

# Commercial Ductester Operation Manual

## Models 440x/450x Systems



Made by Retrotec  
1060 East Pole Road  
Everson, WA USA 98247

For support:

Call 1(888) 330-1345 in USA  
+1 (360) 738-9835 outside USA [support@retrotec.com](mailto:support@retrotec.com) or  
Fax +1(360) 647-7724

Manual for:

Models 440x & 450x with DM32/DM32X and former Models 440 & 450

All rights reserved.

This document contains materials protected under International and Federal Copyright Laws. No part of this book may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system without express written permission from Retrotec.

Retrotec makes no warranties with respect to this documentation and disclaims any implied warranties of merchantability, quality, or fitness for any particular purpose. The information in this document is subject to change without notice. Retrotec reserves the right to make revisions to this publication without obligation to notify any person or entity of any such changes.

DucTester, Infiltrometer, FanTestic are Trademarks of Retrotec. Other trademarks or brand names mentioned herein are trademarks or registered trademarks of their respective owners.

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

2016-08-17 Appendix H on calibration added.

# Table of Contents

.....	<b>1</b>
<b>Important equipment-related safeguards</b> .....	<b>5</b>
<b>Important occupant safeguards during testing</b> .....	<b>6</b>
<b>1. Model 300x / 400x System Types:</b> .....	<b>8</b>
<b>2. DucTester systems using Model 400 Calibrated fan</b> .....	<b>9</b>
<b>2.1 Retrotec calibrated fan: Model 400 Operation</b> .....	<b>10</b>
<b>2.2 450 systems include 10-2.5 (250-63 mm) Adapter for 4 inch (100mm) Flex Duct</b> ....	<b>11</b>
2.2.1. 450 Range Configurations.....	12
2.2.2. 450 Flows .....	12
<b>2.3 440 systems connect directly to 10" (250 mm) Flex Duct</b> .....	<b>14</b>
2.3.1. Flow Range Configurations .....	14
2.3.2. Test Blower Min/Max Flows .....	14
<b>2.4 Digital Gauge</b> .....	<b>15</b>
<b>2.5 Flex Duct</b> .....	<b>15</b>
<b>2.6 Additional duct testing components</b> .....	<b>16</b>
2.6.1. Grill Mask for sealing registers .....	16
2.6.2. Umbilical for connecting fan and DM32 gauge.....	16
2.6.3. Optional 10 to 2.5 (250 to 63 mm) inch adapter makes it a Model 450 .....	16
2.6.4. Duct Connection Flange.....	17
2.6.5. Toolbag keeps all testing components in one place .....	17
2.6.6. DucTester Tubing Accessory Kit.....	17
<b>3. Types of Duct Leakage Tests</b> .....	<b>18</b>
<b>4. Prepare for the Duct Leakage Test</b> .....	<b>19</b>
<b>4.1 Unpack, connect the gauge to the DucTester</b> .....	<b>19</b>
<b>4.2 Charge the gauge</b> .....	<b>20</b>
<b>4.3 Follow the Quick Guide that came with your system</b> .....	<b>20</b>
<b>5. Test Procedure – (Steps 1 to 7)</b> .....	<b>21</b>
<b>5.1 Step 1 - Prepare the gauge</b> .....	<b>21</b>
<b>5.2 Step 2 – Determine test criteria and prepare the ducts</b> .....	<b>22</b>
<b>5.3 Step 3 – Connect DucTester to ducts</b> .....	<b>23</b>
5.3.1. Select a test direction .....	23

5.3.2.	Setting up for pressurization .....	24
5.3.3.	Setting up for depressurization .....	24
5.3.4.	Install Range Configuration on fan .....	24
<b>5.4</b>	<b>Step 4 –Tubing, control, and power connections .....</b>	<b>25</b>
<b>5.5</b>	<b>Step 5 – Setup Test Pressure and Area in Gauge .....</b>	<b>27</b>
<b>5.6</b>	<b>Step 6 – Run Test Blower to Measure the Leakage .....</b>	<b>28</b>
<b>5.7</b>	<b>Step 7 – Test Passes.....</b>	<b>28</b>
<b>6.</b>	<b>Troubleshooting .....</b>	<b>29</b>
6.1	If test fails .....	29
6.2	If no Results are displayed (“--” appears on display).....	29
6.3	Cannot achieve test pressure .....	30
6.4	Gauge “Flow” reading does not change? Turn off [ @ ] .....	30
6.5	Fan does not run .....	30
6.6	Avoid common mistakes .....	30
<b>7.</b>	<b>Find duct leaks .....</b>	<b>31</b>
7.1	Using a smoke puffer.....	31
7.2	Using theatrical smoke .....	31
7.3	Using an infrared camera .....	31
7.4	Using a wet hand.....	31
<b>8.</b>	<b>Field Check the DucTester to find out what is not working .....</b>	<b>32</b>
8.1	Field Check the gauge.....	32
8.2	Field Check the DucTester as a system .....	32
<b>Appendix A</b>	<b>Flow Conversion Tables.....</b>	<b>34</b>
<b>Appendix B</b>	<b>U.S. Duct Leakage - Calculation (SMACNA) .....</b>	<b>39</b>
B.1	Leakage Class .....	39
B.2	Leakage Class Lookup .....	41
B.3	Leakage Factor .....	42
B.4	Pressure Class.....	45
<b>Appendix C</b>	<b>U.S. Duct Leakage - Measurement Procedure 1 (CFM/100 sq ft).46</b>	
C.1	How much duct surface area can be tested at one time?.....	47
C.2	Checklist.....	48
C.2.3.	Step 2 – Determine test criteria and prepare the ducts .....	49
C.2.4.	Step 3 – Connect DucTester to ducts.....	50

C.2.5.	Step 4 –Tubing, control and power connections .....	50
C.2.6.	Step 5 – Set up Test Pressure and Area in Gauge .....	50
C.2.7.	Step 6 – Measure Leakage Factor in CFM/100 sq ft .....	51
C.2.8.	Step 7 – Test Passes.....	51
<b>C.3</b>	<b>If ducts fail, measure the Leakage Class.....</b>	<b>51</b>
<b>Appendix D</b>	<b>U.S. Duct Leakage - Measurement Procedure 2 (CFM at Test Pressure or % Leakage) .....</b>	<b>52</b>
D.1	How much duct surface area can be tested at one time?.....	53
D.2	What Air Handler Flow Rate can be tested at one time?.....	54
D.3	Checklist.....	55
<b>Appendix E</b>	<b>UK Duct Leakage Calculation (DW/143).....</b>	<b>59</b>
E.1	Ductwork Classification and Air Leakage Limits .....	59
E.2	Test Sheet .....	59
E.3	UK Measurement Procedure (Summary) .....	60
E.4	UK Measurement Procedure (Detailed).....	61
<b>Appendix F</b>	<b>European Duct Leakage Calculation (EN12237).....</b>	<b>65</b>
F.1	Ductwork Classification .....	65
F.2	Air Leakage Limits .....	65
F.3	EU Measurement Procedure .....	66
F.4	EU How much duct surface area can be tested at one time? .....	67
F.5	European Measurement Procedure for Airtightness Class .....	68
<b>Appendix G</b>	<b>Calculate Flow using gauge readings .....</b>	<b>72</b>
<b>Appendix H</b>	<b>Calibration Procedure for Model 450 .....</b>	<b>73</b>
H.1	Pressure Gauge .....	73
H.2	Flow Measurement .....	73
H.3	Flow Calibration Field Check.....	74
H.4	Fan Calibration Data.....	74
<b>Glossary</b> .....		<b>75</b>

### **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:*

- This blower will create high pressures that may damage duct work if speed is not increased slowly.
- 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 blower housing before operating it.
- 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 blower motor by leaving the openings in the rear of the blower housing open at all times.
- 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 working 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 carport 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 building and cause back drafting where it did not occur before. For example, a return leaking to outdoors may have pressurized a building 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. Model 300x / 400x System Types:

340x	350x	300x	440x/450x
			
<p>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.</p>	<p>'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.</p>	<p>The Model 300 is ideal for testing tight houses as large as a 1600 square feet of floor area that leak as much as 3 Air Changes per Hour.</p>	<p>Commercial duct testing up to 20 in WC (5000 Pa) in a compact package.</p>

The Model numbers with only 00 400 refer to the fan body.

The middle 4 in the Model 440 shows the system has a 10 to 2.5 inch (250 to 63 mm) Adapter that goes over the fan inlet to allow for Depressurization.

The "x" refers to the newer shell model, which replaced the original Model 300 and Model 400 shells.

The Model 400 Blower shares its housing, inlet nozzles and Flow Plates with the 300 models as shown below. Each system is specialized for a certain application, and uses the most appropriate Blower for the application.

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 350 but still a fraction of the width of old fashioned Commercial duct testers in common use. The Model 440 system is for pressurization testing only, and the Model 450 can be used to test both directions.

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, apartments, rooms or enclosures.

This manual focuses on the Model 400 Blower and attachments that make up 440 and 450 Systems. Be sure to refer to the QuickGuide that came with your system or which can be obtained online at:

<http://retrotec.com/support/manuals-guides>

## 2. DucTester systems using Model 400 Calibrated 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 SMACNA, RESNET, ASTM E1554-07, ANSI/ASHRAE 152, ASTM E779-10, EN 13829, ATTMA TS-1, CGSB 149.10, ASME, FD50-784, and FD E51-767 standards.

The 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 test blower is operated, the Fan (Blower) 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 0.01 to 1400 m<sup>3</sup>/h. These restricting plates are called Ranges or Range Configurations.

The Model 400 blower will create a variable flow over a wide range of pressures. Models 440 and 440 systems include all the accessories needed to connect to ducts under a positive test pressure. Models 450 and 452 include additional accessories to test under negative pressure also.

Many U.S. Standards require the test apparatus to have an accuracy of +/- 7.5% for flow rate and test pressure and must have a certificate signifying conformance with the ASME. The Model 400 has a standard accuracy of 5% for flow and less than 1% for pressure and complies with ASME, ASTM and ISO standards. Accuracies of 1.5% for flow and 0.5% for pressure that are NIST traceable are available with special calibrations but the standard accuracy is much greater than necessary for normal testing.

## 2.1 Retrotec calibrated fan: Model 400 Operation

The Model 400 fan has 1700 Watt blower. Choose 120 or 240 Volts AC; 50 to 60 Hz is acceptable for either choice. The Model 400 Fan has an on/off switch on the left hand Control Panel.

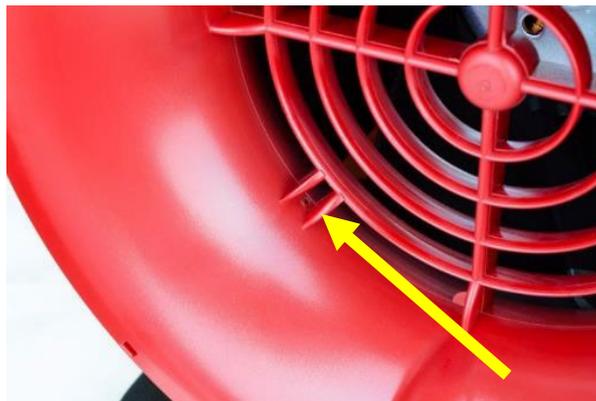
The Model 400 Fan has a speed control built into the Fan . Speed is controlled using the knob on the 400 fan which is located on the right hand control panel or the Retrotec digital gauge. Either choice can control the fan to any desired Set Speed.

The right hand control panel has two CAT-5 connectors. One of these is used to connect to any Retrotec gauge for speed control purposes; the fan itself is never 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 and making two fans run in unison. The control signal from one gauge will thus run both fans.  
power input connection



**Figure 1: Retrotec Model 400 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 400 has 8 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. The End Plate is permanently taped on so you normally don't get this view. The Polyurethane tape may be removed for cleaning: use the long lasting tape that comes with your system to reinstall the End Plate.



**Figure 2: 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.



Figure 3 Back view shows massive blower with cover and cooling openings that should not be restricted.



Figure 4: Self-referencing pressure pickup connect to the green port and must never be taped over.

## 2.2 450 systems include 10-2.5 (250-63 mm) Adapter for 4 inch (100mm) Flex Duct

A complete 450 DucTester Kit includes a calibrated fan, intake range plates, 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 optional tubing accessory kit contains T connectors and tube lengths for other non-typical tasks.

### 2.2.1. 450 Range Configurations

All Retrotec calibrated fans have multiple Range Configurations in order to measure a wide range of air leakage flow rates. To select the correct Range Configuration, start with range 47 and attempt to reach target test pressure by increasing fan speed. If a range selection is too small the gauge will display “- -” on Channel A. It may also show “+ +” on Channel B. This indicates the range is too restrictive to reach the pressure target, or the fan pressure generated is too high to measure.

If the range selection is too large the gauge will display “- -” on Channel B. This indicates the range is not restrictive enough, the pressure measured inside the fan is too low to calculate flow rate.

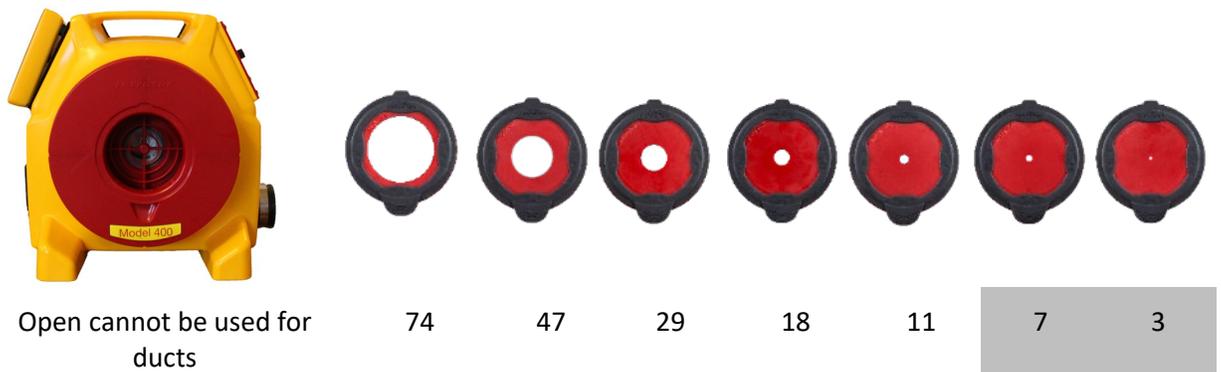


Figure 5: Range 74 is for the leakiest ducts while the smaller ranges are for progressively tighter ducts.

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 0.01 to 1400 m<sup>3</sup>/h.

The 450 system has 5 standard Range Configurations: 74, 47, 29, 18, 11. The numbered Ranges are 100 mm Plugs that snap into the End Plate, (labeled “Model 400”), and will restrict the flow to allow you to develop enough fan pressure to measure lower flow rates. The numbers refer to the approximate hole diameter in millimeters. Most ducts can be tested using Range 47.

