses on the Model 350. Be sure to refer to the Quick Guide that came with your system or can be obtained retrotec.com.

340x	350x	300x	440x/450x
			
The US DucTester system is powerful enough to test leaky ducts that are found in both new and existing homes. New ranges will go down to tight ducts also.	‘European DucTester’ tailored for European ducts. Comes with all the Ranges needed for the tightest ducts but just add the aluminum frame to test houses.	The Model 300x is ideal for testing tight houses as large as a 1600 square feet of floor area that leak as much as 3 Airchanges per Hour.	Commercial duct testing up to 20 in WC (5000 Pa) in a compact package.

4. Types of Duct Leakage Tests

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 later sections.

In the US, duct leakage to outdoors is measured but in Europe the ducts are up to 100 times tighter so where the duct leaks to is somewhat irrelevant.

This is a schematic of a duct leakage test. Registers are sealed, the duct tester fan is connected to a return and the pressure gauge picks up the pressure in the ducts.

Locate the step by step Quick Guide that came with your equipment or access it at www.retrotec.com.

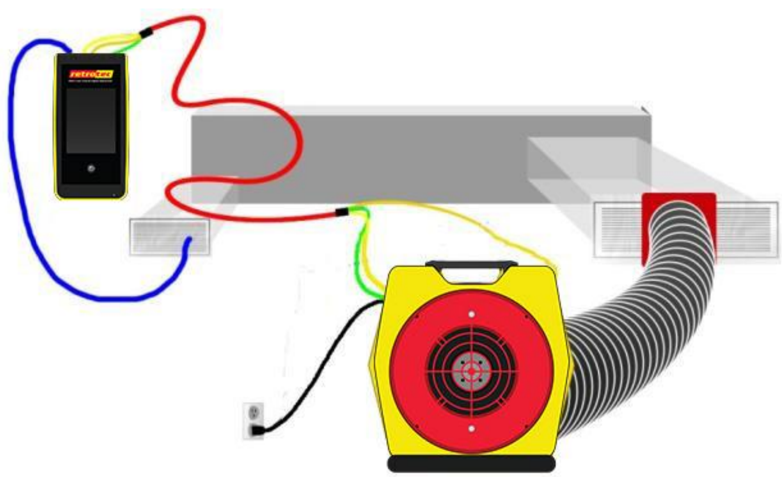

Figure 1: DucTester setup, including tubing locations and necessary connections.

5. Model 350 DucTesters

Models include 350x and 350 with 4 inch Flex Duct

A complete DucTester includes a calibrated fan, a digital dual-channel Model DM32 digital touch screen 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 for other non-typical tasks.

Figure 2: A complete duct testing system.

5.1 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 xx. For procedures on how to test an enclosure using a Blower Door system, see *Residential Pressure & Air Leakage Testing Manual* from the Retrotec web site.

5.1.1. Range Configurations

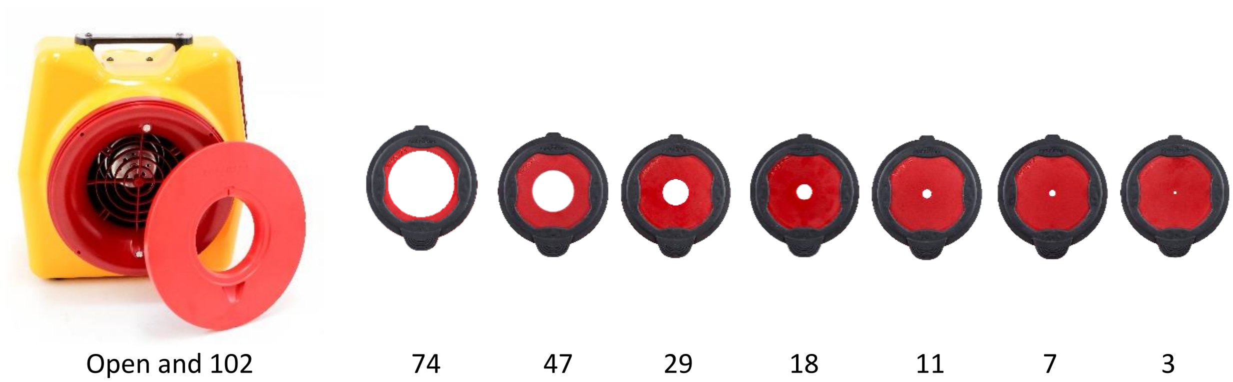

Figure 3: Range 102 is for the leakiest ducts while the smaller ranges are for progressively tighter ducts.

All Retrotec calibrated fans have multiple Range Configurations in order to measure a wide range of air leakage flow rates. Select the correct Range Configuration by running the fan speed up to ensure it is running at over 50% speed and the gauge is giving a flow result. If not change to a lower range and repeat.

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 is calculated using flow equations that are inside the Retrotec gauge and FanTestic software.

When the fan slows down, the Fan Pressure can become too small to accurately measure flow. 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 approximately 0.17 m^3/h (0.1 CFM) to 1388 m^3/h (817 CFM).

The Model 300 has 9 standard Range Configurations: Open, 74, 47, 29, 18, 11, 7 and 3. Open range is not used for testing ducts but when testing houses, it is accessed by removing the cover over the fan inlet called End Plate 300 which may be taped in place. The numbered Ranges are 100 mm Plugs that snap into the End Plate 300 and will restrict the flow to allow you to measure lower flow rates. The numbers refer to the approximate hole diameter in millimeters. Most residential ducts in new homes can be tested using Range 7. Older existing houses can be tested using Range 11 or higher.

