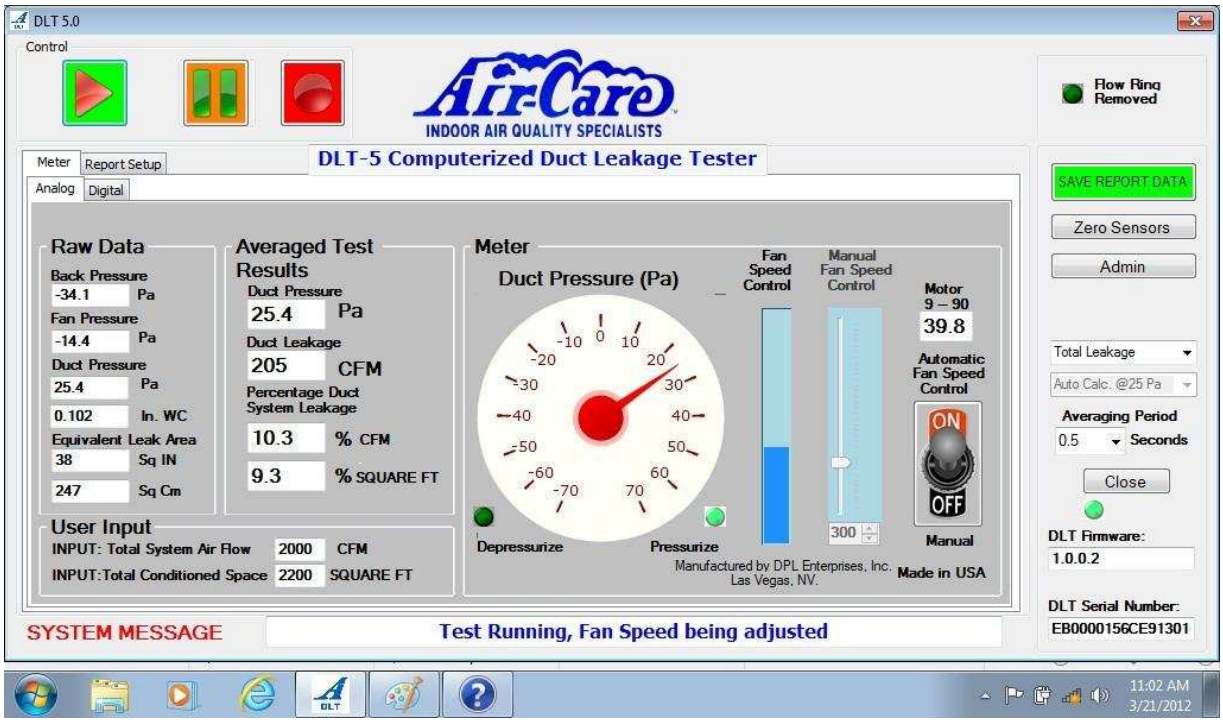
INDOOR AIR QUALITY SPECIALISTS

Air-Care DLT-5

(Duct Leakage Testing System)

With Full Function Software for Netbook or Laptop computer



Note to Operators: The Air-Care DLT-5 is designed to provide simple set up with user friendly software for data collection and report generation. The operator can accurately perform many types of pressurization, depressurization leakage tests on air systems in rooms and small buildings with the information in this manual. Some energy audits require a very specific protocol to be followed and to insure that the technicians are competent to follow that protocol; some states require the technician to take certification training and an exam.

Air-Care is a proud member of:

NADCA
National Air Duct Cleaners Association

ISSA
International Sanitary Supply Association

NAFA
National Air Filter Association

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Introduction

Man has managed to build homes and workplaces with totally controlled environments that provide lighting, heating and cooling for a comfort all year round.

The quest of the last few decades has been to increase occupant comfort while reducing energy consumption with multi-zone systems and by sealing leaks in the building to prevent outside contaminates and unconditioned air from infiltrating the occupied area. The goal is to minimize the loss of conditioned air seeping out of the building through poorly sealed windows, doors and the HVAC system itself.

Many utility companies reimburse contractors for building leakage tests. There are tests for air leaks in the structure with pressurized doors with sensitive air flow meter. Once the air leaks were located in windows, doors, ceilings, floors and other areas in the structure they could be sealed. These programs saved building owners and power companies a great deal of money and energy, allowing power companies to postpone building new power plants for some time.