### 2.2.2. 450 Flows

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

CFM minimum	CFM maximum	Range Name	Included
115	305	<b>74</b>	yes

CFM minimum	CFM maximum	Range Name	Included
110	274	<b>74*</b>	yes
48	206	<b>47</b>	yes
17	77	<b>29</b>	yes
6.8	30	<b>18</b>	yes
2.7	12	<b>11</b>	yes
1.1	4.7	<b>7</b>	optional
0.29	1.3	<b>3</b>	optional
0.14	0.49	<b>2</b>	optional
0.05	0.20	<b>1</b>	optional

m <sup>3</sup> /h minimum	m <sup>3</sup> /h maximum	Range Name	Included
195	500	<b>74</b>	yes
187	495	<b>74*</b>	yes
81	350	<b>47</b>	yes
29	130	<b>29</b>	yes
12	51	<b>18</b>	yes
4.6	20.5	<b>11</b>	yes
1.8	8.0	<b>7</b>	optional
0.50	2.2	<b>3</b>	optional
0.25	0.83	<b>2</b>	optional
0.09	0.33	<b>1</b>	optional

\*When Range 74 is used with 10-4" adapter on fan inlet (fan is depressurizing duct and Channel A is negative)

**Table 1 Minimum and Maximum flows for 450 Range Plugs**



## 2.3 440 systems connect directly to 10" (250 mm) Flex Duct

A complete 440 DucTester includes a calibrated fan, a digital dual-channel Model DM32 digital touch screen pressure gauge, and a 4" Flex Duct to attach the Test Blower to the duct.

### 2.3.1. Flow Range Configurations

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 over 50% speed and checking that the gauge is giving a flow result. If not, change to a lower range and repeat.

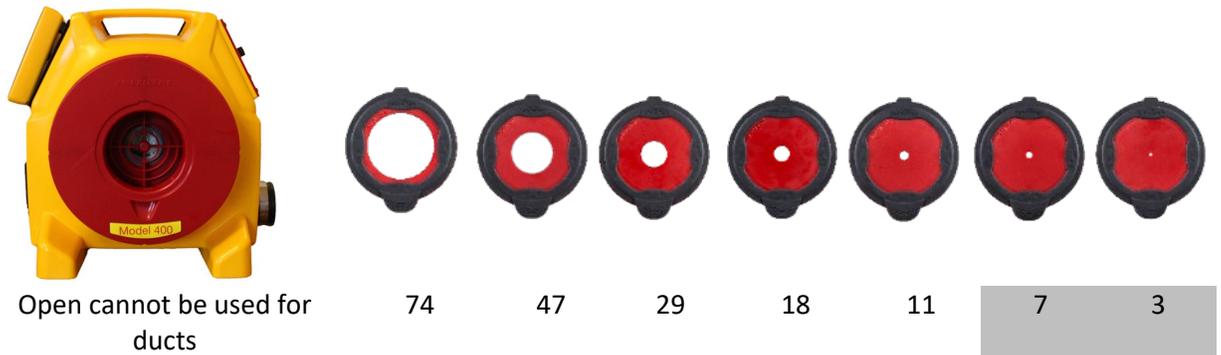


Figure 6: Range 74 is for the leakiest ducts while the smaller ranges are for progressively tighter ducts.

The 440 system has 5 standard Range Configurations: 74, 47, 29, 18, 11. The numbered Ranges are 100 mm Plugs that snap into the End Plate, (labeled "Model 400"), and will restrict the flow to allow you to develop enough fan pressure to measure lower flow rates. The numbers refer to the approximate hole diameter in millimeters. Most ducts can be tested using Range 47.

### 2.3.2. Test Blower Min/Max Flows

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

CFM minimum	CFM maximum	Range name	Included
115	285	<b>74</b>	yes
48	206	<b>47</b>	yes
17	77	<b>29</b>	yes
6.8	30	<b>18</b>	yes
2.7	12	<b>11</b>	yes
1.1	4.7	<b>7</b>	optional
0.29	1.3	<b>3</b>	optional
0.14	0.49	<b>2</b>	optional
0.05	0.20	<b>1</b>	optional

m <sup>3</sup> /h minimum	m <sup>3</sup> /h maximum	Range name	Included
195	485	<b>74</b>	yes
81	350	<b>47</b>	yes
29	130	<b>29</b>	yes
12	51	<b>18</b>	yes
4.6	20.5	<b>11</b>	yes
1.8	8.0	<b>7</b>	optional
0.50	2.2	<b>3</b>	optional
0.25	0.83	<b>2</b>	optional
0.09	0.33	<b>1</b>	optional

Table 2 Minimum and Maximum flows for 440 Range Plugs

## 2.4 Digital Gauge



Figure 7: DM32-20A digital gauge.

The latest Retrotec DM32X Digital Gauge is included with all Retrotec DucTester systems. 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 can be combined with a calibrated fan for automatic control to Set Pressure in an enclosure, or to Set Speed. 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 DM32X, see the *DM32X Operation Manual*.

## 2.5 Flex Duct

Retrotec's duct testing systems US350 and EU350 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 10 to 2.5 inch (250 to 63 mm) Adapter.

## 2.6 Additional duct testing components

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

### 2.6.1. 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. 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.



### 2.6.2. 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 7 foot (2m) 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.



### 2.6.3. Optional 10 to 2.5 (250 to 63 mm) inch adapter makes it a Model 450

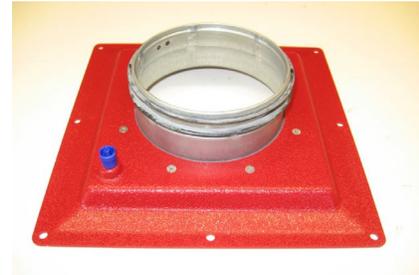


Adapters included have a 10 inch opening on one end that must fit over the inlet of the Test Blower for depressurization testing. The inlet end is 2.5 inches which accepts the 2.5 inch male connector on the flex.



#### 2.6.4. Duct Connection Flange

Connection Plate, for flex to duct. Female collar on flex slips over the double seal for fast leak proof connection. Blue connection point for measuring duct pressure. Tape flange to duct; screws may be added for additional strength of connection.



#### 2.6.5. 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.



#### 2.6.6. DucTester Tubing Accessory Kit

The DucTester Tubing Accessory Kit comes with two blue pressure tubes approximately 35 ft each, 1/8" inner diameter (11 m each, 3 mm ID), male-to-male pressure tube connectors, T-connectors for pressure tubes, and a Static Pressure Probe. 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.



For parts, please see:

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

For more information on these parts, contact:

[sales@retrotec.com](mailto:sales@retrotec.com)

### 3. Types of Duct Leakage Tests

Locate the step by step Quick Guide that came with your equipment or access it at [www.retrotec.com](http://www.retrotec.com).

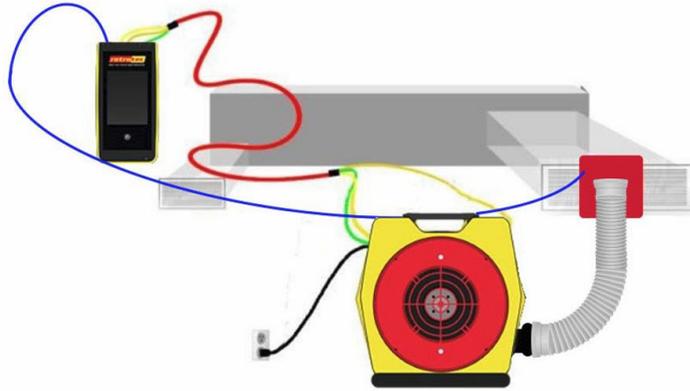


Figure 9: DuctTester setup, including tubing locations and necessary connections.

In all tests, ducts are first pressurized and the leakage rate measured at a test pressure. In some geographic areas, that test can be followed by a depressurization test. Readings are usually written down but may have to be recorded over a prolonged period and the data logged. Retrotec FanTestic software performs that task and provides a formatted report. Data can be logged automatically or entered manually.

## 4. Prepare for the Duct Leakage Test

### 4.1 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.



Model 440 above can be packed as shown.



Model 450 above is a tight fit and needs to be packed in exactly the correct order, or the components will not fit.

1. Blower with Flow Plug facing to right.
2. Flex with 2 180 bends placed as shown.
3. Gauge case
4. Connector with plate flat on bottom of case. Slide it under the gauge case.
5. Adapter. Additional items may be placed inside Adapter.
6. Fit other components in open spaces.



Model 450 with the 10 to 2.5 Adapter above can be packed as shown.

## **4.2 Charge the gauge**

The batteries should be charged when you first get your gauge but we advise you to leave your gauge on the charger overnight to make sure. Battery life is about 9 hours on a single charge for the DM32, and 8.5 hours for the DM32X.

The batteries will charge more quickly if the gauge is turned off and when plugged to a wall outlet (instead of to a computer).

On the DM32, a large battery icon will be displayed on the screen when your battery is receiving a charge. On the DM32X, a flashing light near the charging port at the bottom of the gauge will be displayed when your battery is receiving a charge. When plugged into your computer, the battery will not get drained but will not charge up completely either. Running FanTestic software is better done wired for this reason as well as because it's a faster more stable connection.

## **4.3 Follow the Quick Guide that came with your system**

The QuickGuide 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.

## 5. Test Procedure – (Steps 1 to 7)

### 5.1 Step 1 - Prepare the gauge

Once the Gauge has been set up, all settings are restored when the gauge is turned back on. Appendices C,D and F show specific set up for US, UK and European testers.

<input type="checkbox"/> <b>Home</b> screen must show Model 450 on Range 47 	<p>If not, tap picture, then tap [Change Device] and select the Model 450.</p> <p>Then Tap the icon “47” to get Range 47</p>
<input type="checkbox"/> <b>Home</b> screen must show pressure units of CFM, m <sup>3</sup> /h, CFM per 100 square feet or m <sup>3</sup> /(h*m2). 	<p>On the DM32, tap [Settings] and [Result to be displayed].</p> <ul style="list-style-type: none"> <li>• Tap pressure units until you see “in WC” for inches of Water Column.</li> <li>• Then tap flow units until you see Flow/Area: CFM/100 sq ft</li> <li>• Tap On button to return Home.</li> </ul> <p>On the DM32X, Tap the Channel A and Channel B images to change.</p> <p>Once set, you’ll never have to change it again.</p>
<input type="checkbox"/> <b>Home</b> screen must time average as 5 seconds.	<p>If not, tap [Settings] and [Time Averaging] until “ 5 s avg” is displayed. Tap On button to return Home.</p> <p>This will create a running average that will smooth out results, making them easier to read. If the result fluctuates, increase up to 30 seconds. Refer to manual for more information.</p>
<p>The Gauge is set up now and you’re ready for your first test.</p>	

## 5.2 Step 2 – Determine test criteria and prepare the ducts

How the ducts are prepared will be impacted by the test pressure and test direction required. Determine the specified Leakage Class and Test Pressure in order to decide how to break up the ducts in sections for the test. You will need to have sufficient blower power to take the ducts up to the specified test pressure. In other words, you should have enough flow to test the ducts if they just pass.

Extremely leaky ducts may require much more flow to get them to the test pressure but that is not needed to see if they fail. After all it is unfair to provide excessive amounts of flow if you can determine the ducts will fail anyway. Blowing power is expensive.

Once you determine the maximum flow you'll need, use Table 3 to see if your Model 450 is up to the task.

If Test Pressure is not specified, use a Pressure Class of 1 in WC except upstream of VAV boxes, use 2 in WC. Use a positive test pressure unless specified otherwise. Use 1000 Pa in Europe.



Select a limited section of duct that you have sufficient power to test. Measure the duct surface area in square feet.

Ensure sealing is complete. Ensure sealing materials have cured for the prescribed time or at least 24 hours OR follow manufacturer's directions.

Blank off and seal the tested ductwork by inserting temporary plugs plates, sheets, balloons, bags into intentional openings.

### 5.3 Step 3 – Connect DucTester to ducts

The DucTester has a 4 inch (100 mm) flex with a 4 inch (100 mm) collar that connects to the duct system. When considering where to connect the DucTester to the duct system, it is important to think about airflow restriction and accessibility. Always pressurize first. If you pass and need to test in the other direction, do so afterwards.



Figure 10 Model 400 Blower set up to test ducts prior to installation of the Flow Plug that is needed to measure flow.

1. Attach the 4 inch (100 mm) Flange to the ductwork.
2. Attach 4 inch (100 mm) collar on flex to flange.
3. Connect DucTester exhaust to flex with the 2.5 inch (63mm) connector.
4. Install Range 47 Flow Plug. Range 47 provides 52 to 206 CFM, which is sufficient to test most duct runs. Refer to Table Minimum and Maximum flows for all Range Plugs.

#### 5.3.1. 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 but generally in the USA ducts are pressurized only and in Europe they are tested in both directions. Both test directions provide similar results, however pressurization testing is faster.

### 5.3.2. Setting up for pressurization

The advantage of pressurizing is that it makes changing Range Rings on the fan easier so always test in this direction first. Simply install the Flex Duct on the outlet side of the Blower. Wiggle the fitting inside the rubber collar on the Blower Housing.



### 5.3.3. Setting up for depressurization

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 xx. Install the Flex Duct over the fan inlet, covering the Range Rings and tighten the strap.



Figure 11: Install Flex Duct over the fan inlet, covering the Range Rings, for depressurization. Later systems have a 2.5 inch connector instead of the 4 inch (100 mm) shown.

### 5.3.4. Install Range Configuration on fan

Each Retrotec Model 400 Blower includes five Range Configurations to maximize accuracy and versatility: Range 74, 47, 29, 18 and 11 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 Adapter must be removed to change Range Configurations. The Flow Plugs must always go on the inlet of the fan.

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.



#### 5.4 Step 4 –Tubing, control, and power connections

If the rechargeable batteries in the DM32 are below one quarter power during a test, the battery charger should be connected to the micro-USB port on the DM32. Always charge them fully overnight.

Connect yellow and green tubes between DucTester and gauge. 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 12: Inserting a Flow Plug into the end plate.



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

Connect blue tube to gauge and to ducts using static probe or connection on flange. In duct systems that are relatively tight (200 CFM or less), the induced test pressure in the system is uniform, and all locations will provide similar results.

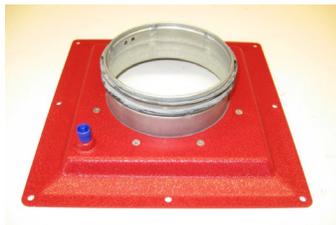


Figure 14: A Static Pressure Probe attached to a pressure tube allows the measurement of pressure without disturbances due to turbulence.

Plug in the Speed Control Cable between DucTester and Gauge. 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.



**Figure 15A:** 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.



**Figure 16B:** The DM32X uses a USB-C Cable for charging, as well as for connecting to a PC.

Plug in to power source. Ensure the power switch is Off which means speed control is set to 0. Connect the power cord to a wall outlet and to the fan. 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 16: color-coded tubing connections (green and yellow) and Control Cable

To test control of the fan, press **[Set Speed] [1] [Set]** on the gauge. This sets the fan to 1% speed on the gauge but achieves about 15% speed on the blower.