When depressurizing, the Flex Duct must be removed in order to change the Ranges.

Refer to the DM32 Flow Calculator on retrote.com for Range Plug flow capacities.

* Flow with no backpressure. Flow will vary depending on the following factors: voltage, frequency, barometric pressure, backpressure, blade pitch, air temperature, bearing tightness, inlet air turbulence

5.1.2. Retrotec calibrated fan: Model 300

The Model 300 fan has 165 Watt backward curved impeller that uses 48 Volts that comes from the supplied power supply. Any input voltage from 100 to 280 Volts AC, 50 to 60 Hz is acceptable. Speed is controlled using the knob on the 300 fan or the Retrotec digital gauge, which will control the fan to any desired Set Pressure or Set Speed.

The Model 300 Fan has a speed control built into the Fan Top with a power input connection, a speed control knob, an on/off switch, and the Fan Pressure fittings all on one Control Panel. Two CAT-5 connectors are used to connect to any Retrotec gauge for speed control purposes; not to be connected to the Internet. The second CAT-5 connection allows this fan to be daisy chained to a second fan, making them receive the same % speed signal thereby making two fans run in unison. The control signal from one gauge will run both fans.

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Figure 4: Retrotec Model 300 has a speed control knob and two Ethernet style Speed Control Ports for daisy chaining speed controls for running many fans together. The yellow and green color coded tubing connections to the gauge are shown.

The Model 300 has 4 Flow (Fan Pressure) sensors located inside the fan inlet, and 4 self-referencing pickups located just above and below the fan inlet which are connected to the single green and yellow ports.

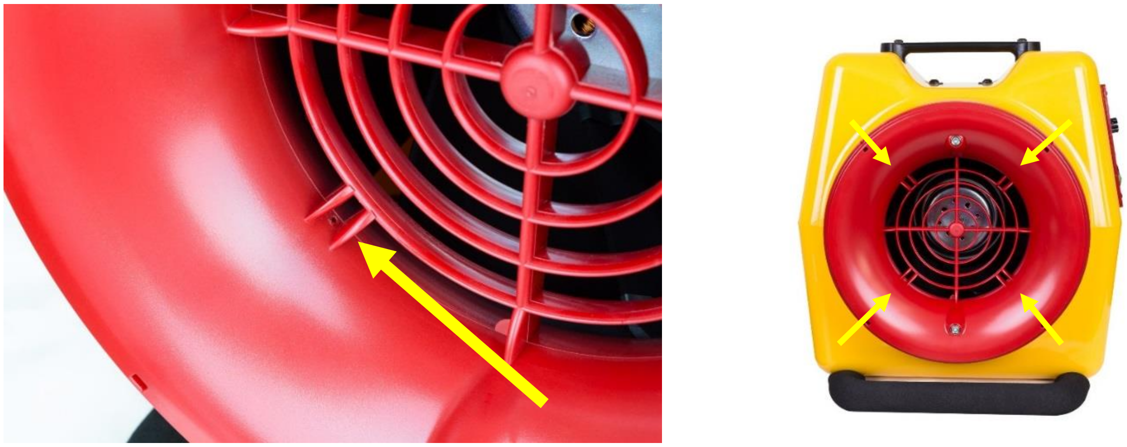

Figure 5: Fan Pressure sensors are located in the fan inlet.

The 4 Flow 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.

The exterior of the inlet has the 4 self-referencing pressure pickups. They are connected to the green Input B port, and are used as the reference for the Flow (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 and whether or not a flex duct is attached to the inlet of the fan or not.

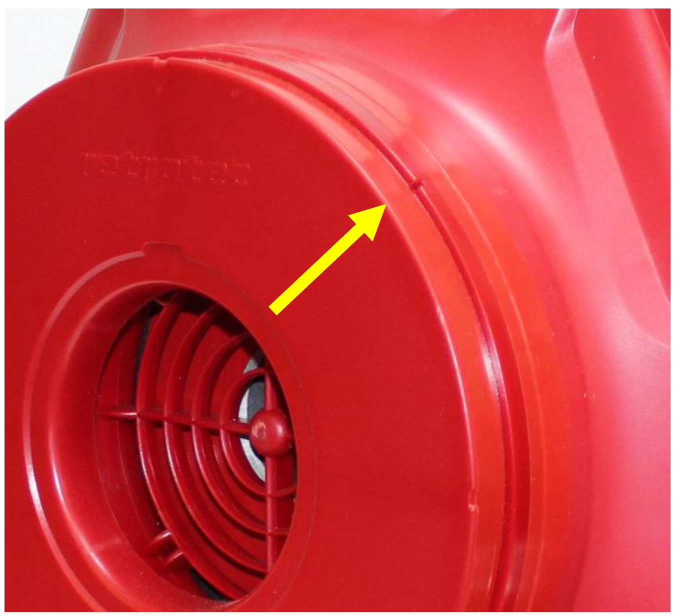

Figure 6: Self-referencing pressure pickup connect to the green port and must never be taped over.

5.2 Digital Gauge

Figure 7: DM-32 digital gauge.

Model 350 use the DM32 gauge while Model 352 signifies the WiFi enabled gauge that works exactly the same in every other respect.

The latest Retrotec Digital Gauge is included with all Retrotec DucTester systems. The gauge can be combined with the Model 300 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.

For more information on configuring and using the DM-32, see the *DM-32 Operation Manual*.