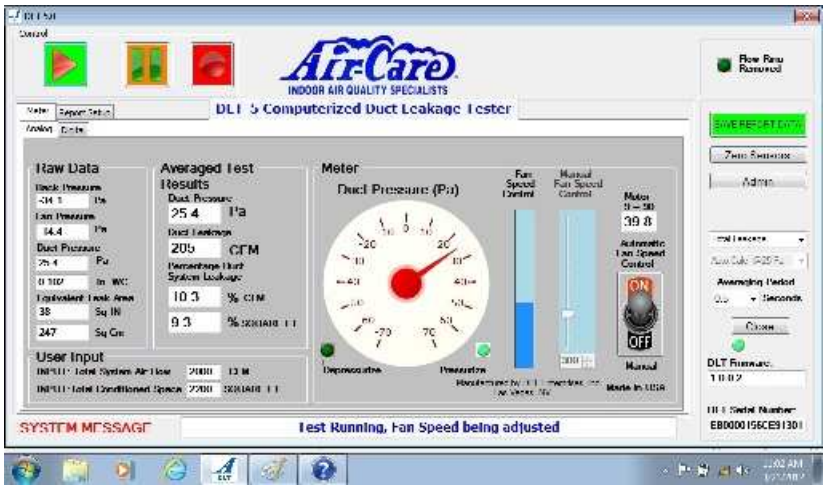
The 21st Century has experienced even higher energy costs and has seen an increase in the efficiency of furnaces and air conditioners, better insulation in residential and commercial buildings, and less leakage through the structure's doors, windows and walls.

With tighter structures and more efficient air systems the search for additional energy savings and improved occupant comfort has lead to a study of the air ducts that deliver the conditioned air to the occupied area, and return air to the air handler. Often air leaks are caused by inappropriate use of wall cavities and floor joists as air ducts. These parts of the building were never designed or built to be airtight and they can be sites of energy loss. Often ducts are routed through unconditioned spaces, such as attics, crawl spaces under the floor or even the garage. Most ducts in these areas are insulated to prevent energy loss due to heat transfer, but until recently there has not been a simple way to measure how much air escapes out of the pressurized supply ducts or how much unconditioned air is being sucked into the depressurized return ducts.

With the advent of more sensitive and portable pressure and airflow instruments and by adapting the basic concept used to measure air leaks in buildings, there are now ways to test the amount of air leaking into or out of the air system. Properly trained technicians and the proper equipment can measure this very accurately. Typically, the maximum allowable level of leakage in new residential buildings is 6% while 15% or less in existing residential buildings is the standard. Many studies across the United States have found 30% leakage to be common for existing homes. It is incredible that nearly 1/3 of the air being circulated by the furnace or air conditioner is lost. That loss must be made up by the system running longer and using 30% more energy that was actually needed, which ads 30% to energy costs.

The purpose of DLT is to measure the loss from air ducts and locate the problem areas so that they can be sealed to improve comfort, energy efficiency and Indoor Air Quality. It is obvious that this is a need that must be filled and will be beneficial to everyone.

DLT-5 Air Duct Leakage Tester
QUICK START Reference Guide



1. Turn off the furnace and air conditioner.
2. Remove the filters from the air system
3. Connect the DLT to the largest duct opening which is usually the return or directly to the furnace.
4. Seal ALL openings with duct film or other methods.
5. Open Window to outside and open doors to all rooms with supply or return ducts, attic and basement.
6. Plug the DLT in to a wall outlet; connect the Computer power to the aux outlet on the DLT.
7. Connect the USB cable from the Computer to the USB port on the Power Panel of the DLT.
8. Turn on the power switch. Open the computer and turn it on.
9. Attach the green ¼" tube to the duct pressure probe and connect the other end of the tube to the "Duct Pressure" port on the DLT Control Panel. Insert the probe into a supply vent.
10. Click START, then Click on the A-DLT Icon. Wait for it to initialize and Auto Zero then "READY".
11. Click on "Reports Setup" tab and enter customer information. Click on "Meter" tab to prepare to run the duct test. You should first enter values for Total System Air Flow and Square footage.
12. The default setup is: Duct Pressure = 25 Pa, with AUTO fan control and "@25" Pascal calculations active. This is the same setup for Pressurization or Depressurization tests.
13. For **Pressurization** tests, the 10" hose and collar needs to be connected to the "Blowing" end of the fan Left side viewed from rear. For **Depressurization** tests, the 10" hose and collar are attached to the INLET (Right) side of the fan (Brass Pressure Probe side).
14. Click on "RUN" at the upper left of the screen, and Fan will start in 6 seconds. When duct Pressure is over 10 Pa., the DLT-5 will begin to display Estimates for the Leakage in CFM
15. The large central dial displays the duct pressure. In pressurization mode the needle will move to the right. In depressurization mode, the needle will move to the left. The software will estimate and display CFM leakage information even before the duct pressure stabilizes at 25 pa (or 50 pa)
16. Click "View and Save" to Preview the Reports, then click "EXPORT to PDF" and the Reports will be saved to the "C" drive as both Summary and Detail Reports that can be printed, emailed or saved to a flash drive.