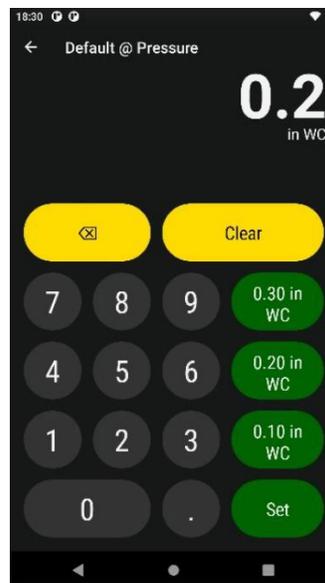
Do not use **[Set Pressure]** since this control has not been linearized and it will oscillate. Future models will have a fix for this.

Press **[Stop]** to stop the fan.

For details on gauge operation, see DM32X or DM32 manuals.

## 5.5 Step 5 – Setup Test Pressure and Area in Gauge

Default in gauge must match the specified Test Pressure. If not, tap **[Settings]**, then “Default @ Pressure.” **[Set]** value to specified Test Pressure.



Since you must not exceed the test pressure, the actual pressure will be lower but entering this default will ensure that all flow results are displayed as a value extrapolated to the exact test pressure entered.

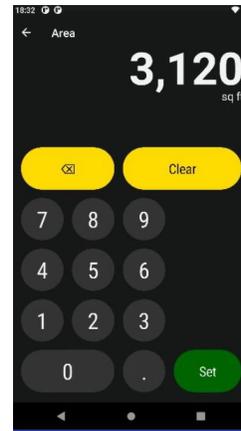
Measure the duct surface area in square feet and enter it into the gauge. Select a limited section of duct for which the estimated leakage will not exceed the capacity of the test apparatus. Area can also be accessed from **[Settings]**.

**[Area]** then use the number pad and tap **[Set]**.

## On DM32

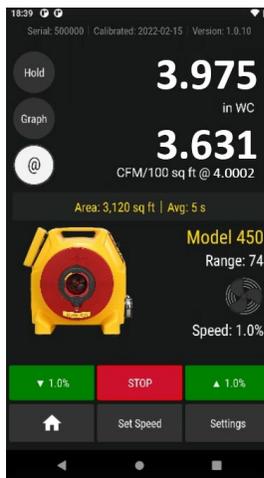


## On DM32X



### 5.6 Step 6 – Run Test Blower to Measure the Leakage

Running the blower requires adjusting the speed from low to high to avoid damage to ducts. Always start by pressurizing since it's easier to change ranges in this configuration and ducts are stronger under positive pressure. Usually, the same result will be achieved in each test direction



Tap [Set Speed] on the Home screen and [1] on the number pad to achieve 1% Blower speed.

To prevent over-pressurizing, slowly increase fan speed using Set Speed. If the pressure increments are too large, Tap [Set Speed], 1.2% for example to get a smaller increase in flow rate. Otherwise Jog the speed up 1% at a time until a CFM value appears on the display. Continue to increase fan speed up to but do not exceed the Pressure Class. If you do not reach the Pressure Class, results will still be calculated at that Pressure Class.

Tap "@" on the display to get flow at the Default pressure set earlier. This will give a result at the exact Test Pressure entered even though you might be slightly below it which is preferred. Or above which is not preferred. Once close to your desired test speed, when "@" is displayed, the flow will vary very little as speed is changed.

### 5.7 Step 7 – Test Passes

Complete the test reports and, if required, obtain witness's signature. Use Retrotec's FanTestic Software to generate a report automatically. You can edit a template to add logos and other details that will print out each time you complete a test. In minutes.

Remove temporary blanks and seals. Restore ducts 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.

## 6. Troubleshooting

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

### 6.1 If test fails

If you can create 0.1 In WC (25 Pa), the DM32 or the software will still give an accurate result. There is usually no need to achieve the test pressure if the ducts will still fail. First check all seals and connections for leaks. Use a positive pressure and survey all sections of ducts with your hands if you have access. To increase the sensitivity, wet your hands. If ductwork is hard to reach, you can use smoke inside the duct to locate the leak, but this can be messy.

If it fails, additional sealing is needed.

### 6.2 If no Results are displayed (“--” appears on display)

The 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.

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.
1. Change Range Configuration on the gauge to match the Range Ring installed on the fan.
2. 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 section of duct 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, remove the flex duct to provide more leakage to get a reading. Try increasing the fan speed. If the flow still reads “--” then the yellow or green tubes could be blocked or disconnected.
5. Try running a gauge or system field check. See our online tool for this at [retrotec.com/gauge-field-calibration-check.html](http://retrotec.com/gauge-field-calibration-check.html)

If test pressure has been reached but “++” appears on Channel B, the fan is running too quickly to accurately measure flow (flow pressure above maximum allowed).

1. Switch to larger Range Plug. Make sure to Change [Range] on DM32X/DM32 to match.
2. Readjust Fan Speed

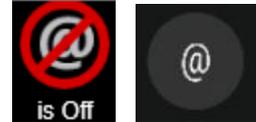
## 6.3 Cannot achieve test pressure

If the Test Blower 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. Look for large disconnects in the duct system by pressurizing the ducts then use your hand to find leaks.

If that fails, use the @ feature to read the flow that would occur if you reached the desired test pressure. Set the @ by tapping [Settings] then [Default @ Pressure]. Set to the desired test pressure.

## 6.4 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.

## 6.5 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. Ensure that the speed control cable is not connected to the bottom ethernet port of the DM32.

## 6.6 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
- Not covering all intentional duct openings
- Tape sealing being blown off, usually happens in pressurization

## **7. Find duct leaks**

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

### **7.1 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.

### **7.2 Using theatrical smoke**

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

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

### **7.3 Using an infrared camera**

An infrared camera can graphically display areas where cold air is infiltrating into a building 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.

### **7.4 Using a wet hand**

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

## 8. 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.

### 8.1 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*

Refer to the Pressure Gauge Operation Manual for the DM32X or DM32, 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.

### 8.2 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. a temporary one can be easily manufactured using thin, solid, cardboard or metal with a 2" x 2" square hole (4 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. Set % Speed until 1 in WC (250 Pa) is reached. The flow should read 68 CFM (32 l/s)
6. Compare this value with the reading on the DucTester.

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

# Appendix A Flow Conversion Tables

**Table 4: Flow in CFM for various fan pressures, Retrotec 400 series fans**

\*When Range 74 is used with 10-4" adapter on fan inlet, i.e. fan is depressurizing duct and Channel A is negative

Fan Pressure		Range									
Pa	In WC	74	74*	47	29	18	11	7	3	2	1
250	1.0	114.7	113.0	49.6	17.2	6.79	2.69	1.06	0.294	---	---
275	1.1	120.4	118.6	51.9	18.0	7.12	2.82	1.11	0.310	---	---
300	1.2	125.8	123.9	54.2	18.8	7.43	2.95	1.16	0.325	---	---
325	1.3	131.0	129.0	56.4	19.6	7.73	3.07	1.21	0.340	---	---
350	1.4	136.0	133.9	58.4	20.3	8.03	3.19	1.25	0.354	0.145	0.054
375	1.5	140.8	138.7	60.4	21.1	8.31	3.30	1.29	0.368	0.150	0.056
400	1.6	145.5	143.3	62.4	21.7	8.58	3.41	1.34	0.381	0.156	0.058
425	1.7	150.0	147.7	64.2	22.4	8.84	3.51	1.38	0.394	0.161	0.060
450	1.8	154.4	152.0	66.1	23.1	9.10	3.61	1.42	0.407	0.166	0.062
475	1.9	158.6	156.2	67.8	23.7	9.35	3.71	1.46	0.420	0.170	0.064
500	2.0	162.8	160.3	69.5	24.3	9.59	3.81	1.50	0.432	0.175	0.066
525	2.1	166.8	164.3	71.2	24.9	9.83	3.91	1.53	0.443	0.180	0.068
550	2.2	170.8	168.2	72.9	25.5	10.1	4.00	1.57	0.455	0.184	0.070
575	2.3	174.7	172.1	74.5	26.1	10.3	4.09	1.60	0.466	0.189	0.072
600	2.4	178.5	175.8	76.0	26.6	10.5	4.18	1.64	0.478	0.193	0.073
625	2.5	182.2	179.4	77.5	27.2	10.7	4.26	1.67	0.488	0.197	0.075
650	2.6	185.8	183.0	79.0	27.7	10.9	4.35	1.71	0.499	0.201	0.077
675	2.7	189.4	186.6	80.5	28.2	11.1	4.43	1.74	0.510	0.205	0.078
700	2.8	192.9	190.0	82.0	28.7	11.3	4.51	1.77	0.520	0.209	0.080
725	2.9	196.3	193.4	83.4	29.3	11.5	4.59	1.80	0.530	0.213	0.082
750	3.0	199.7	196.7	84.8	29.8	11.7	4.67	1.83	0.540	0.217	0.083
775	3.1	203.1	200.0	86.1	30.2	11.9	4.75	1.86	0.550	0.221	0.085
800	3.2	206.3	203.2	87.5	30.7	12.1	4.83	1.89	0.560	0.225	0.086
825	3.3	209.6	206.4	88.8	31.2	12.3	4.90	1.92	0.570	0.228	0.088
850	3.4	212.8	209.6	90.1	31.7	12.5	4.97	1.95	0.579	0.232	0.089
875	3.5	215.9	212.6	91.4	32.1	12.7	5.05	1.98	0.589	0.236	0.091
900	3.6	219.0	215.7	92.6	32.6	12.9	5.12	2.01	0.598	0.239	0.092
925	3.7	222.0	218.7	93.9	33.0	13.0	5.19	2.03	0.607	0.243	0.093
950	3.8	225.0	221.7	95.1	33.5	13.2	5.26	2.06	0.616	0.246	0.095
975	3.9	228.0	224.6	96.3	33.9	13.4	5.33	2.09	0.625	0.250	0.096
1000	4.0	230.9	227.5	97.5	34.3	13.6	5.40	2.12	0.634	0.253	0.098
1025	4.1	233.8	230.3	98.7	34.8	13.7	5.46	2.14	0.642	0.256	0.099
1050	4.2	236.7	233.1	99.9	35.2	13.9	5.53	2.17	0.651	0.260	0.100
1075	4.3	239.5	235.9	101.0	35.6	14.1	5.60	2.19	0.660	0.263	0.102
1100	4.4	242.3	238.7	102.2	36.0	14.2	5.66	2.22	0.668	0.266	0.103
1125	4.5	245.1	241.4	103.3	36.4	14.4	5.73	2.24	0.676	0.269	0.104

Fan Pressure		Range									
Pa	In WC	74	74*	47	29	18	11	7	3	2	1
1150	4.6	247.8	244.1	104.4	36.8	14.5	5.79	2.27	0.685	0.272	0.106
1175	4.7	250.5	246.7	105.5	37.2	14.7	5.85	2.29	0.693	0.275	0.107
1200	4.8	253.2	249.4	106.6	37.6	14.8	5.91	2.32	0.701	0.279	0.108
1225	4.9	255.8	252.0	107.7	38.0	15.0	5.98	2.34	0.709	0.282	0.109
1250	5.0	258.4	254.6	108.8	38.4	15.2	6.04	2.37	0.717	0.285	0.111
1275	5.1	261.0	257.1	109.8	38.8	15.3	6.10	2.39	0.725	0.288	0.112
1300	5.2	263.6	259.7	110.9	39.1	15.5	6.16	2.41	0.733	0.291	0.113
1325	5.3	266.2	262.2	111.9	39.5	15.6	6.22	2.44	0.741	0.294	0.114
1350	5.4	268.7	264.7	112.9	39.9	15.7	6.28	2.46	0.748	0.296	0.116
1375	5.5	271.2	267.1	113.9	40.3	15.9	6.33	2.48	0.756	0.299	0.117
1400	5.6	273.7	269.6	114.9	40.6	16.0	6.39	2.50	0.764	0.302	0.118
1425	5.7	276.1	272.0	115.9	41.0	16.2	6.45	2.53	0.771	0.305	0.119
1450	5.8	278.5	274.4	116.9	41.3	16.3	6.50	2.55	0.779	0.308	0.120
1475	5.9	281.0	276.7	117.9	41.7	16.5	6.56	2.57	0.786	0.311	0.121
1500	6.0	283.3	279.1	118.9	42.0	16.6	6.62	2.59	0.793	0.314	0.123
1525	6.1	285.7	281.4	119.8	42.4	16.7	6.67	2.61	0.801	0.316	0.124
1550	6.2	288.1	283.8	120.8	42.7	16.9	6.73	2.64	0.808	0.319	0.125
1575	6.3	290.4	286.1	121.7	43.1	17.0	6.78	2.66	0.815	0.322	0.126
1600	6.4	292.7	288.3	122.7	43.4	17.1	6.83	2.68	0.822	0.324	0.127
1625	6.5	295.0	290.6	123.6	43.8	17.3	6.89	2.70	0.829	0.327	0.128
1650	6.6	297.3	292.8	124.5	44.1	17.4	6.94	2.72	0.836	0.330	0.129
1675	6.7	299.6	295.1	125.5	44.4	17.5	6.99	2.74	0.843	0.332	0.130
1700	6.8	301.8	297.3	126.4	44.8	17.7	7.05	2.76	0.850	0.335	0.131
1725	6.9	304.0	299.5	127.3	45.1	17.8	7.10	2.78	0.857	0.338	0.133
1750	7.0	306.3	301.7	128.2	45.4	17.9	7.15	2.80	0.864	0.340	0.134
1775	7.1	308.5	303.8	129.1	45.7	18.1	7.20	2.82	0.871	0.343	0.135
1800	7.2	310.6	306.0	129.9	46.0	18.2	7.25	2.84	0.878	0.345	0.136
1825	7.3	312.8	308.1	130.8	46.4	18.3	7.30	2.86	0.884	0.348	0.137
1850	7.4	315.0	310.2	131.7	46.7	18.4	7.35	2.88	0.891	0.350	0.138
1875	7.5		312.4	132.6	47.0	18.6	7.40	2.90	0.898	0.353	0.139
1900	7.6		314.4	133.4	47.3	18.7	7.45	2.92	0.904	0.355	0.140
1925	7.7		316.5	134.3	47.6	18.8	7.50	2.94	0.911	0.358	0.141
1950	7.8			135.1	47.9	18.9	7.55	2.96	0.917	0.360	0.142
1975	7.9			136.0	48.2	19.0	7.60	2.98	0.924	0.363	0.143
2000	8.0			136.8	48.5	19.2	7.64	2.99	0.930	0.365	0.144
2025	8.1			137.6	48.8	19.3	7.69	3.01	0.937	0.368	0.145
2050	8.2			138.5	49.1	19.4	7.74	3.03	0.943	0.370	0.146
2075	8.3			139.3	49.4	19.5	7.79	3.05	0.950	0.372	0.147
2100	8.4			140.1	49.7	19.6	7.83	3.07	0.956	0.375	0.148
2125	8.5			140.9	50.0	19.8	7.88	3.09	0.962	0.377	0.149
2150	8.6			141.7	50.3	19.9	7.93	3.10	0.968	0.379	0.150