5.3 Flex Duct

Retrotec's duct testing systems US350 include a 4" diameter, 12' long flexible duct to connect the test fan to a register, or duct system. The 250 mm Adapter friction fits over the inlet OR outlet of the fan to provide a quick means to test in both the depressurize and pressurize directions.

Figure 8: Flex Duct for duct testing system with 250 to 100 mm Adapter.

5.4 Additional included duct testing components

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

5.4.1. 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.

5.4.2. Umbilical for connecting fan and DM32 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 DM32 to communicate with the fan. For detailed instructions on how to connect the DucTester fan and the DM32 gauge using the Umbilical, refer to section 6.1.

5.4.3. 10 to 4 inch adapter

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 **6.6**.

5.4.4. Set of Adapters.

Adapters inclued begin with a 100 to 100 mm metal collar. Into this you may plug in the 100 to 75mm, 100 to 100 mm, 100 to 125 mm, 100 to 150 mm or 100 to 200 mm adpaters. There is also a 100 to open end that may be used to connect to a flat surface.

5.4.5. Toolbag keeps all testing components in one place

The Deluxe Cordura Tool bag 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.

5.4.6. Tubing Accessory Kit

The Tubing Accessory Kit comes with blue, red, yellow and green pressure tubes approximately 37 ft each, 1/8” inner diameter (11 m each, 3 mm ID), four short male-to-male pressure tube connectors, two T-connectors for pressure tubes, a Static Pressure Probe, and a metal tube. 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 metal tube can be passed through a small such as under a door or window to prevent the tube from being pinched, and affecting the pressure reading.

5.4.7. Power Cord

The power cord is used to power your Model 300 fan. Once it is connected to a wall outlet, the Mains Power status light turns green, indicating power is connected.

5.4.8. 9v Power Supply adapter for charging DM32 gauge

A battery charger is included to charge the DM32 gauge’s batteries. For instructions on charging the DM32 batteries refer to the DM32 Manual.

5.4.9. Additional parts and accessories for the DucTester

For options and accessories look at:

https://retrotec.com/product/accessories.html

....all on the Retrotec website

For more information on these parts, contact:

sales@retrotec.com

6. Prepare for the Duct Leakage Test

6.1 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.

6.2 Charge the gauge

The rechargeable batteries should be charged when you get it but leave it on the charger overnight to make sure. These rechargeables will save you about $300 per year so it's worth having a charger with the equipment and one in your vehicle. Battery life is about 11 hours on a single charge with WiFi disabled. Battery life will last 9 hours on a single charge with WiFi enabled.
The batteries will charge more quickly if the DM32 is turned off and when plugged to a wall outlet (instead of to a computer). A large battery icon will be displayed on the screen, as shown below.

Figure 9: The screen of the DM32 while the batteries are being charged.

6.3 Follow the Quick Guide that came with your system

The Quick Guide is intended to walk you through the test Step by Step. Check it off as you go. Use this manual for additional guidance and watch the videos on the Retrotec website and take the on-line training course.


351/352 DucTester QuickGuide

Umbilical
Gauge case
DucTester
Range Plugs
QuickGuides
Extra tubing
DM32 gauge (Battery included)
Tubing Accessory Kit
Battery Charger

Unpack, connect gauge

Check boxes for each step.
- ☐ Remove everything from the case.
- ☐ Press on the gauge, then tap the screen, and check the battery state indicator at the top right:
- ☐ If the battery display is not green, connect USB to power outlet to charge the gauge.
- ☐ Connect yellow, green and blue tubes to the gauge.

Gauge remains connected like this for all tests.

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6.4 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.

6.4.1. 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.
1. Remove all filters inside the ductwork including any filter that is behind the return grill (that the DucTester will be connected to).
2. Seal off all remaining supply and return registers using Grill Mask. A roll is provided with all DucTester systems.

Figure 12: Turn off the air handler

Figure 10: Seal all supply and return registers with Grill Mask

Figure 11: 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.

3. 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.
4. Turn off all exhaust fans, dryers, and room conditioners.
5. Turn off vented combustion appliances, if there is a possibility that the area containing the appliance will become depressurized during the testing procedure.
6. 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 8.1). 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.

6.5 Make all connections on the gauge and fan

1. 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 13: Pressure ports on the top of the gauge are color-coded to match the tubing.

Figure 14: Electrical connections on the bottom of the gauge include Network (Ethernet) Cable that goes from the DM32 to a PC (if Retrotec PC software is used for data collection), micro USB cable for PC software and/or charging, and a reset button.

2. 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 15: Model 300 Fan Top with power cord, color-coded tubing connections (green and yellow) and Control Cable.

3. 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.
4. Connect the yellow and green tubes on the fan.
5. 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 16: Insert the blue tube into a supply register closest to the air handler

6. If the rechargeable batteries in the DM32 are below one quarter power, the battery charger should be connected to the micro-USB port on the DM32. Charge them fully overnight.
7. To test control of the fan, press **[Set Speed] [20] [Set]** on the DM32. This sets the fan to 20% speed. The preferred method is using **[Set Pressure] [25] [Enter]**. (Some standards require 50 Pa).
8. Press **[Stop]** to stop the fan.

For details on DM32 operation, see DM32 manual.

6.6 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 17: 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.

6.7 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 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.

6.7.1. 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.

7. Choose the main return with the most direct connection to the air handler. Remove filters behind the return grill.
8. Attach the Flange to the return grill using Grill Mask or high quality masking tape. Seal the remaining openings with Grill Mask.
9. 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.
10. Place the DucTester in such a position as to minimize any major bends in the Flex Duct.