Chapter 1
Why Measure Duct Leakage?

1.1 Leaks compromise air system balance

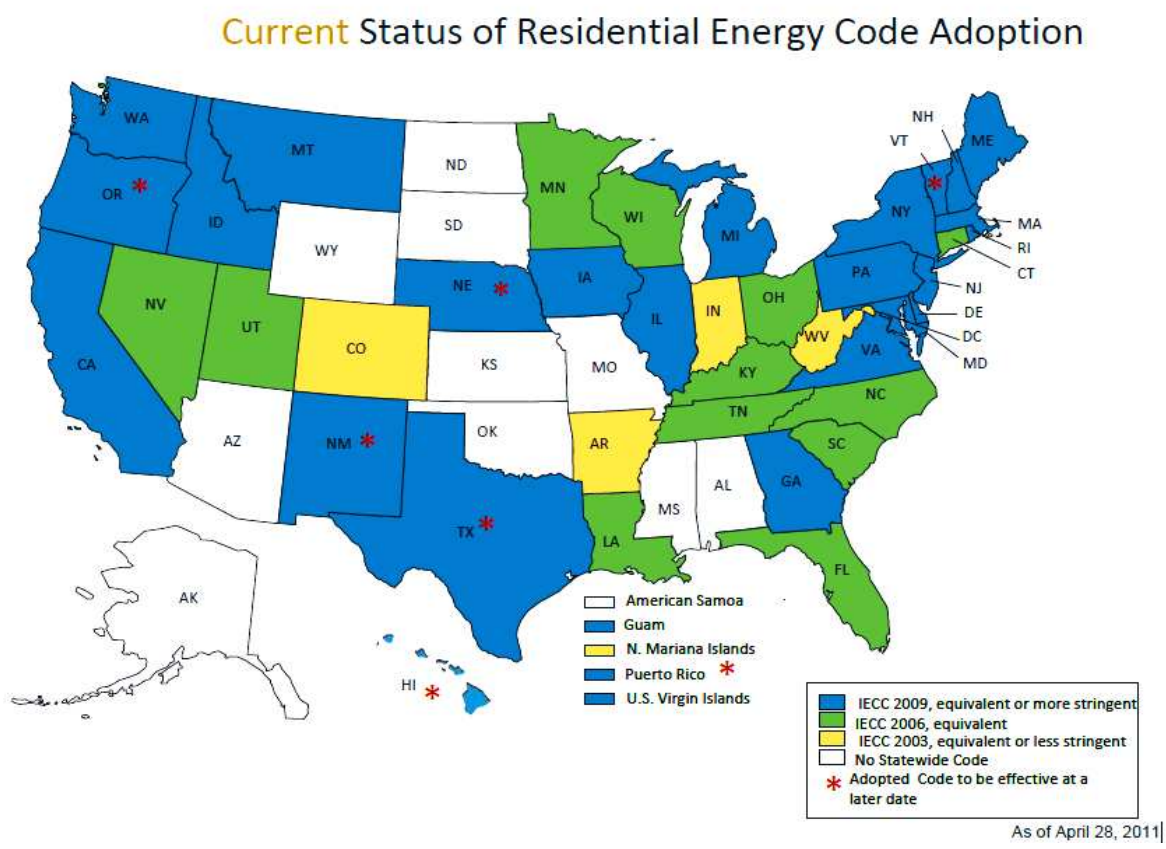
Any air system, residential or commercial, is designed to operate at very specific airflow rates to provide stable temperatures in all occupied spaces. When a leak allows some of the conditioned air to escape to an unintentional space, or to the exterior of the building, the original balance is compromised resulting in uneven ventilation and temperatures.