Fan Pressure		Range									
Pa	In WC	74	74*	47	29	18	11	7	3	2	1
2175	8.7			142.5	50.6	20.0	7.97	3.12	0.975	0.382	0.151
2200	8.8			143.3	50.9	20.1	8.02	3.14	0.981	0.384	0.152
2225	8.9			144.1	51.2	20.2	8.06	3.16	0.987	0.386	0.153
2250	9.0			144.9	51.5	20.3	8.11	3.18	0.993	0.389	0.154
2275	9.1			145.7	51.8	20.4	8.16	3.19	1.00	0.391	0.155
2300	9.2			146.4	52.0	20.5	8.20	3.21	1.01	0.393	0.156
2325	9.3			147.2	52.3	20.7	8.24	3.23	1.01	0.395	0.157
2350	9.4			148.0	52.6	20.8	8.29	3.25	1.02	0.398	0.158
2375	9.5			148.8	52.9	20.9	8.33	3.26	1.02	0.400	0.158
2400	9.6			149.5	53.2	21.0	8.38	3.28	1.03	0.402	0.159
2425	9.7			150.3	53.4	21.1	8.42	3.30	1.04	0.404	0.160
2450	9.8			151.0	53.7	21.2	8.46	3.31	1.04	0.407	0.161
2475	9.9			151.8	54.0	21.3	8.51	3.33	1.05	0.409	0.162
2500	10.0			152.5	54.2	21.4	8.55	3.35	1.05	0.411	0.163
2525	10.1			153.3	54.5	21.5	8.59	3.37	1.06	0.413	0.164
2550	10.2			154.0	54.8	21.6	8.64	3.38	1.06	0.415	0.165
2575	10.3			154.7	55.1	21.7	8.68	3.40	1.07	0.417	0.166
2600	10.4			155.5	55.3	21.8	8.72	3.41	1.08	0.420	0.167
2625	10.5			156.2	55.6	22.0	8.76	3.43	1.08	0.422	0.168
2650	10.6			156.9	55.8	22.1	8.80	3.45	1.09	0.424	0.169
2675	10.7			157.7	56.1	22.2	8.85	3.46	1.09	0.426	0.169
2700	10.8			158.4	56.4	22.3	8.89	3.48	1.10	0.428	0.170
2725	10.9			159.1	56.6	22.4	8.93	3.50	1.10	0.430	0.171
2750	11.0			159.8	56.9	22.5	8.97	3.51	1.11	0.432	0.172
2775	11.1			160.5	57.1	22.6	9.01	3.53	1.12	0.434	0.173
2800	11.2			161.2	57.4	22.7	9.05	3.54	1.12	0.436	0.174
2825	11.3			161.9	57.7	22.8	9.09	3.56	1.13	0.438	0.175
2850	11.4			162.6	57.9	22.9	9.13	3.58	1.13	0.440	0.176
2875	11.5			163.3	58.2	23.0	9.17	3.59	1.14	0.443	0.176
2900	11.6			164.0	58.4	23.1	9.21	3.61	1.14	0.445	0.177
2925	11.7			164.7	58.7	23.2	9.25	3.62	1.15	0.447	0.178
2950	11.8			165.4	58.9	23.3	9.29	3.64	1.15	0.449	0.179
2975	11.9			166.0	59.2	23.4	9.33	3.65	1.16	0.450	0.180
3000	12.0			166.7	59.4	23.5	9.37	3.67	1.16	0.453	0.181
3025	12.1			167.4	59.7	23.6	9.41	3.68	1.17	0.455	0.181
3050	12.2			168.1	59.9	23.7	9.45	3.70	1.18	0.457	0.182
3075	12.3			168.7	60.1	23.8	9.49	3.71	1.18	0.459	0.183
3100	12.4			169.4	60.4	23.9	9.53	3.73	1.19	0.461	0.184
3125	12.5			170.1	60.6	23.9	9.56	3.74	1.19	0.463	0.185
3150	12.6			170.7	60.9	24.0	9.60	3.76	1.20	0.465	0.186
3175	12.7			171.4	61.1	24.1	9.64	3.77	1.20	0.466	0.186

Fan Pressure		Range									
Pa	In WC	74	74*	47	29	18	11	7	3	2	1
3200	12.8			172.1	61.4	24.2	9.68	3.79	1.21	0.468	0.187
3225	12.9			172.7	61.6	24.3	9.72	3.80	1.21	0.470	0.188
3250	13.0			173.4	61.8	24.4	9.76	3.82	1.22	0.472	0.189
3275	13.1			174.0	62.1	24.5	9.79	3.83	1.22	0.474	0.190
3300	13.2			174.7	62.3	24.6	9.83	3.85	1.23	0.476	0.191
3325	13.3			175.3	62.5	24.7	9.87	3.86	1.23	0.478	0.191
3350	13.4			175.9	62.8	24.8	9.90	3.88	1.24	0.480	0.192
3375	13.5			176.6	63.0	24.9	9.94	3.89	1.24	0.482	0.193
3400	13.6			177.2	63.2	25.0	10.0	3.91	1.25	0.484	0.194
3405	13.7			177.9	63.5	25.1	10.0	3.92	1.25	0.486	0.195
3450	13.8			178.5	63.7	25.2	10.1	3.93	1.26	0.487	0.195
3475	13.9			179.1	63.9	25.3	10.1	3.95	1.26	0.489	0.196
3500	14.0			179.7	64.2	25.3	10.1	3.96	1.27	0.491	0.197
3505	14.1			180.4	64.4	25.4	10.2	3.98	1.27		
3550	14.2			181.0	64.6	25.5	10.2	3.99	1.28		
3575	14.3			181.6	64.8	25.6	10.2	4.01	1.28		
3600	14.4			182.2	65.1	25.7	10.3	4.02	1.29		
3625	14.5			182.9	65.3	25.8	10.3	4.03	1.29		
3650	14.6			183.5	65.5	25.9	10.3	4.05	1.30		
3675	14.7			184.1	65.7	26.0	10.4	4.06	1.30		
3700	14.8			184.7	66.0	26.1	10.4	4.08	1.31		
3725	14.9			185.3	66.2	26.1	10.4	4.09	1.31		
3750	15.0			185.9	66.4	26.2	10.5	4.10	1.32		
3775	15.2			186.5	66.6	26.3	10.5	4.12			
3800	15.3			187.1	66.8	26.4	10.6	4.13			
3825	15.4			187.7	67.1	26.5	10.6	4.14			
3850	15.5			188.3	67.3	26.6	10.6	4.16			
3875	15.6			188.9	67.5	26.7	10.7	4.17			
3900	15.7			189.5	67.7	26.7	10.7	4.18			
3925	15.8			190.1	67.9	26.8	10.7	4.20			
3950	15.9			190.7	68.2	26.9	10.8	4.21			
3975	16.0			191.3	68.4	27.0	10.8	4.22			
4000	16.1			191.9	68.6	27.1	10.8	4.24			
4025	16.2			192.4	68.8	27.2	10.9	4.25			
4050	16.3			193.0	69.0	27.3	10.9	4.26			
4075	16.4			193.6	69.2	27.3	10.9	4.28			
4100	16.5			194.2	69.4	27.4	11.0	4.29			
4125	16.6			194.8	69.6	27.5	11.0	4.30			
4150	16.7			195.3	69.9	27.6	11.0	4.32			
4175	16.8			195.9	70.1	27.7	11.1	4.33			
4200	16.9			196.5	70.3	27.8	11.1	4.34			

Fan Pressure		Range									
Pa	In WC	74	74*	47	29	18	11	7	3	2	1
4225	17.0			197.0	70.5	27.8	11.1	4.36			
4250	17.1			197.6	70.7	27.9	11.2	4.37			
4275	17.2			198.2	70.9	28.0	11.2	4.38			
4300	17.3			198.7	71.1	28.1	11.2	4.39			
4325	17.4			199.3	71.3	28.2	11.3	4.41			
4350	17.5			199.9	71.5	28.2	11.3	4.42			
4375	17.6			200.4	71.7	28.3	11.3	4.43			
4400	17.7			201.0	71.9	28.4	11.4	4.44			
4405	17.8			201.5	72.1	28.5	11.4	4.46			
4450	17.9			202.1	72.3	28.6	11.4	4.47			
4475	18.0			202.7	72.5	28.6	11.5	4.48			
4500	18.1			203.2	72.7	28.7	11.5	4.49			
4525	18.2			203.8	72.9	28.8	11.5	4.51			
4550	18.3			204.3	73.1	28.9	11.6	4.52			
4575	18.4			204.8	73.3	29.0	11.6	4.53			
4600	18.5			205.4	73.5	29.0	11.6	4.54			
4625	18.6			205.9	73.7	29.1	11.6	4.56			
4650	18.7			206.5	73.9	29.2	11.7	4.57			
4675	18.8			207.0	74.1	29.3	11.7	4.58			
4700	18.9			207.6	74.3	29.4	11.7	4.59			
4725	19.0			208.1	74.5	29.4	11.8	4.61			
4750	19.1			208.6	74.7	29.5	11.8	4.62			
4775	19.2			209.2	74.9	29.6	11.8	4.63			
4800	19.3			209.7	75.1	29.7	11.9	4.64			
4825	19.4			210.2	75.3	29.7	11.9	4.65			
4850	19.5			210.8	75.5	29.8	11.9	4.67			
4875	19.6			211.3	75.7	29.9	12.0	4.68			
4900	19.7			211.8	75.9	30.0	12.0	4.69			
4925	19.8			212.4	76.1	30.1	12.0	4.70			
4950	19.9			212.9	76.3	30.1	12.1	4.71			
4975	20.0			213.4	76.5	30.2	12.1	4.73			

The Flow Calibration Equations used to create this were generated using an ISO 17025 Accredited Flow Chamber to calibrated a Model 400 Fan.

# Appendix B U.S. Duct Leakage - Calculation (SMACNA)

When testing, these factors may have to be calculated prior to the test. In some cases, this calculation is done by the design engineer so the tester only has to supply leakage values.

## B.1 Leakage Class

Leakage Class, $C_L$	$C_L = F / P^{0.65}$ $C_L = F$ (leakage rate in CFM/ 100 sq ft) divided by the Pressure in in WC to the 0.65 Power. Leakage Constant is an equivalent term.
----------------------	---

Leakage classification identifies a permissible leakage rate in CFM per 100 square feet of duct surface according to the relationship  $CL = F / P^{0.65}$ .

F is the leakage factor, a rate in CFM/100 sq ft of duct surface area and varies with pressure.

P is the pressure.

$C_L$  is the Leakage Class

If, at the specified test pressure, the leakage factor (F), by test, is lower than or equal to that associated with the specified leakage class, the duct is in compliance. Alternatively, if the leakage constant ( $C_L$ ) determined from tests is lower than or equal to the specified leakage class, the duct is in compliance.

Assignment of leakage classes involves careful consideration of system size, duct location, sealing and construction class. Arbitrary assignment of an allowable % of leakage in disregard of these factors can require unobtainable results.

A ½% allowance, for example, on a 3900 CFM system with 1300 sq ft of duct or on a 39,000 CFM system with 13,000 sq ft of duct would mean an unrealistic leakage factor of 1.5 CFM/100 sq ft in each case. Similarly, arbitrary assignment of 10" wg class construction for a system operating at 1" wg in order to get leak class 3 rectangular duct would not be cost effective. Assigning a leakage class 3 to a 1" wg rectangular duct system may address an achievable result but the associated difficulty and costs will be excessive.

SMACNA Table 4-1 Leakage Class, 1985 version

Duct Construction Class	½", 1", 2" wg	3" wg	4", 6", 10" wg
Seal Class	C	B	A
Sealing applicable	Transverse joints only	All transverse joints and longitudinal seams only	All transverse joints, longitudinal seams, and duct to wall penetrations
Leakage Class			
Rectangular metal	24	12	6
Round metal	12	6	3

Table 5 SMACNA 1985 Leakage Class

SMACNA Table 4-1 (reproduced here) represents the leakage expected using Seal Classes A, B, and C as indicated on duct construction of the types typically selected for each pressure class. Conceivably Seal

Class B or A could be applied at construction pressure classes lower than indicated in SMACNA Table 4-1. However, unless joint type, seam type, duct wall thickness and specific sealing method were already collectively prequalified by tests (or by an acceptable experience record at a higher pressure) leakage rate is less predictable. The benefits of setting allowable leakage rates lower than shown in SMACNA Table 4-1 should be carefully weighed against the costs of achieving them.

SMACNA Table 4-1 Leakage Class, 2012 version

Duct Construction Class	½", 1", 2" wg	3" wg	4", 6", 10" wg
Seal Class	C	B	A
Sealing applicable	Transverse joints only	All transverse joints and longitudinal seams only	All transverse joints, longitudinal seams, and duct to wall penetrations
Leakage Class			
Rectangular metal	16	8	4
Round metal	8	4	2

Table 6 SMACNA 2012 Leakage Class

1. Leakage classes in SMACNA Table 4-1 apply when the designer does not designate other limits and has specified Seal Class C for ½" and 1" wg See text on sealing in the HVAC-DCS manual.
2. Unsealed rectangular metal duct may follow Leakage Class 48.
3. Fibrous glass duct may follow Leakage Class 6 (at 2" wg or less).
4. Unsealed flexible duct leakage average is estimated to be Class 30. Sealed nonmetal flexible duct is an average of Class 12.
5. See SMACNA HVAC Duct Systems Design Manual Table 5-1 for longitudinal seam leakage rates.
6. Although Seal Class A or B might be assigned for lower pressures, the leakage class may not conform to those associated with the higher pressure. Other construction details influence results.
7. The duct pressure classification is not the fan static pressure nor the external static pressure (on an HVAC unit) unless the system designer has made such an assignment in his contract documents. Unless construction class is otherwise specified it means a static pressure classification in the SMACNA HVAC-DCS. Those classifications pertain to maximum operating pressure in the duct as follows: 0.5" wg maximum.

- 0.6" to 2" wg maximum
- 1.1" to 2" wg maximum
- 2.1" to 3" wg maximum
- 3.1" to 4" wg maximum
- 4.1" to 6" wg maximum
- 6.1" to 10" wg maximum

## B.2 Leakage Class Lookup

If you know the Leakage Factor and the Pressure Class, use the following table to determine Leakage Class. You may also use Retrotec FanTestic Software or a calculation spreadsheet.

Select the pressure value shown under the flow rate on the X axis (in this example, 2 in WC). Then select the closest Leakage Factor (in CFM/100 sq ft) as was observed on the DM32. Where they coincide, is the Leakage Class.

Eg. @ Pressure is 2 in WC and Leakage Factor is 8 then the Leakage Class is 5.1.