Figure 19: Flange taped onto a return register before attaching the Flex Duct

Figure 18: Flex Duct connected to the Flange.

6.7.2. 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.

Figure 20: Preparing to connect to ducts via air handler

11. 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 Range 74dle of the piece of cardboard that is slightly smaller than the square Flange.
12. 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.
13. 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.
14. 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.

6.7.3. 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 10.3.

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.

6.8 Install Range Configuration on fan

Each Retrotec DucTester includes three Range Configurations to maximize accuracy and versatility: Open, 74, 47 and 29 as standard. 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.

Figure 21: Inserting a range plug into the end plate.

Use a Range with a larger opening for leakier ducts and smaller opening 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, "-----"will appear on the DM32 gauge display indicating you must change to a more restrictive range.

6.9 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.

6.9.1. Setting up for depressurization

1. Install Range 47, since most systems can be tested on this Range Configuration. For more information about selecting and changing Range Configurations, refer to section 6.8.
2. Install the Flex Duct over the fan inlet, covering the Range Rings and tighten the strap.

Figure 22: Install Flex Duct over the fan inlet, covering the Range Rings, for depressurization.

6.9.2. 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 23: Install Flex Duct over the fan exhaust, for pressurization.

7. Set up the gauge to display Duct Leakage Results

Read the Total Duct Leakage results directly from the gauge on 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.

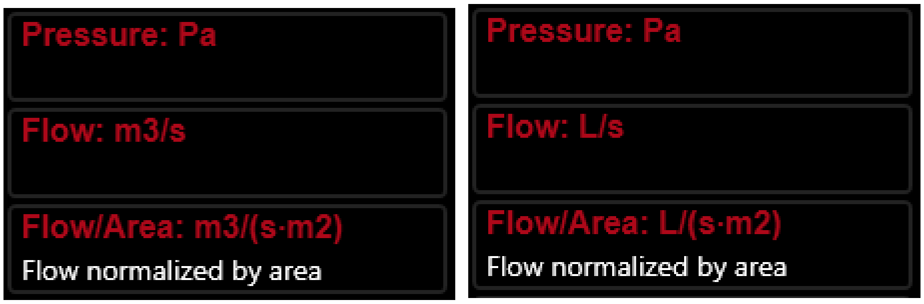


Figure 24: Some of the most common results that can be read directly off the gauge.

7.1 Mode Setup for various standards around the world

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

Table 2: Gauge Mode Setup for various standards around the world

Standard	EN 12237	DW/143	FD E51-767
Region:	**Europe**	**UK**	**France**
Pressure	Pa	Pa	Pa
Flow	m^3/s	l/s	m^3/s
Flow per Area of Conditioned floor area	$m^3/s/m^2$	$l/s/m^2$	$m^3/s/m^2$

7.2 Setting up and using the DM32 gauge for Duct testing

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

   Tap **[Channel B]** on the screen to select a different Result, or tap the **[Result to be displayed]** button in the **[Settings]** menu. Typically, choose between Flow or Flow/Area.

   Units for flow are typically m^3/s or l/s, and units for Flow/Area are typically $m^3/s/m^2$ or $l/s/m^2$.

   If Flow/Area is the Result is selected, the **[Area]** button will be appear on the Home screen. Tap the **[Area]** and enter a value to change the area in units of m^2. The **[Area]** can also be changed from the **[Settings]** menu.

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

   Press the **[Device]** button (fan icon from the Home screen) and select **[350].**

   Next, select Range Configuration **[74]**. If Range Ring installed on fan is not Range 74-Range, adjust the setting on the gauge to match what is installed.

5. Set up the gauge for proper time averaging.

   Press the **[Settings]** button and toggle **[Time Averaging]** to get "5 seconds", or go to 10 seconds if results are fluctuating.

6. Adjust fan speed on DucTester

   Use **[Set Pressure]** on gauge: Press **[Set Pressure]** on DM32 gauge's Home Screen, then **[500]** or (another test pressure)**, [Set]**. The fan will automatically accelerate and maintain a pressure of 500 Pa in the duct system. Press **[@]** button until "@ is On" is displayed to view the result at exactly 500 Pa.

   OR

   Use **[Set Speed]** on gauge: Press **[Set Speed]** on DM32 gauge's Home Screen, then **[50], [Set]** to set the fan speed to 50%. Press **[▲]** or **[▼]** buttons to adjust the speed until Duct Pressure (Channel A) displays close to 500 Pa. Press **[@] button** until "@ is ON" is displayed to view the result estimated at 500 Pa. If your standard requires 1000 Pa, change the **[Default @ Pressure]** to 1000 Pa from the **[Settings]** menu.

   OR

   Use the manual Speed Control Knob on the Fan Top. Increase the fan speed until a stable pressure of 500 Pa (or -500 Pa) is displayed for Duct Pressure (Channel A). Press **[@]** button until "@ is ON" is displayed to view the results at exactly 500 Pa. If your standard requires 1000 Pa, change the **[Default @ Pressure]** to 1000 Pa from the **[Settings]** menu.

7. If "--" 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 6.8).

8. Conduct the Duct Leakage tests

8.1 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. 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 25 for Total Duct Leakage under depressurization and Figure 26 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.