In addition, a leak can reduce the pressure in the ducts and increase the airflow through the furnace / air conditioner. Changing the flow rate through the air handler may cause the air handler to operate outside its ideal efficiency range. This is much more critical on the new high efficiency multi-speed air handlers, and may result in the system never actually running at peak efficiency.

The average leakage in homes across the country is about 30%, that is a huge waste of energy! With that much air going to unintended locations or that much air being pulled into the system from the attic, outside, garage, or even from areas exposed to sewer odors may seriously alter the balance of the air system leading to Indoor Air Quality problems and provide conditions that may support mold growth in parts of the building.

1.2 Duct leakage regulations

As of April 2011, 40 states have adopted the Federal Energy Star protocol for testing and reporting duct leakage.



Generally, new residential buildings must have less than 6% duct leakage and a less stringent 15% leakage is required for existing residential buildings. There are already guidelines for commercial buildings, especially those using high-pressure air distribution systems. Inevitability, every builder, and remodeling company will be required to measure, record, and in some cases seal the ducts in nearly all buildings. The energy savings make it impossible to ignore this relatively inexpensive way to conserve energy.

1.3 Why are air ducts leaky?

With all of this emphasis on building tightness and air duct tightness and an apparent history of ducts being leaky leads one to wonder if this was sloppy workmanship, defective products or some other negligent act. That may be true in a very few incidents, but the reality is that until very recently, there was no practical and economical way to measure the amount of duct leakage, or "duct tightness". The very best and most conscientious HVAC contractor working with the very best materials and tools had no way of knowing if the system was tight or leaky.

Air-Care's DLT-5 Duct Leak Tester provides a simple test of an air system's tightness, and also provides a way to identify the leaks so the contractor can seal them. There are several methods of sealing the ducts, from simply reinstalling a loose flex duct to its supply to introducing micro particles that cling to and solidify in the cracks. Sealing methods will be discussed in a later chapter.

1.4 Who should measure duct leakage?

To meet state, federal or trade organization guidelines usually requires an independent 3rd party company and a technician who is certified by an appropriate school to test duct leakage. These schools usually provide training to a specific protocol, such as the California Title 24, or EPA (Energy Star requirements) or a more general HERS (Home Energy Rating System) program. Certification will be discussed in a later chapter. After a certified inspector tests a system and it fails to meet criteria for the applicable protocol, the contractor must correct the problem and have the system re-inspected. This can be a costly process that can result in delays.

With the Air-Care DLT-5 duct leakage tester, some basic training and a little experience, a contractor can inspect the ducts for leakage. There is no certification required to do this type of pre-inspection, but by inspecting and sealing the air system you are virtually assured of passing the certified inspector's test the first time.

In the case of California Title 24, the system must be tested prior to remodeling or additions to a system and the leakage must be reduced by a prescribed percentage. There are alternatives to upgrading the original air duct system. A room addition can be serviced by a whole new air system without any modifications to the original system. Instead of repairing the ducts Title 24 allows the contractor to replace the original furnace with a more efficient unit that will save an equivalent amount of energy to that lost through duct leakage.

Whatever method used to meet energy and air balance standards and guidelines, the decision requires measurement of duct leakage in the air system.

Chapter 2
Overview of Instrumentation

2.1 Air Mover

The motorized fan provides the airflow and pressure to the ducts to simulate normal operating conditions during the leakage (tightness) test. The motor-blower combination has a stable speed control and provides 15 to 600 cfm of airflow at 25 pascals (0.100" WG) or 50 Pascals (0.200" WG)

Air flow is measured and the USB cable links this data to the computer software which calculates and displays the results. All values are visible at one time in standard units which eliminates the need to switch between displays for CFM leakage, Percent of Airflow Leakage or Percentage of leakage per square foot of conditioned space. Only the power cord, the 10" flex duct and the Duct Pressure probe need to be connected to be operational. All other control cables and pressure tubing is pre-connected internally.