		Leakage Class, C <sub>L</sub>									
@ Pressure, in WC >>>		0.2	0.5	1	2	3	4	6	8	10	
Leakage Factor, F	CFM/100 sq ft										
0.6		1.7	0.9	0.6	0.4	0.3	0.2	0.2	0.2	0.1	
0.8		2.3	1.3	0.8	0.5	0.4	0.3	0.2	0.2	0.2	
1		2.8	1.6	1.0	0.6	0.5	0.4	0.3	0.3	0.2	
1.2		3.4	1.9	1.2	0.8	0.6	0.5	0.4	0.3	0.3	
1.4		4.0	2.2	1.4	0.9	0.7	0.6	0.4	0.4	0.3	
1.6		4.6	2.5	1.6	1.0	0.8	0.6	0.5	0.4	0.4	
1.8		5.1	2.8	1.8	1.1	0.9	0.7	0.6	0.5	0.4	
2		5.7	3.1	2.0	1.3	1.0	0.8	0.6	0.5	0.4	
2.5		7.1	3.9	2.5	1.6	1.2	1.0	0.8	0.6	0.6	
3		8.5	4.7	3.0	1.9	1.5	1.2	0.9	0.8	0.7	
3.5		10.0	5.5	3.5	2.2	1.7	1.4	1.1	0.9	0.8	
4		11.4	6.3	4.0	2.5	2.0	1.6	1.2	1.0	0.9	
4.5		12.8	7.1	4.5	2.9	2.2	1.8	1.4	1.2	1.0	
5		14.2	7.8	5.0	3.2	2.4	2.0	1.6	1.3	1.1	
5.5		15.7	8.6	5.5	3.5	2.7	2.2	1.7	1.4	1.2	
6		17.1	9.4	6.0	3.8	2.9	2.4	1.9	1.6	1.3	
6.5		18.5	10.2	6.5	4.1	3.2	2.6	2.0	1.7	1.5	
7		19.9	11.0	7.0	4.5	3.4	2.8	2.2	1.8	1.6	
7.5		21.3	11.8	7.5	4.8	3.7	3.0	2.3	1.9	1.7	
8		22.8	12.6	8.0	5.1	3.9	3.2	2.5	2.1	1.8	
8.5		24.2	13.3	8.5	5.4	4.2	3.5	2.7	2.2	1.9	
9		25.6	14.1	9.0	5.7	4.4	3.7	2.8	2.3	2.0	
9.5		27.0	14.9	9.5	6.1	4.7	3.9	3.0	2.5	2.1	
10		28.5	15.7	10.0	6.4	4.9	4.1	3.1	2.6	2.2	
12		34.2	18.8	12.0	7.6	5.9	4.9	3.7	3.1	2.7	
14		39.9	22.0	14.0	8.9	6.9	5.7	4.4	3.6	3.1	
16		45.5	25.1	16.0	10.2	7.8	6.5	5.0	4.1	3.6	
18			28.2	18.0	11.5	8.8	7.3	5.6	4.7	4.0	
20			31.4	20.0	12.7	9.8	8.1	6.2	5.2	4.5	
22			34.5	22.0	14.0	10.8	8.9	6.9	5.7	4.9	
24			37.7	24.0	15.3	11.8	9.7	7.5	6.2	5.4	
26			40.8	26.0	16.6	12.7	10.6	8.1	6.7	5.8	
28			43.9	28.0	17.8	13.7	11.4	8.7	7.2	6.3	
30			47.1	30.0	19.1	14.7	12.2	9.4	7.8	6.7	
35				35.0	22.3	17.1	14.2	10.9	9.1	7.8	
40				40.0	25.5	19.6	16.2	12.5	10.4	9.0	
45				45.0	28.7	22.0	18.3	14.0	11.6	10.1	
50					31.9	24.5	20.3	15.6	12.9	11.2	
55					35.1	26.9	22.3	17.2	14.2	12.3	
60					38.2	29.4	24.4	18.7	15.5	13.4	
65					41.4	31.8	26.4	20.3	16.8	14.6	
70					44.6	34.3	28.4	21.8	18.1	15.7	
75					47.8	36.7	30.5	23.4	19.4	16.8	
85						41.6	34.5	26.5	22.0	19.0	
95						46.5	38.6	29.6	24.6	21.3	
105							42.6	32.8	27.2	23.5	

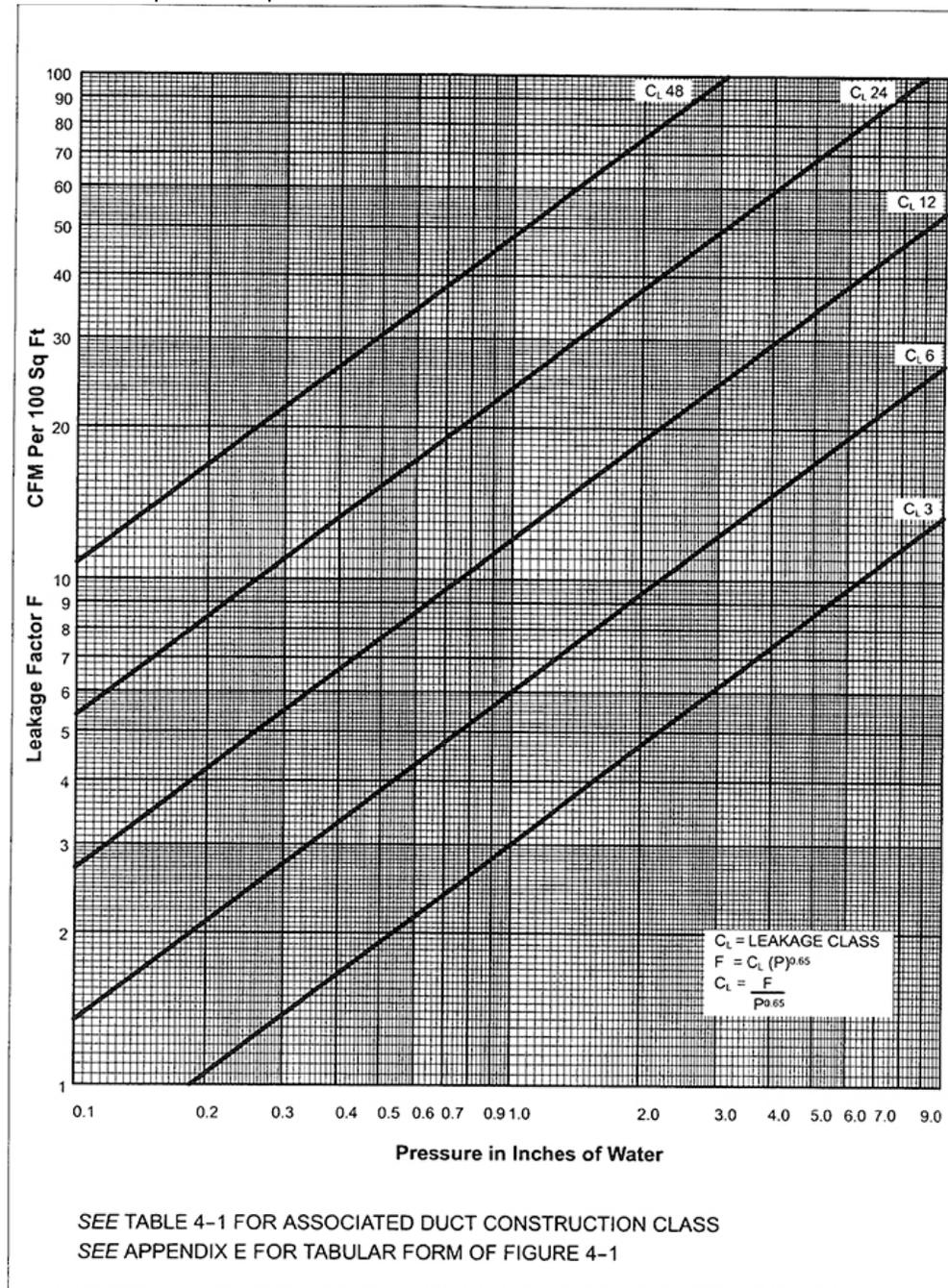
Figure 17 Leakage Class lookup table.

## B.3 Leakage Factor

Leakage Factor, F, is the maximum allowable leakage in CFM per 100 square feet of ductwork (not counting blanking plates used to seal the ducts). This can be obtained from the graph, the table or the formula.

### B.3.1. Leakage Factor from the graph

For example, if the Test Pressure was 2 in WC and the Leakage Class was 12 then the Leakage Factor, F would be 18.8 CFM per 100 square feet.



### **B.3.2. Leakage Factor from the formula**

$$F = C_L \times P^{0.65}$$

Where:

$C_L$  is the Leakage Class

$P$  is the Test Pressure in in WC

0.65 is the exponent.

Example:

$C_L = 12$

$P = 2.0$  in WC

0.65 is the exponent.

$F = 12 \times 2.0^{0.65} = 18.83$  CFM per 100 square feet.

### B.3.3. Leakage Factor from a table

Test Pressure, in WC	Leakage Factor, F in CFM/100 square feet				
	Class 3	Class 6	Class 12	Class 24	Class 48
0.05	0.4	0.9	1.7	3.4	6.7
0.10	0.7	1.3	2.7	5.4	10.7
0.20	1.1	2.1	4.2	8.4	16.8
0.30	1.4	2.7	5.5	11.0	21.9
0.40	1.7	3.3	6.6	13.2	26.4
0.50	1.9	3.8	7.6	15.3	30.6
0.60	2.2	4.3	8.6	17.2	34.4
0.70	2.4	4.8	9.5	19.0	38.1
0.80	2.6	5.2	10.4	20.8	41.5
0.90	2.8	5.6	11.2	22.4	44.8
1	3	6	12	24	48
1.5	3.9	7.8	15.6	31.2	62.4
2.0	4.7	9.4	18.8	37.7	75.4
2.5	5.4	10.9	21.7	43.4	86.8
3.0	6.1	12.2	24.5	49.0	98.0
3.5	6.7	13.6	27.1	54.2	108.5
4.0	7.4	14.8	29.5	59.0	118.1
4.5	8.0	16.0			
5.0	8.6	17.1			
5.5	9.1	18.2			
6.0	9.6	19.2			
7.0	10.6	21.2			
8.0	11.6	23.2			
9.0	12.5	25.0			
10.0	13.4	26.8			
11.0	14.3	28.5			

Table 7 Leakage Factor

## **B.4 Pressure Class**

### **B.4.1. Duct pressure classifications**

The duct system designer should designate the Pressure Class or classes for construction of each duct system and clearly identify these in the contract document.

Where no pressure classes are specified by the designer, the 1 inch Water Column (in WC) Pressure Class will be the basis of compliance with SMACNA, regardless of velocity in the duct, except variable volume duct upstream of VAV boxes which must have a 2" in WC Pressure Class.

Conventional leak testing requires a positive test pressure.

### **B.4.2. Specified Test Pressure**

The ducts should be tested at this pressure if specified but the Test Pressure shall not exceed the Pressure Class. Normally the designer will specify the Test Pressure.

## Appendix C U.S. Duct Leakage - Measurement Procedure 1 (CFM/100 sq ft)



Picture of DM32 display showing Leakage Factor of 10.54 CFM/100 sq ft @ 4.0000 in WC on Channel B.

Notice the duct surface area of 1255 square feet is displayed. The actual test pressure is 3.2157 in WC but the gauge displays in units of flow at the specified Test Pressure of 4.000 in WC using the extrapolation feature identified because “@” pressure is “On”.

## C.1 How much duct surface area can be tested at one time?

The table below shows the maximum surface area that one Model 400 blower will test if the ducts just pass. Since ducts will usually be tighter than the minimum specified, much larger areas can normally be tested than those shown on the table.

Test Pressure, in WC	Duct Leakage Class ( $C_L$ ), CFM/100 square feet of leakage that would occur at pressures in inches WC shown on top row						
	1	2	4	8	16	32	48
20	4,066	2,033	1,017	508	254	127	85
10	6,380	3,190	1,595	798	399	199	133
6	8,893	4,446	2,223	1,112	556	278	185
4	11,575	5,787	2,894	1,447	723	362	241
3	13,955	6,977	3,489	1,744	872	436	291
2	18,162	9,081	4,541	2,270	1,135	568	378
<b>1</b>	<b>28,500</b>	<b>14,250</b>	<b>7,125</b>	<b>3,563</b>	<b>1,781</b>	<b>891</b>	<b>594</b>
0.5	44,721	22,361	11,180	5,590	2,795	1,398	932
0.1	127,305	63,652	31,826	15,913	7,957	3,978	2,652
	<b>Duct Surface Area, square feet</b>						

Table 8 Duct Surface area that can be tested with one Model 400

The extrapolation feature in the gauge allows accurate readings to be taken at 0.1 in WC, so the bottom row may be used to determine the surface area of duct that can be tested at one time. Duct systems with larger areas will have to be broken down into sections using barriers and the results added up..

If you cannot achieve 0.1 in WC for the surface areas listed, the ducts will fail the test and must be sealed up more before additional testing is attempted. Also look for disconnect and sections that are not correctly blanked off. Check all temporary plugs, plates, sheets, balloons, bags used to seal intentional openings.

## C.2 Checklist

Test Technician \_\_\_\_\_ Test Date \_\_\_\_\_

Test Location \_\_\_\_\_

Follow the color Model 440/450 Quick Guide that comes with your system. Print out these four pages to direct your test. Use this Test Form if Leakage Factor is the pass/fail criteria for the test. If not, use "Appendix X2 U.S. CFM at Test Pressure or % leakage".

Check off each box to learn the procedure for your first test.

### Pass Fail for U.S. tests

Leakage Factor in CFM/100 sq ft at a specified Test Pressure is often the pass/fail criteria. Leakage Factor is measured and read out directly on the DM32 Gauge.

*This is common wording for the pass/fail criteria:*

1. *"If, at the specified test pressure, the Leakage Factor (F), by test, is lower than or equal to that associated with the specified Leakage Class, the duct is in compliance."*
2. *"If the Leakage Class ( $C_L$ ) determined from tests is lower than or equal to the specified leakage class, the duct is in compliance."*

Follow Steps 1 to 7.

**If you fail** and the specifying Engineer wants a higher Test Pressure, measure the Leakage Class to convince the Engineer that you have sufficient test flow but the ducts are too leaky to pass regardless of Test Pressure.

Notes:

---

---

---

---

---

---

---

### C.2.2. Step 1 - Prepare the gauge - first time only

Once the Gauge has been set up, all settings are restored when the gauge is turned back on.

<input type="checkbox"/> <b>Home</b> screen must show Model 450 on Range 47	If not, tap picture, then [Change Device]. Tap “450”. Then select Range 47.
<input type="checkbox"/> <b>Home</b> screen must show pressure units of CFM at a pressure in WC per 100 square feet.	If not, tap [Settings] and [Results to be displayed]. Tap pressure units until you see inches of Water Column: Then tap flow units until you see [Flow/Area: CFM/100 sq ft] Tap On button to return Home. Once set, you’ll never have to change it again.
<input type="checkbox"/> <b>Home</b> screen must time average as 5 seconds.	If not, tap [Settings] and [Time Averaging] until “ 5 s avg” is displayed. Tap On button to return Home. This will create a running average that will smooth out results, making them easier to read. If the result fluctuates, increase up to 30 seconds. Refer to manual for more information.
The Gauge is set up now and you’re ready for your first test.	