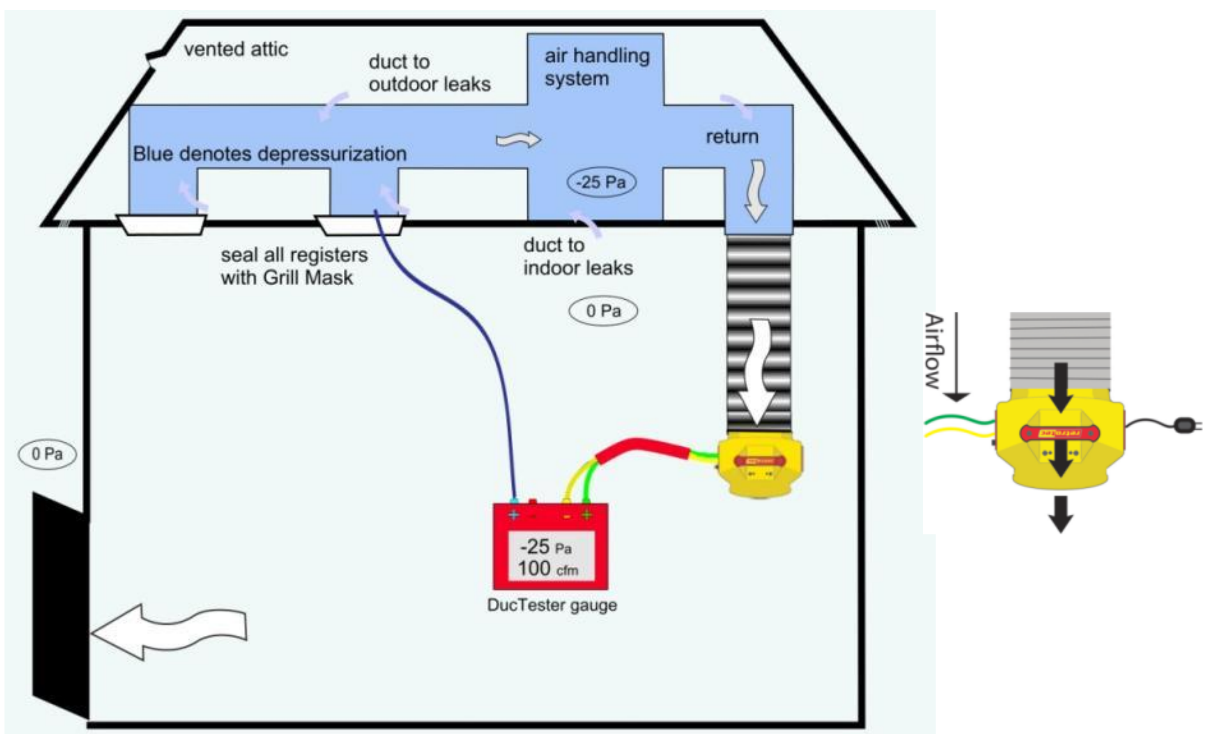


Figure 25: Total Duct Leakage under depressurization - DucTester and tubing setup.

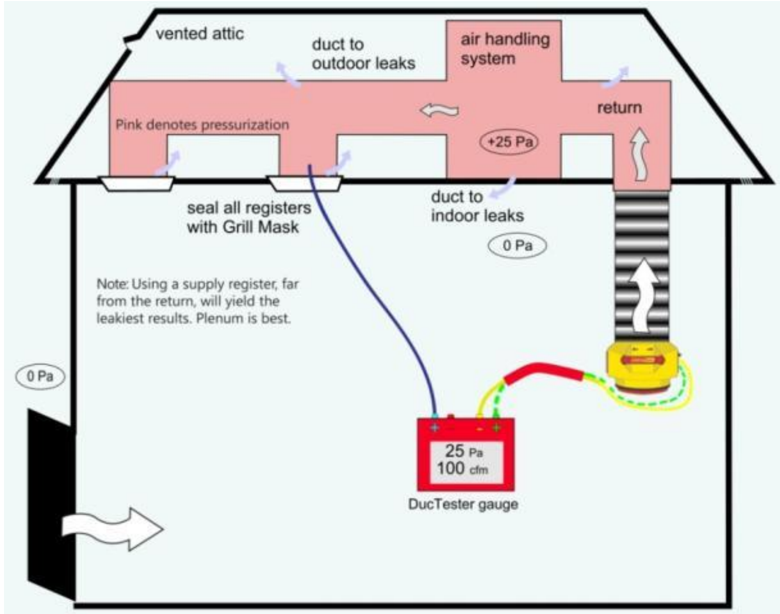
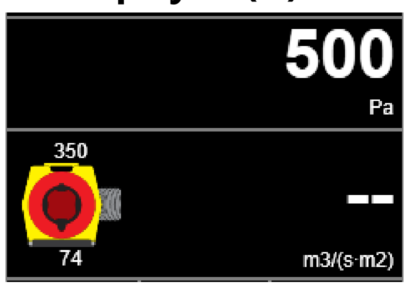


Figure 26: Total Duct Leakage under pressurization - DucTester and tubing setup.

8.2 If no Results are displayed (--)



If the target pressure has been reached, but "--" 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 Configuration on the gauge to match the Range Ring installed on the fan.
3. Re-adjust DucTester fan speed.

If the Range Ring installed is the smallest hole, there are no more Range Rings to install, and "--" still appears:

1. Make sure Range Configuration on the gauge actually matches 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 Channel A pressure 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 Channel A 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 Channel A. If the flow still reads "--" 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 "--" 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 "--", 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).

8.3 Cannot achieve test pressure

If the DucTester fan reaches 100% speed on the "Range 74" 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 Configuration setting on the gauge to match the fan.
3. Re-adjust DucTester fan speed.