### C.2.3. Step 2 – Determine test criteria and prepare the ducts

<input type="checkbox"/> Determine the Leakage Class	<b>Determine the specified Leakage Class from design Engineer or determine using SMACNA Table 4-1.</b> See section on Leakage Class.
<input type="checkbox"/> Determine the Pressure Class	<b>Use specified value.</b> If not specified, use a Pressure Class of 1 in WC except upstream of VAV boxes, use 2 in WC. Use a positive test pressure unless specified otherwise. Test pressure shall not exceed the Pressure Class according to SMACNA “HVAC Air Duct Leakage Test Manual”.
<input type="checkbox"/> Measure duct area	Select a limited section of duct for which the estimated leakage will not exceed the capacity of the test apparatus. Measure the duct surface area in square feet. See Table Duct Surface area that can be tested with one Model 400.
<input type="checkbox"/> Ensure sealing is complete	Ensure sealing materials have cured for the prescribed time or at least 24 hours OR follow manufacturer’s directions.
<input type="checkbox"/> Blank off ductwork	Blank off and seal the tested ductwork by inserting temporary plugs plates, sheets, balloons, bags into intentional openings.

**C.2.4. Step 3 – Connect DucTester to ducts**

<input type="checkbox"/> Attach 4 inch Flange to ductwork.	
<input type="checkbox"/> Attach 4 inch collar on flex to flange	
<input type="checkbox"/> Connect DucTester exhaust to flex	
<input type="checkbox"/> Install Range 47 Flow Plug	Range 47 provides 52 to 206 CFM, which is sufficient to test most duct runs.

**C.2.5. Step 4 –Tubing, control and power connections**

<input type="checkbox"/> Connect yellow and green tubes between DucTester fan and gauge	
<input type="checkbox"/> Connect blue tube between gauge and ducts using static probe or connection on flange	
<input type="checkbox"/> Plug in the Speed Control Cable between DucTester fan and Gauge	
<input type="checkbox"/> Plug fan in to power source, turn fan power on.	

**C.2.6. Step 5 – Set up Test Pressure and Area in Gauge**

<input type="checkbox"/> Default @ Pressure in gauge must match the specified Test Pressure	<p>If not, tap [Settings] and TAP [Default @ Pressure]. Then [Set] value to specified Test Pressure.</p> <p>Since you must not exceed the test pressure, the actual pressure will be lower but entering this default will ensure that all results are displayed at the exact pressure entered.</p>
<input type="checkbox"/> [Area] then use the number pad and tap [Set].	<p>Measure the duct surface area in square feet and enter it into the DM32. Select a limited section of duct for which the estimated leakage will not exceed the capacity of the test apparatus. Area can also be accessed from [Settings] menu.</p>

### C.2.7. Step 6 – Measure Leakage Factor in CFM/100 sq ft

<input type="checkbox"/> [Set Speed] to 1% then Jog up to the Test Pressure.	<b>WARNING:</b> To prevent over-pressurizing, slowly increase fan speed using Set Speed. Jog the speed up 1% at a time until a CFM value appears on the display. Continue to increase fan speed up to but do not exceed the Pressure Class. If you do not reach the Pressure Class, results will still be calculated at that Pressure Class.
<input type="checkbox"/> Tap “@” on the display and “CFM/100 sq ft @ 1.0000” will appear	Measure the Leakage Factor, F by tapping “@” on the display and CFM/100 square foot @ the Pressure Class will appear. In our example we set the Default pressure to 1 in WC.
<input type="checkbox"/> Leakage Factor is displayed  <input type="checkbox"/> Passes if value is lower than that specified	<p>The Leakage Factor, F is displayed as:</p>  <p>If this Leakage Factor is lower than or equal to the value specified, the duct is in compliance. If it fails, measure Leakage Class per section below.</p>

### C.2.8. Step 7 – Test Passes

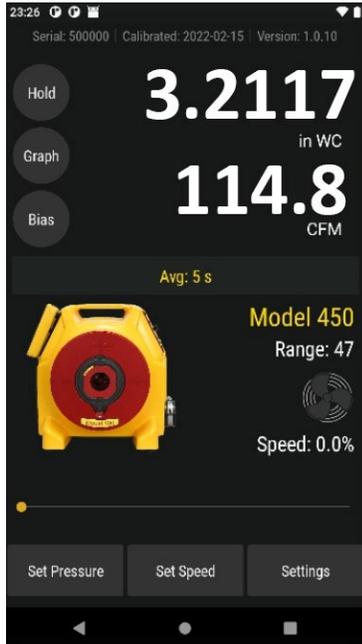
Complete test reports	Complete test reports and, if required, obtain witness’s signature.
Remove temporary seals.	Remove temporary blanks and seals.

## C.3 If ducts fail, measure the Leakage Class

This is an option if you fail the test or the specification calls for this result.

Look up the Leakage Class	If this Leakage Class calculated is lower than or equal to the value specified, the duct is in compliance. See Figure 18 Leakage Class lookup table.
If it fails, additional sealing is needed.	

## Appendix D U.S. Duct Leakage - Measurement Procedure 2 (CFM at Test Pressure or % Leakage)



Picture of DM32 display showing Leakage of 114.8 CFM @ 4.0000 in WC on Channel B.

Notice that NO square footage is displayed in lower left of screen

AIR SYSTEM: Supply 6" pressure class				LEAKAGE CLASS:6/3							
FAN CFM: NA				SPECIFIED TEST PRESSURE: 6"wc							
				DUCT CONSTRUCTION PRESSURE CLASS: 6" wc							
DESIGN DATA			FIELD TEST DATA RECORD								
SUBJECT DUCT	Surface Area Test Section	ALLOWABLE LEAKAGE		DIAMETER		PRESSURE " W.G.		DATE	PERFORMED BY	WITNESSED BY	ACTUAL CFM
		FACTOR CFM/100FT <sup>2</sup>	CFM TEST SECTION	ORIFICE	TUBE	DUCT	ACROSS ORIFICE				
2.07.01 Round	122	9.61	12								
2.07.01 Square	272	19.23	52								
<b>2.07.01 Total</b>			<b>64</b>	<b>127061</b>	<b>1010263</b>						
2.07.04 Round	137	9.61	13								
2.07.04 Square	112	19.23	22								
<b>2.07.04 Total</b>			<b>35</b>	<b>127061</b>	<b>1010263</b>						
2.07.05 Round	74	9.61	7								
2.07.05 Square	285	19.23	55								
<b>2.07.05 (#1)Total</b>			<b>62</b>	<b>127061</b>	<b>1010263</b>						
2.07.05 Round	110	9.61	11								
2.07.05 Square	141	19.23	27								
<b>2.07.05 (#2)Total</b>			<b>38</b>	<b>127061</b>	<b>1010263</b>						

When CFM is being measured at the specified Test Pressure, a sheet is often used where there are multiple duct runs. Individual measurements are made and added to the spreadsheet. Sometimes results are measured at different test pressure; they should be added to any data collection sheet the tester has been supplied with. Flows should be totaled.

### D.1 How much duct surface area can be tested at one time?

The table below shows the maximum surface area that one Model 400 Blower will test if the ducts just pass. Since ducts will usually be tighter than the minimum specified, much larger areas can normally be tested than those shown on the table.

Test Pressure, in WC	Duct Leakage Class ( C <sub>L</sub> ), CFM/100 square feet of leakage that would occur at pressures in inches WC shown on top row						
	1	2	4	8	16	32	48
20	4,066	2,033	1,017	508	254	127	85
10	6,380	3,190	1,595	798	399	199	133
6	8,893	4,446	2,223	1,112	556	278	185
4	11,575	5,787	2,894	1,447	723	362	241
3	13,955	6,977	3,489	1,744	872	436	291
2	18,162	9,081	4,541	2,270	1,135	568	378
<b>1</b>	<b>28,500</b>	<b>14,250</b>	<b>7,125</b>	<b>3,563</b>	<b>1,781</b>	<b>891</b>	<b>594</b>
0.5	44,721	22,361	11,180	5,590	2,795	1,398	932
0.1	127,305	63,652	31,826	15,913	7,957	3,978	2,652
	<b>Duct Surface Area, square feet</b>						

**Table 9 Duct Area that can be tested**

The extrapolation feature in the gauge allows accurate readings to be taken at 0.1 in WC, so the bottom row may be used to determine the surface area of duct that can be tested at one time. Duct systems with larger areas will have to be broken down into sections using barriers and the results added up.

If you cannot achieve 0.1 in WC for the surface areas listed, the ducts will fail the test and must be sealed up more before additional testing is attempted. Also look for disconnect and sections that are not correctly blanked off. Check all temporary plugs, plates, sheets, balloons, bags used to seal intentional openings.

## D.2 What Air Handler Flow Rate can be tested at one time?

The table below shows the maximum air handler flow rate that one Model 400 blower will test if the ducts just pass. Since ducts will usually be tighter than the minimum specified, much flow rates can normally be accommodated by the Model 400 than those shown on the table.

Test Pressure, in WC	Allowable Loss Rate, %						
	1	2	3	4	5	6	8
20	4,066	2,033	1,355	1,017	813	678	508
10	6,380	3,190	2,127	1,595	1,276	1,063	798
6	8,893	4,446	2,964	2,223	1,779	1,482	1,112
4	11,575	5,787	3,858	2,894	2,315	1,929	1,447
3	13,955	6,977	4,652	3,489	2,791	2,326	1,744
2	18,162	9,081	6,054	4,541	3,632	3,027	2,270
<b>1</b>	<b>28,500</b>	<b>14,250</b>	<b>9,500</b>	<b>7,125</b>	<b>5,700</b>	<b>4,750</b>	<b>3,563</b>
0.5	44,721	22,361	14,907	11,180	8,944	7,454	5,590
0.1	127,305	63,652	42,435	31,826	25,461	21,217	15,913
	<b>Air Handler Flow Rate, CFM</b>						

**Table 10 Airhandler Flow rate that can be tested**

## D.3 Checklist

Test Technician \_\_\_\_\_ Test Date \_\_\_\_\_

Test Location \_\_\_\_\_

Follow the color Model 440/450 Quick Guide that comes with your system. Print out these four pages to direct your test. Use this Test Form if total CFM at a Test Pressure or Percent Leakage of the air handler is the pass/fail criteria for the test. If not, use "Appendix B U.S. Measurement Procedure for Leakage Factor or Leakage Class".

Check off each box to learn the procedure for your first test.

### Pass Fail for U.S. tests

Total Duct Leakage at the specified test pressure is the pass/fail criteria and is a value given by the system designer. CFM flow at the test pressure are read out directly on the DM32 Gauge or from Retrotec's FanTestic software.

*This is common wording for the pass/fail criteria:*

3. "If, at the specified test pressure(s), the Leakage is lower than or equal to the total specified CFM, the system Passes. "
4. "If, at the specified test pressure, the Leakage is lower than or equal to the specified percentage of airhandler flow, the system Passes. "

Follow Steps 1 to 7.

Notes:

---

---

---

---

---

---

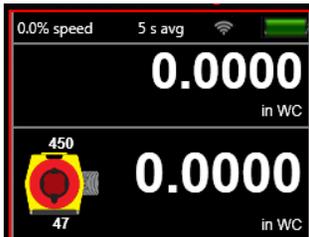
---

---

### D.3.1. Step 1 - Prepare the gauge - first time only

Once the Gauge has been set up, all settings are restored when the gauge is turned back on.

<input type="checkbox"/> <b>Home</b> screen must show Model 450 on Range 47	<p>If not, tap picture, then [Change Device].</p> <p>Tap ... until "Retrotec DucTester" page appears.</p> <p>Tap "450".</p> <p>Tap the icon with 47 below it to get Range 47</p>
<input type="checkbox"/> <b>Home</b> screen must show pressure units of in WC and flow result of CFM	<p>If not, tap [Settings] and [Results to be displayed].</p> <p>Tap pressure units until you see inches of Water Column. Then tap flow units until you see Flow:CFM.</p> <p>Tap On button to return Home.</p> <p>Once set, you'll never have to change it for this type of test.</p>
<input type="checkbox"/> <b>Home</b> screen must time average as 5 seconds.	<p>If not, tap [Settings] and [Time Averaging] until "5 s avg" is displayed. Tap On button to return Home.</p> <p>This will create a running average that will smooth out results, making them easier to read. If the result fluctuates, increase up to 30 seconds. Refer to manual for more information.</p>
<p>The Gauge is set up now and you're ready for your first test.</p>	



### D.3.2. Step 2 – Prepare the ducts

<input type="checkbox"/> Determine the Pressure Class	<b>Use specified value.</b> If not specified, use a Pressure Class of 1 in WC except upstream of VAV boxes, use 2 in WC. Use a positive test pressure unless specified otherwise. Test pressure shall not exceed the Pressure Class according to SMACNA “HVAC Air Duct Leakage Test Manual”.
<input type="checkbox"/> Measure duct area <input type="checkbox"/> – But not if using % airhandler flow as pass/fail criteria.	Select a limited section of duct for which the estimated leakage will not exceed the capacity of the test apparatus. Measure the duct surface area in square feet.
<input type="checkbox"/> Ensure sealing is complete	Ensure sealing materials have cured for the prescribed time or at least 24 hours OR follow manufacturer’s directions.
<input type="checkbox"/> Blank off ductwork	Blank off and seal the tested ductwork by inserting temporary plugs plates, sheets, balloons, bags into intentional openings.

### D.3.3. Step 3 – Connect DucTester to ducts

<input type="checkbox"/> Attach 4 inch Flange to ductwork.	
<input type="checkbox"/> Attach 4 inch collar on flex to flange	
<input type="checkbox"/> Connect DucTester exhaust to flex	
<input type="checkbox"/> Install Range 47 Flow Plug	Range 47 provides 52 to 206 CFM, which is sufficient to test most duct runs.

### D.3.4. Step 4 –DucTester tubing, control and power connections

<input type="checkbox"/> Connect yellow and green tubes between DucTester and gauge	
<input type="checkbox"/> Connect blue tube to gauge and to ducts using static probe or connection on flange	
<input type="checkbox"/> Plug in the Speed Control Cable between DucTester and Gauge	
<input type="checkbox"/> Plug fan in to power source, and turn power on to fan	

### D.3.5. Step 5 – Set up Test Pressure in Gauge

<input type="checkbox"/> Default in gauge must match the specified Test Pressure	<p>If not, tap [Settings] and tap [Default @ Pressure.] Then [Set] value to specified Test Pressure.</p> <p>Since you must not exceed the test pressure, the actual pressure will be lower but entering this default will ensure that all results are displayed at the exact pressure entered.</p>
--	--

### D.3.6. Step 6 – Run test

<input type="checkbox"/> [Set Speed] to 1% then Jog up to the Test Pressure.	<p><b>WARNING:</b> To prevent over-pressurizing, slowly increase fan speed using Set Speed. Jog the speed up 1% at a time until a CFM value appears on the display. Continue to increase fan speed up to but do not exceed the Pressure Class. If you do not reach the Pressure Class, results will still be calculated at for that Pressure Class.</p>
<input type="checkbox"/> Tap “@” on the display and “CFM @ Test Pressure” will appear.	<p>Measure the CFM at the exact test pressure by tapping “@” on the display and CFM @ the Pressure Class will appear. In our example we set the Default pressure to 1 in WC.</p>
<input type="checkbox"/> CFM at specified test pressure is displayed  <input type="checkbox"/> Passes if value is lower than that specified	<p>The Flow is displayed as:</p> <p>In this example the flow is 92.91 CFM at 1.0000 inches of Water Column.</p> <p>If the total leakage is lower than or equal to the value specified, the duct is in compliance. If it fails.</p> 

### D.3.7. Step 7 – Test Passes

<input type="checkbox"/> Complete test reports	<p>Complete test reports and obtain witness’s signature.</p>
<input type="checkbox"/> Remove temporary seals.	<p>Remove temporary blanks and seals.</p>

## Appendix E UK Duct Leakage Calculation (DW/143)

Engineer specifies the required Airtightness Class for the Ducts.

### E.1 Ductwork Classification and Air Leakage Limits

UK Ductwork Classification			
Airtightness Class	A	B	C
Positive static pressure limit ( $p_s$ ), Pa	500	1 000	2 000
Negative static pressure limit ( $p_s$ ), Pa	500	750	750
Air Leakage limit ( $f_{max}$ ), L/(s * m <sup>2</sup> )	$0.027 * p_t^{0,65}$	$0.009 * p_t^{0,65}$	$0.003 * p_t^{0,65}$

Where  $p_t$  = test pressure, Pa

Table 11 UK Airtightness Class and Leakage limits

### E.2 Test Sheet

Test details	
Date	[YYYY-MM-DD], [Time]
Tester	[Technician Name], [Company]
Witness	[Official's Name]
Project	[Building Name]
Building location	[Address] [City], [State], [Country], [Zip code]
Elevation, m	
Temperature, °C	
Duct Parameters	
Ductwork section tested	[Supply system], [Floor]
Ductwork Classification	[A/B/C]
Static Pressure (from designers), Pa	
Surface Area of ductwork tested, m <sup>2</sup>	
Equipment Specifications	
Test fan manufacturer	Retrotec
Test fan model series	400
Test gauge model	DM32
Test fan flow capacity	144 L/s (at 250 Pa duct pressure)
Test data	
Duct pressure induced, Pa	[from gauge's Channel A pressure]
Air Leakage result, L/(s * m <sup>2</sup> )	[from gauge's Channel B Flow/Area result]
Air Leakage Limit at test pressure, $f_{max}$ , L/(s * m <sup>2</sup> )	[from <b>Table 11</b> ]
Pass/Fail?	["Pass"/"Fail"]
Duration of Test, min	[15 minutes or greater]

### **E.3 UK Measurement Procedure (Summary)**

Connect DucTester fan to ductwork.

Set Duct Pressure [“Adjust test rig until static pressure differential is obtained”].

Verify results are within Air Leakage Limit.

Maintain test for 15 minutes and verify air leakage rate has not increased.

Stop the fan, immediately Set Pressure again, and verify air leakage rate is not greater than previous reading.

Record test data into Test Sheet or enter test data into FanTestic software.

## E.4 UK Measurement Procedure (Detailed)

Test Technician \_\_\_\_\_ Test Date \_\_\_\_\_  
Test Location \_\_\_\_\_

Follow the color Model 440/450 Quick Guide that comes with your system. Print out these four pages to direct your test.

Check off each box to learn the procedure for your first test.

### Pass Fail for UK tests

Air Leakage in  $L/(s * m^2)$  at a specified Test Pressure is often the pass/fail criteria. Air Leakage is measured and read out directly on the DM32 Gauge.

*This is common wording for the pass/fail criteria:*

*“If, at the specified test pressure, the Air Leakage of test is lower than or equal to that associated with the specified Air Leakage Limit ( $f_{max}$ ) from **Table 11**, the duct is in compliance. “*

Follow Steps 1 to 7.

Notes:

---

---

---

---

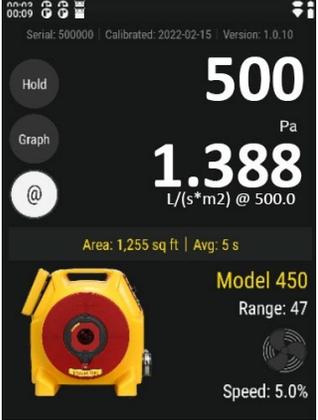
---

---

---

### E.4.1. UK Step 1 - Prepare the gauge - first time only

Once the Gauge has been set up, all settings are restored when the gauge is turned back on.

<input type="checkbox"/> <b>Home</b> screen must show Model 450 on Range 47	If not, tap picture, then [Change Device]. Tap ... until "Retrotec DucTester" page appears. Tap "450". Tap the icon with 47 below to get Range 47
<input type="checkbox"/> <b>Home</b> screen must show pressure units of Pa and Channel B result of L/(s * m <sup>2</sup> ) @ a pressure in Pa. 	If not, tap [Settings] and [Results to be displayed].  Tap pressure units until you see Pressure: in WC. Then tap flow units until you see Flow/Area: CFM/100 sq ft.  Tap On button to return Home. Once set, you'll never have to change it again.
<input type="checkbox"/> <b>Home</b> screen must time average as 5 seconds.	If not, tap [Settings] and [Time Averaging] until "5 s avg" is displayed. Tap On button to return Home. This will create a running average that will smooth out results, making them easier to read. If the result fluctuates, increase up to 30 seconds. Refer to manual for more information.
The Gauge is set up now and you're ready for your first test.	

### E.4.2. Step 2 – Determine test criteria and prepare the ducts

<input type="checkbox"/> Determine the Pressure to use	<b>Use 80 Pa, 160 Pa or 250 Pa depending on the type of building being tested (Residential, Multi-Family, or Commercial)</b>
<input type="checkbox"/> Measure duct area	<b>Select a limited section of duct for which the estimated leakage will not exceed the capacity of the test apparatus. Measure the duct surface area in square meters. See Table 13 Duct Surface area that can be tested with one Model 400 (metric).</b>
<input type="checkbox"/> Ensure sealing is complete	Ensure sealing materials have cured for the prescribed time or at least 24 hours OR follow manufacturer's directions.
<input type="checkbox"/> Blank off ductwork	Blank off and seal the tested ductwork by inserting temporary plugs plates, sheets, balloons, bags into intentional openings.

### E.4.3. UK Step 3 – Connect DucTester to ducts

<input type="checkbox"/> Attach 100 mm Flange to ductwork.	
<input type="checkbox"/> Attach 100 mm collar on flex to flange	
<input type="checkbox"/> Connect DucTester exhaust to flex	
<input type="checkbox"/> Install Range 47 Flow Plug	Range 47 provides 52 to 206 CFM, which is sufficient to test most duct runs.

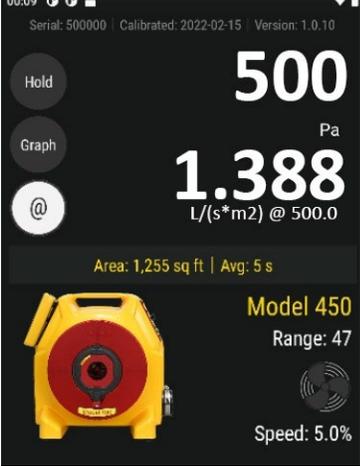
### E.4.4. UK Step 4 –Tubing, control and power connections

<input type="checkbox"/> Connect yellow and green tubes between DucTester and gauge	
<input type="checkbox"/> Connect blue tube to gauge and to ducts using static probe or connection on flange	
<input type="checkbox"/> Plug in the Speed Control Cable between DucTester and Gauge	
<input type="checkbox"/> Plug fan in to power source, and turn on power.	

### E.4.5. UK Step 5 – Set up Test Pressure and Area in Gauge

<input type="checkbox"/> Default in gauge must match the specified Test Pressure (250 Pa for Commercial buildings)	If not, tap [Settings] and [Default @ Pressure.] Then [Set] value to specified Test Pressure. Since you must not exceed the test pressure, the actual pressure will be lower but entering this default will ensure that all results are displayed at the exact pressure entered.
<input type="checkbox"/> [Area] then use the number pad and tap [Set]	Measure the duct surface area in square feet and enter it into the DM32. Select a limited section of duct for which the estimated leakage will not exceed the capacity of the test apparatus. Area can also be accessed from [Settings] menu.

### E.4.6. UK Step 6 – Measure Air Leakage rate in m<sup>3</sup>/h.m<sup>2</sup>

<input type="checkbox"/> [Set Speed] to 1% then Jog up to the Test Pressure.	<b>WARNING:</b> To prevent over-pressurizing, slowly increase fan speed using Set Speed. Jog the speed up 1% at a time until a flow rate value appears on the display. Continue to increase fan speed up to but do not exceed the Test Pressure. If you do not reach the Pressure, results will still be calculated at that Pressure
<input type="checkbox"/> Tap “@” on the display and “m <sup>3</sup> /(h.m <sup>2</sup> ) @ 250 Pa” will appear	Measure the Leakage rate, f by tapping “@” on the display and m <sup>3</sup> /(h.m <sup>2</sup> ) @ the Default @ Pressure will appear. In our example we set the Default @ pressure to 250 Pa.
<input type="checkbox"/> Leakage Factor is displayed  <input type="checkbox"/> Passes if value is lower than that specified	<p>The Leakage rate, f is displayed as:</p>  <p>If this Leakage rate is lower than or equal to the Air Leakage Limit specified, the duct is in compliance.</p>

### E.4.7. Step 7 – Test Passes

Complete test reports	Complete test reports and, if required, obtain witness’s signature.
Remove temporary seals.	Remove temporary blanks and seals.

## Appendix F European Duct Leakage Calculation (EN12237)

The Engineer specifies the required Airtightness Class for the Ducts.

### F.1 Ductwork Classification

After the test, the Ducts can be given a classification based on the result by looking it up in

Table 12 European Airtightness Class and Leakage limit.

European Ductwork Classification				
Airtightness Class	A	B	C	D
Positive static pressure limit ( $p_s$ ), Pa	500	1 000	2 000	2 000
Negative static pressure limit ( $p_s$ ), Pa	500	750	750	750
Air Leakage limit ( $f_{max}$ ), $m^3/(s * m^2)$	0.027 * $p_t^{0,65}/1\ 000$	0.009 * $p_t^{0,65}/1\ 000$	0.003 * $p_t^{0,65}/1\ 000$	0.001 * $p_t^{0,65}/1\ 000$

Table 12 European Airtightness Class and Leakage limits

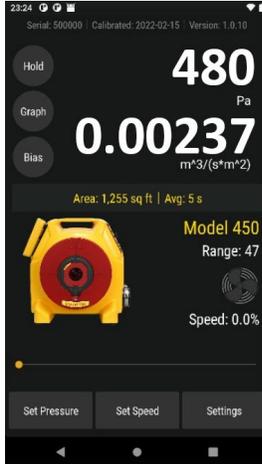
### F.2 Air Leakage Limits

Air Leakage Limit,  $f_{max}$ , is the maximum allowable leakage in  $m^3/(s * m^2)$  of ductwork for that ductwork to be in that Class.

For example, if the Test Pressure was 500 Pa,  $f_{max}$  would be 0.00153. If the measured  $f$  was 0.00143 then the Airtightness Class would have been measured to be A and would Pass if A was the required Airtightness Class.

The ducts would pass or fail depending on what the required Airtightness Class for the Duct was specified to be.

### F.3 EU Measurement Procedure



Picture of DM32 display showing Leakage rate of 12.10 CFM/100 sq ft @ 4.0000 in WC on Channel B.

Notice the duct surface area of 690 square feet is displayed in lower left of the screen. The actual test pressure is 3.235 in WC but the gauge displays in flow at the specified Test Pressure of 4.000 in WC.

## F.4 EU How much duct surface area can be tested at one time?

The table below shows the maximum surface area that one Model 400 blower will test if the ducts just pass. Since ducts will usually be tighter than the minimum specified, much larger areas can normally be tested than those shown on the table.

Test Pressure, Pa	Air Tightness Class		
	A	B	C
80	4.066	2.033	1.017
160	6.380	3.190	1.595
250	8.893	4.446	2.223
	<b>Duct Surface Area, m<sup>2</sup></b>		

**Table 13** Duct Surface area that can be tested with one Model 400

The extrapolation feature in the gauge allows accurate readings to be taken at 0.1 in WC, so the bottom row may be used to determine the surface area of duct that can be tested at one time. Duct systems with larger areas will have to be broken down into sections using barriers and the results added up.

If you cannot achieve 25 Pa for the surface areas listed, the ducts will fail the test and must be sealed up more before additional testing is attempted. Also look for disconnect and sections that are not correctly blanked off. Check all temporary plugs, plates, sheets, balloons, bags used to seal intentional openings.

## F.5 European Measurement Procedure for Airtightness Class

Test Technician \_\_\_\_\_ Test Date \_\_\_\_\_

Test Location \_\_\_\_\_

Follow the color Model 440/450 Quick Guide that comes with your system. Print out these four pages to direct your test.

- Check off each box to learn the procedure for your first test.

### Pass Fail for European tests

Air Leakage Factor,  $f_{\max}$  m<sup>3</sup>/(h \* m<sup>2</sup>) at a specified Test Pressure is often the pass/fail criteria. Air Leakage,  $f$ , is measured and read out directly on the DM32 Gauge.

*This is common wording for the pass/fail criteria:*

*“If, at the specified test pressure, the Air Leakage of test is lower than or equal to that associated with the specified Maximum Allowable Air Leakage Limit ( $f_{\max}$ ) from **Table 113**, the duct is in compliance. “*

Follow Steps 1 to 7.

**If you fail** and the specifying Engineer wants a higher Test Pressure, measure the Leakage Class to convince the Engineer that you have sufficient test flow but the ducts are too leaky to pass regardless of Test Pressure.

Notes:

---

---

---

---

---

---

---

---

### F.5.1. EU Step 1 - Prepare the gauge - first time only

Once the Gauge has been set up, all settings are restored when the gauge is turned back on.

<input type="checkbox"/> <b>Home</b> screen must show Model 450 on Range 47	If not, tap picture, then [Change Device]. Tap ... until "Retrotec DucTester" page appears. Tap "450". Tap the icon with 47 below to get Range 47
<input type="checkbox"/> <b>Home</b> screen must show pressure units of Pa and Channel B result of m3/(h·m2) @ a pressure Pa.	If not, tap [Settings] and [Results to be displayed].  Tap pressure units until you see Pressure: in WC. Then tap flow units until you see Flow/Area: CFM/100 sq ft.  Tap On button to return Home. Once set, you'll never have to change it again.
<input type="checkbox"/> <b>Home</b> screen must time average as 5 seconds.	If not, tap [Settings] and [Time Averaging] until " 5 s avg" is displayed. Tap On button to return Home. This will create a running average that will smooth out results, making them easier to read. If the result fluctuates, increase up to 30 seconds. Refer to manual for more information.
The Gauge is set up now and you're ready for your first test.	