If there is 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:

4. If the duct pressure is close to the required test pressure (within 5 Pa), use the **[@]** key to extrapolate to what the flow would be at the desired pressure.
5. Try the Duct Leakage to Outdoors test, which will neutralize duct leakage to the house.
6. 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.

9. 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.
2. Replace all filters from the return(s) and air handler.
3. Turn the furnace, air conditioning, HVAC system back on.
4. Ensure any combustible appliances that were turned off are turned back on, and that they are properly vented again.
5. Unseal any closed ventilation, or reconnect the ducts if it was disconnected.
6. Close any exterior doors or windows that were opened during total duct leakage test.

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

9.1 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.

9.2 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 inject it into the flex duct just after the fan. Injecting the smoke directly into the fan motor will void the warranty of your DucTester. Use of the quick connect collar aids in this operation. 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.

9.3 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.

9.4 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.

9.5 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 27: Pressure Pans, large and small shown

Table 3: 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 theRetrotec *Residential Pressure & Air Leakage Testing Manual*

10. Measure the Air Handler system flow

10.1 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.

10.2 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.

10.3 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.

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.

Figure 28: Measuring air flow with a Powered Flow Hood

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.

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 Channel A 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] [Set]** 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 will 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.

10.4 Measure with a DucTester on the air handler cabinet

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 Channel A 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 **[@]** 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 **[@]** 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 "---"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.

10.5 Measure with a gauge and a flow grid

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

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 Channel A 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 **[@]** 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]**, **[Set]** to get the DucTester to recreate the original pressure in the plenum. Press the **[@]** 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 "---"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.

10.6 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 pressing **[Settings] [Result to be Displayed]** and toggle the **[Pressure]** button until the desired units is displayed, 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.

10.7 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 device to “HoleFlow”. 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.

10.8 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 Channel A 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]**, **[Set]** to get the Blower Door to recreate the original pressure in the plenum. Read the CFM result directly from the gauge

If “---“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.

10.9 Other methods

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

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

Download the Pressure Gauge Operation Manual for DM32 from:

http://retrotec.com/sites/default/files/manual-guides-specs/Manual-DM32%20Operation.pdf

and look at the Section named "Verify your gauge accuracy between factory calibrations".

You will also Field Check the tubes using the procedure outlined there.

This test requires one color of tube be connected between channel A and B. 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.

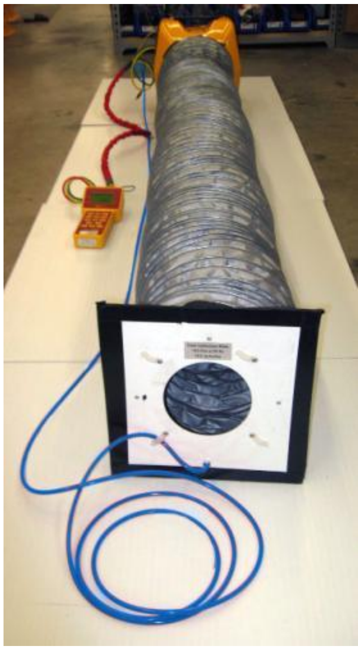
Pressure dropping to zero in 10 seconds or less indicates a leak somewhere; try another tube and try the same tube on a different port to see which piece is faulty, the tube or the gauge. If the tube end is damaged, slice 1/8 inch off the tube and try again.

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

11.2 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. Install Range 74 Flow Plug and set same Range on the Gauge.
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] [Set]** and the fan will automatically control to 25 Pa. Press **[@]** 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 29: 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 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 the @ Pressure function is turned on during this test because it creates a divide by zero error. Press **[@]** to remove "@" from under the result. 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 use your duct testing fan as 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 30 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 30 below:

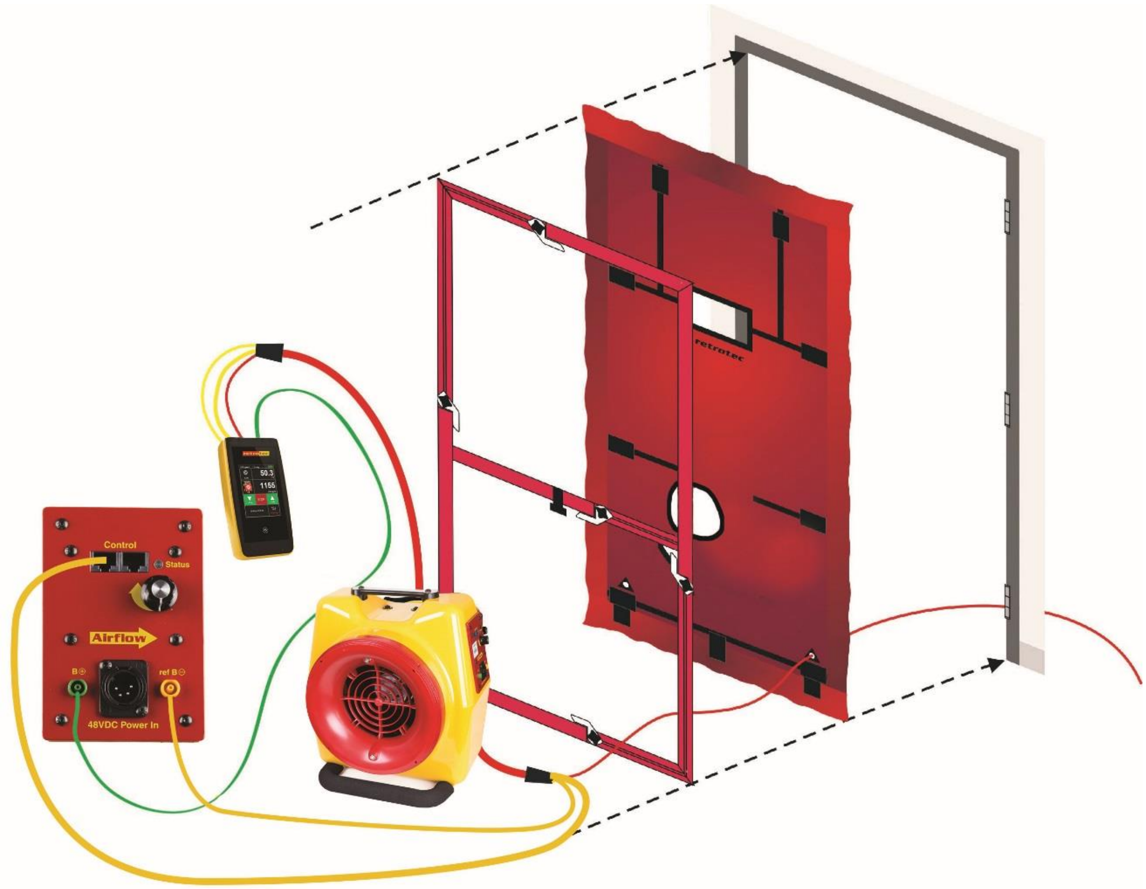


Figure 30: Blower Door setup using a Model 300 fan to test tight enclosures. The left image shows the Fan Top from a side view of the Model 300 fan with tubing and Control Cable connections.

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-Door Fan Operation* and *QuickGuide-Blower Door*.

13.2 Blower Door systems for testing tight enclosures

Includes 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 300 fan into a doorway. 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 31: 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 4: Aluminum Frame Door Panel dimensions (approximations)

	Window Frame	Regular Frame	Large Frame
Panel width	46.4-68.5 cm (18.3-27.0 in)	74-114 cm (29.5-45.0 in)	81-127 cm (32-50 in)
Panel height	76.9-129.5 cm (30.3-50.0 in)	135-246 cm (53.-97 in)	153-276 cm (60-109 in)
Frame thickness	5.3 cm (1.75 in)	5.3 cm (1.75 in)	5.3 cm (1.75 in)
Frame weight	7.3 kg (16 lb)	7.3 kg (16 lb)	11.4 kg (25 lb)

Appendix A: Calculate Air Flow based on Channel B Fan 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 DU300 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 DU300 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:

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

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: $|\text{FP}| > \text{MF}$ And: $|\text{FP}| \geq |\text{DP}| \times \text{K2}$

Table 5: N and K coefficients for all supported fans in the gauge.

	Range	n	K	K1	K2	K3	MF	
Model 300	Open	0.5010	28.9100	0	0.4	0	20	
	102	0.590	10.7	0	0.4	0	100	Range 102 is not available for Model 340
	74	0.5045	7.077	0	0.25	0	15	
	47	0.500	3.241	0	0.1	0	10	
	29	0.502	1.190	0	0.2	0	20	
	18	0.499	0.457	0	0.25	0	25	These Ranges are optional for Model 340
	11	0.480	0.2080	0	0.25	0	25	
	7	0.500	0.0718	0	0.11	0	25	
	3	0.485	0.02160	0	0.3	0	25	
	2	0.530	0.00650	0	0.3	0	25	
	1	0.593	0.002044	0	0.3	0	40	

Appendix B: 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. If the user chooses the 340 device, n-value of 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 **Error! Reference source not found.** will result if the **[@ Pressure]** function is used at the Achieved P ressure to estimate a result at 50 Pa.

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 6 will result if the **[@ Pressure]** function is used at the Achieved Pressure to estimate a result at 50 Pa.

Table 6: Errors in Estimated Flow at 50 Pa if gauge "*n*" = 0.60 differs from actual *n*

Assumed n = 0.6	Achieved Pressure (Pa)	Actual Flow Exponent (n) of Enclosure					
		0.50	0.55	0.60	0.65	0.70	0.75
	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%

Assumed n = 0.6	Achieved Pressure (Pa)	Actual Flow Exponent (n) of Enclosure					
		0.50	0.55	0.60	0.65	0.70	0.75
	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 **[@]** 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:

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

$$CFM_{25} = CFM_{P} * \left(\frac{25}{P}\right)^{n}$$

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 7 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 7 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 7 is for *n* of 0.60 which is typical for ducts.

Table 7: 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 8 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 8 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 8 is for "*n*" of 0.60 which is typical for ducts.

Table 8: Factors for when a duct pressure of 50 Pa cannot be reached (assumed "*n*" value of 0.60).

Pressure achieved	Cannot reach 50 factor
50	1.00
49	1.01

Pressure achieved	Cannot reach 50 factor
25	1.52
24	1.55

Pressure achieved	Cannot reach 50 factor
48	1.02
47	1.04
46	1.05
45	1.07
44	1.08
43	1.09
42	1.11
41	1.13
40	1.14
39	1.16
38	1.18
37	1.20
36	1.22
35	1.24
34	1.26
33	1.28
32	1.31
31	1.33
30	1.36
29	1.39
28	1.42
27	1.45
26	1.48

Pressure achieved	Cannot reach 50 factor
23	1.59
22	1.64
21	1.68
20	1.73
19	1.79
18	1.85
17	1.91
16	1.98
15	2.06
14	2.15
13	2.24
12	2.35
11	2.48
10	2.63
9	2.80
8	3.00
7	3.25
6	3.57
5	3.98

Appendix C: 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.