### F.5.2. EU Step 2 – Determine test criteria and prepare the ducts

<input type="checkbox"/> Determine the Pressure to use	<b>Use 80 Pa, 160 Pa or 250 Pa depending on the type of building being tested (Residential, Multi-Family, or Commercial)</b>
<input type="checkbox"/> Measure duct area	<b>Select a limited section of duct for which the estimated leakage will not exceed the capacity of the test apparatus. Measure the duct surface area in square feet. See Table 13 Duct Surface area that can be tested with one Model 400 (metric).</b>
<input type="checkbox"/> Ensure sealing is complete	Ensure sealing materials have cured for the prescribed time or at least 24 hours OR follow manufacturer's directions.
<input type="checkbox"/> Blank off ductwork	Blank off and seal the tested ductwork by inserting temporary plugs plates, sheets, balloons, bags into intentional openings.

**F.5.3. EU Step 3 – Connect DucTester to ducts**

<input type="checkbox"/> Attach 100 mm Flange to ductwork.	
<input type="checkbox"/> Attach 100 mm collar on flex to flange	
<input type="checkbox"/> Connect DucTester exhaust to flex	
<input type="checkbox"/> Install Range 47 Flow Plug	Range 47 provides 52 to 206 CFM, which is sufficient to test most duct runs.

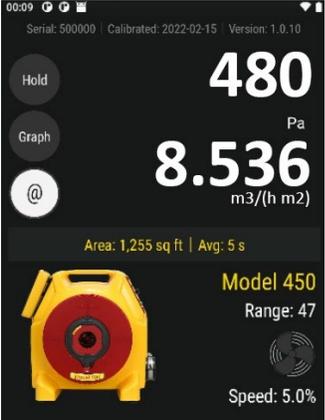
**F.5.4. EU Step 4 –Tubing, control and power connections**

<input type="checkbox"/> Connect yellow and green tubes between DucTester and gauge	
<input type="checkbox"/> Connect blue tube to gauge and to ducts using static probe or connection on flange	
<input type="checkbox"/> Plug in the Speed Control Cable between DucTester and Gauge	
<input type="checkbox"/> Plug fan in to power source, and turn on power.	

**F.5.5. EU Step 5 – Set up Test Pressure and Area in Gauge**

<input type="checkbox"/> Default in gauge must match the specified Test Pressure (250 Pa for Commercial buildings) <input type="checkbox"/>	<p>If not, tap [Settings] and tap [Default @ Pressure.] Then [Set] value to specified Test Pressure.</p> <p>Since you must not exceed the test pressure, the actual pressure will be lower but entering this default will ensure that all results are displayed at the exact pressure entered.</p>
<input type="checkbox"/> [Area] then use the number pad and tap [Set].	<p>Measure the duct surface area in square feet and enter it into the gauge. Select a limited section of duct for which the estimated leakage will not exceed the capacity of the test apparatus. Area can also be accessed from [Settings] menu.</p>

### F.5.6. EU Step 6 – Measure Air Leakage rate in m3/(h m<sup>2</sup>)

<input type="checkbox"/> [Set Speed] to 1% then Jog up to the Test Pressure.	<b>WARNING:</b> To prevent over-pressurizing, slowly increase fan speed using Set Speed. Jog the speed up 1% at a time until a flow rate value appears on the display. Continue to increase fan speed up to but do not exceed the Test Pressure. If you do not reach the Pressure, results will still be calculated at that Pressure
<input type="checkbox"/> Tap “@” on the display and “m3/(h·m2) @ 250 Pa” will appear	Measure the Leakage rate, f by tapping “@” on the display and m3/(h·m2) @ the Default @ Pressure will appear. In our example we set the Default @ pressure to 250 Pa.
<input type="checkbox"/> Leakage Factor is displayed  <input type="checkbox"/> Passes if value is lower than that specified	<p>The Leakage rate, f is displayed as:</p>  <p>If this Leakage rate is lower than or equal to the Air Leakage Limit specified, the duct is in compliance.</p>

### F.5.7. EU Step 7 – Test Passes

Complete test reports	Complete test reports and, if required, obtain witness’s signature.
Remove temporary seals.	Remove temporary blanks and seals.

## Appendix G Calculate Flow using gauge 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 450 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 450 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. In the case of Range 74, the Equations differ in for depressurization as noted by the \* below.

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:

$$CFM = FP ^N * K$$

Where: *FP* is the fan pressure from Channel B displayed as “PrB”

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

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

So before calculating flow ensure that:  $|FP| > MF$  And:  $|FP| \geq |DP| \times K2$

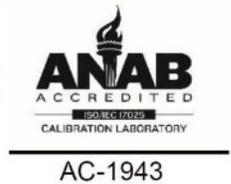
Range	n	K	K2	MF	
74	0.5045	7.0791	0.15	250	
74*	0.5045	6.793	0.15	250	for depressurization with Adapter on inlet where Channel A is negative
47	0.4873	3.253	0.12	250	
29	0.4989	1.094	0.15	250	
18	0.4993	0.4308	0.15	250	
11	0.5022	0.1681	0.14	250	
7	0.5009	0.06650	0.08	250	These Ranges are optional for Model 400
3	0.5540	0.01380	0.1	250	
2	0.530	0.006500	0.12	350	
1	0.560	0.002040	0.12	350	

Table 14 Flow Curve Equations –get latest Published Equations from [http://retrotec.com/products/software/DM32 Flow Calculator](http://retrotec.com/products/software/DM32_Flow_Calculator)

# Appendix H Calibration Procedure for Model 450

## H.1 Pressure Gauge

All Retrotec pressure gauges are calibrated in Retrotec’s ISO 17025 accredited lab. The Model DM32-20 gauge supplied reads pressures from -5000 Pa to + 5000 Pa and has an accuracy better than 1.0 % of reading, NOT of full scale which is more common and much less accurate.



The gauge has two channels. Channel A is used to measure duct pressure. Channel B is used to measure flow but only the negative side of the gauge is used. The gauge takes the Channel B reading and converts it to flow based on the Model and Range shown on the screen.



In the example on the left, the Device is set to “450” and Range to “47”. It is very important to ensure these are both correct. The Range is engraved in the orifice plate which also has a raised color sticker which is printed with “Range 47” in the case of this example.

Note: results are in  $\text{m}^3/(\text{s m}^2)$  which is cubic meters per second per square meter of duct area. Even though the test pressure is 12003 Pa, results are calculated at exactly 1000 Pa; this is what “@ is On” means.

Every system comes with a Calibration Certificate for the Gauge.

## H.2 Flow Measurement

The gauge takes the Channel B reading and converts it to flow in any desired units. “Appendix A Flow Conversion Tables” show how to convert the Channel B Fan Pressure reading to flow in CFM. “Appendix G Calculate Flow using gauge readings” show how to use the flow equations to get an exact flow result which is what the gauge does. Whenever the gauge is taking readings, error traps are employed to ensure the readings are always within the calibrated range of the Device: when using tables, care must be taken to ensure the minimum Fan Pressure values are considered. The DM32 Calculator spreadsheet employs these error traps.

The Flow Calibration Equations were generated using an ISO 17025 Accredited Flow Chamber.

Flow measurement calibration consists of several parts.

1. The flow signal from Channel B already has an ISO 174025 calibration certificate with each system.
2. The Flow Plugs used for each Flow Range have their serial numbers recorded and have their diameters measured on two planes to ensure consistency.
3. The Published Flow Equations are designated in the firmware of the gauge and in the FanTestic Software using Round designation that is made public on Retrotec’s website under: <http://retrotec.com/products/software/Tester Tools/DM32 Flow Calculator>.

4. Every system has a Calibration Verification document where the Device is tested to ensure the Flow Signal is appropriate at one point on one curve. Experience has shown that if one point is verified that the only remaining issue could be the orifice size which is checked in a previous step. We then know that the Published Equations apply.
5. Optionally, every Range can be checked a minimum, middle and maximum flows to ensure the Device is within the calibration limits for a particular standard. This option is especially important if the user wants to ensure the Device is accurate to within  $\pm 5\%$ . Standard calibration  $\pm 5\%$  is guaranteed to be within these tolerances throughout the range the gauge will display results in. It is recommended that Devices are checked after a year of severe service or 3 years of standard service or whenever local standard require calibration.

### H.3 Flow Calibration Field Check

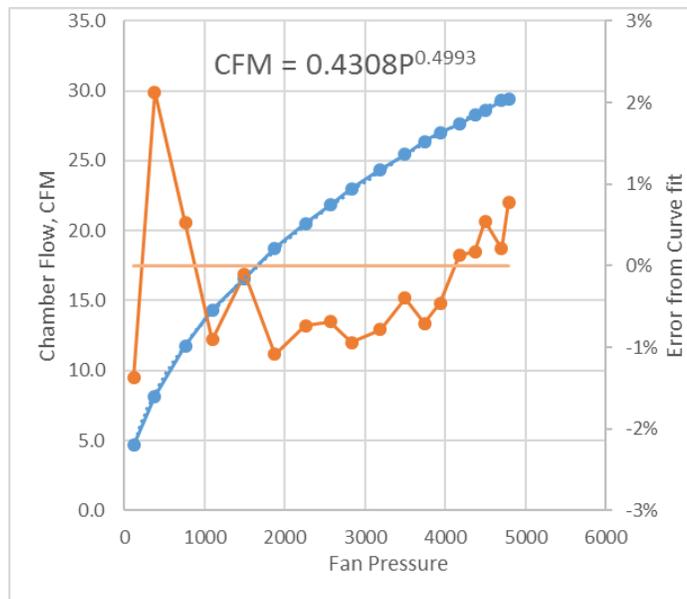
Occasionally when an authority questions the calibration of this Device or the tester wishes to ensure his Device is not malfunctioning, we recommend the Filed Calibration Check. Simply cut a 1x3" hole in a box, depressurize to 900 Pa and flow should read 97 CFM on Range 47. You can measure the hole size using EqLA also. Expect the result to be within 15%. This method will show whether the Device has some kind of problem that prevents it from working properly. Normally the Device readings will be within 2 or 3% of the actual value.

### H.4 Fan Calibration Data

The graph below shows the calibration data that was used to calibrate Range 18 for example. Twenty-two data points were taken to establish the shape of the Flow Equation that is noted as:

CFM = 0.4308 X Fan Pressure in Pa to the 0.4993 power.

The flows shown were generated using an ISO 17025 Accredited Flow Chamber. The error % are the difference between the Flow Equation created in a curve fit and the values measured.



# Glossary

Term	Definition
“ wg”	See “in WC”
airtightness	Pertains to how free air leakage may be in an enclosure. In actual fact, measurements can only be made of air leakage rates not air tightness itself, so one could think of these terms as being opposites. In spite of the confusion, the terms are used interchangeably. Air tightness is determined by measuring the air flow rate required to maintain a specific induced test pressure. (e.g. airtightness can be measured and reported in units of CFM/sq ft of air leakage at a uniform test pressure of 75 Pa)
Blower	Used to refer to a centrifugal fan. Only the Retrotec Model 400 is a Blower.
Construction Class	Unless construction class is otherwise specified it means a static pressure classification in the SMACNA HVAC-DCS. Those classifications pertain to maximum operating pressure in the duct as follows: 0.5” wg maximum 0.6” to 2” wg maximum 1.1” to 2” wg maximum 2.1” to 3” wg maximum 3.1” to 4” wg maximum 4.1” to 6” wg maximum 6.1” to 10” wg maximum
Depressurization	The process of creating a negative pressure in the enclosure by blowing air out of it. Air is drawn in from outside through leakages of the enclosure to replace the air, 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.
DM32	A general term for Digital Manometer 32 both with and without WiFi chip.
DM32 non-WiFi	Specific reference to any DM32 that is not WiFi enabled.
DM32 WiFi	Spoken and marketing term for model DM32W (yellow case with WiFi chip).
Duct Class	see Pressure Class
Flow Plug	The 4-inch plug that goes into a Model 300 or 400 Fan/Blower that is used to measure flow.
Flow Pressure	Use Fan Pressure instead. Flow Pressure was used in a lot of documentation over the years but Fan Pressure is a bit more direct and easier to understand.
Flow Range	See “Range Configuration” which is abbreviated as Range Config on DM-2 gauge.
Housing	The Shell surrounding the fan or blower in Retrotec test Fans.
HVAC	Heating Ventilating and Air conditioning system.
in WC	Inches of Water Column, Water Gauge, “wg and in WC are all equivalent terms. “in WC” is used throughout this manual for consistency. This is a common unit of pressure used in the USA although elsewhere, Pascals (Pa) are more common. One in WC = 249 Pa and is the amount if pressure that will support a column of water for one inch of height.
Inches of Water Column	See “in WC”
Leakage Class, $C_L$	$C_L = F$ (leakage rate in CFM/ 100 sq ft) divided by the Pressure in in WC to the 0.65 Power. $C_L = F / P^{0.65}$ Leakage Constant and Leakage Classification are equivalent terms.
Leakage Classification	Same as Leakage Class
Leakage Constant	Same as Leakage Class
Leakage Factor, F	F is the allowable leakage in CFM/ 100 sq ft = $C_L * P^{0.65}$ Where P is the test pressure in in WC and $C_L$ is the Leakage Class.
Pascal (Pa)	The metric unit of pressure. 1 Pascal is equivalent to 0.000145 psi, or 249 Pascals in 1 in WC (the pressure required to push water up 1” in a tube)
Pressure Class	Duct pressure classifications are equivalent to Duct Class

Term	Definition
Pressurization	The process of inducing a positive pressure in an enclosure by blowing air into it. Air is pushed out through all the leaks, causing the smoke to move away from the operator when checked with an Air Current Tester.
psf	Pounds per square foot. 1 unit is about 47.88 Pa.
Range Configuration	The configuration of the calibrated fan refers to whether the front of the fan is open or if it has a Range Plate or Range Ring attached which will change the calibration curves that must be used to calculate flow. Typically, the gauge is set to the Range Configuration that matches the configuration of the fan being used to measure flow or the flow is looked up in a table where the flow is read under the appropriate Range Configuration and opposite the Fan Pressure.
test fan test blower	For this document, this term is used to represent a calibrated variable speed fan that is typically temporarily mounted in an opening in the envelope for the purpose of providing a test pressure and for measuring the flow rate required to establish that test pressure. Other commonly used terms are "Blower Door" and "Door Fan".
Water Gauge	See "in WC"
test pressure (for commercial ducts in Europe)	Pressure induced by the duct tester that is created between the duct and the surrounding air. $P_{test}$ in the European standard
air leakage rate (for commercial ducts in Europe)	Leakage flow rate per unit surface area of the duct. $f = q_v / A_j$
air leakage limit (for commercial ducts in Europe)	Maximum permitted leakage rate for air tightness class, $f_{max}$