"--" 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 DM32 gauge will automatically sense it and display "--", 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 [@]

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 result extrapolation. To remove result extrapolation, press the **[@]** button until "is Off" is shown.

If **[@]** is active, the gauge calculates a reading for flow at the extrapolation pressure, no matter what the actual "PrA" measures. 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 by tapping Channel B.

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. With the yellow tube connected to the fan and gauge on Channel B, the gauge should read over 700 Pa. If the value is a lot lower, Channel B is leaking. Connect the blue tube to "Input A" on the DM32, and "Ref B" on the fan which is the yellow port. (Yellow tube is disconnected.) Channel A should read about 700 Pa and if not Channel A is leaking.

Adjusting the fan Inlet Nozzle if is rubbing or debris needs to be removed from fan

Remove the tape holding the Nozzle in place. Clean and replace with new tape as supplied with your system.

If your impeller is rubbing. Remove the Inlet Nozzle. Loosen the mounting bolts. Cover the impeller with 2.5 mm of paper or card stock. Retighten the bolts. Remove the nozzle and the paper and replace the nozzle with tape to hold it in position.

Tape replacement method shown above.   Using the roll of special tape supplied, start underneath the nozzle inlet, wrap tape around and finish by smoothing down as shown below.

Sealing the 100mm duct with Self-Fusing Silicone Tape

1. Self-Fusing Silicone Tape is very stretchy, has no adhesive but instantly and permanently sticks to itself. Be careful that the assembly doesn't slide apart while you're working on it.

2. Position clamp on the 100mm duct 300mm or so down, so it's out of the way.
3. Position 100mm duct on connector with about half (50mm) of connector still exposed.
4. Unroll Self Fusing Silicone Tape a little at a time being very careful to not let it touch itself.
5. Hold one end in place as you use your other hands to stretch and wrap tape around the flex duct and connector.
6. When you get back to the starting point over lap the tape about half way and
7. Continue stretching and wrapping to cover about 25mm on the end of the duct and about the same onto the connector creating an airtight seal. 2 layers will be ample.
8. Tighten clamp over the tape to ensure the duct doesn't slide off the connector.

Appendix D: 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.

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

- "inverter output"
- "utility-grade AC power"
- "suitable for sensitive electronics"

Table 9: 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

Honda Generator EU3000 (120V, 2000W, 67 lbs)

- Works will all DucTester fan models.
- Works with both 2200 and 2350 series fans.

The Honda EU3000 provides 3000 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.

GENYX G3000HI (230V, 3000W) generator

- Works with all Retrotec Fans.

The G3000HI is equipped with an inverter, and runs at 230V and a maximum of 3000W for even the most powerful Retrotec equipment.

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.

Black and Decker Electromate 400 Model VEC026BD

- ONLY use with DucTesters with a 2350 Fan Top (per label).

The VEC026BD is a 110/120VAC power supply with a built in 400W inverter.

Appendix E: 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 Range 74	_____
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

Glossary

Term	Definition
ACH50 or ACH @ 50 Pa	Designation for “Air Changes at 50 Pa.” Can be calculated by taking CFM50 x 60 minutes/ hour, and dividing by the house volume
Aluminum Frame	Describes a frame over which cloth is stretched to provide a Door Panel closure for air leakage testing in buildings
Baseline pressure	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.)
Blower	The Retrotec fan unit that induces air flow and provides a Fan Pressure signal from which flow is measured.
CFM	Units: Cubic feet per minute (the units of volumetric flow)
CFM50 or CFM @ 50 Pa	CFM @ 50 Pa is the flow rate, in cubic feet per minute, required to depressurize/pressurize the building to 50 Pascals.
Conditioned Space	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)
Control port	Ethernet port on a Retrotec fan, labeled “Control”
Depressurization	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.
digital gauge	A gauge with an electronic pressure sensor and digital display that is capable of reading in tenths of a Pascal.
DOE	U.S. Department of Energy
Blower Door	A test instrument that fits into an open doorway in order to pressurize or depressurize an enclosure. It is a calibrated fan 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.”
Door Panel	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.
effective leakage area	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).
enclosure	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.
Envelope	The surfaces composed of floor and walls and floors that separate the test volume from volume surrounding the test volume. Also see ”enclosure”
Equivalent Leakage Area (ELA or EqLA)	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
	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. 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).
Fan Pressure	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.
Fan Top	Part on the fan where the fan's tubing, Control Cable, and power connections are. 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.
HVAC	Heating Ventilating and Air conditioning.
Leakage	A general term used to describe holes or the area of holes in in the envelope around an enclosure.
Leakage Area	This is the same as "Leakage" but expressed in sq ft or m^2.
LEED	Leadership in Energy and Environmental Design
Low-Flow Cloth Door Panel	Cloth Door Panel used to test tight enclosures with a Model 200 fan
Manual Speed Control Knob	The dial that is on a Fan Top to control fan speed
Open Range	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.
outdoors	Outside the building in the area around the building.
Pascal (Pa)	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.
Pressurization	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.
Range Configuration	The plastic Range attachments on the Retrotec Fan. On the Model 340, Range Configurations available are Ranges: Open, 74, 47, 29, 18, 11,7, 3, 2 and 1.
reading	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.
reference pressure	The pressure at which the ELA is calculated, usually at the test pressure.
room	See "Enclosure".
room pressure	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.