The DLT-5 molded poly cart holds all of the instrumentation and accessories required for the test. It is lightweight with 2 large wheels and a handle for easy transport to the test area. The top of the cart serves as a desktop for its netbook with preloaded software or your laptop computer. You must load the DLT-5 software if using your own computer. The fan and electronics are totally enclosed and protected.

2.2 Instrument package

The DLT-5 Instrumentation package consists of 3 Digital Micro-Pressure transducers, Five Fan pressure ports, multiplexing and USB encoding and a variable speed drive for the fan. There is also a "Low Flow" ring for the fan inlet with onscreen prompts when it should be removed due to high back pressure.

If the USB link is disrupted, and clicking the "Zero Sensors" button does not restore and Re-Zero the sensors, it is recommended that the software is stopped, the USB cable is momentarily unplugged while the power is switched off, then on at the DLT panel. Reinstall the USB cable and restart the DLT software and it should restart the link, Initialize, and run "Zero Sensor" routines. You will need to Select the Company and Customer again.

2.2.1 DLT-5 Software Functions

The DLT-5 software has a factory default setup that is ideal for most Pressure and Depressure testing. Once your Company information and the Customer info is entered, just click "RUN". A prompt will appear for you to verify you are testing at 25 Pa (Default), then press Enter to start the test. It will detect if the fan has been attached for a Pressurization or Depressurization test and display the mode on the Screen. The software will Calculate and display the leakage and leak area when the Duct Pressure is over 10 Pa. The Duct Pressure will display in Pa and Inches WG, the Sensor readings for the fan and the backpressure in Pa, the cfm of leakage, and the total Leak area as In^2 (Square Inches) and cm^2 (Square centimeters). For the operator's convenience, the Central Dial indicates Pressurization to the Right and Depressurization to the Left without averaging for a faster response.

The DLT-5 software controls the speed of the fan to maintain 25 Pa or 50 Pa as selected by the operator. Also, "Balanced Pressure Tests" can be run using auto or manual depending on the configuration used. The software provides the "Equivalent to" airflow for 25 and 50 Pa when these exact duct pressure cannot be reached or maintained. Manual fan control is also an option for special circumstances and the Balance Mode using room pressure as a reference. Time averaging can be set to 0.5, 1, 2, 4, 8, or 16 seconds. Click on "View and Save Report Data" , then "EXPORT to PDF" to store the Data in a pdf format report on the "C" drive. The "Summary Report" and the "Detailed Report" can be printed on a portable USB printer, emailed or stored on a removable Flash Drive.

The Summary Report has the all the data from the test and calculated system leakage, percent of total system air flow the leakage represents and the leakage as a percent of the floor area of the conditioned space. The Detailed report includes calculated loss of efficiency due to the leakage and the cost of this loss based on the Cost per $100 of heating and cooling bills (if available). The total size of the leaks is calculated in square inches and square centimeters as a helpful reference for the customer.

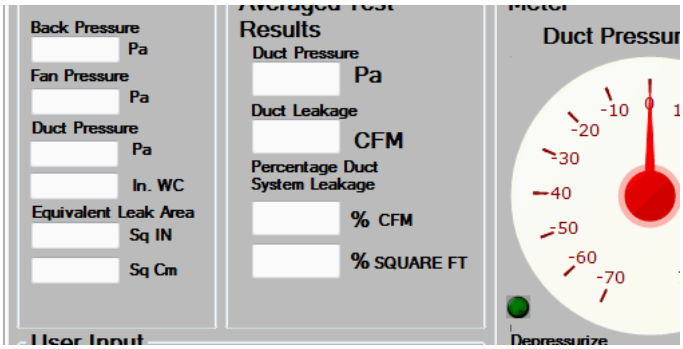
2.2.2 Duct pressure adjustment

Normal air system operating duct pressure is approximately 25 pascals (Pa); therefore 25 Pa is the target pressure for most duct leakage test protocols. Once the duct openings are sealed and the DLT-5 10" diameter hose is attached to it with the duct pressure probe in place, click "START"  button to begin the test. The Motor will start after 6 seconds.

Zeroing Sensors and Baseline adjustments are made automatically. If there is any doubt that a reading is correct, there is a Manual "Zero Sensors" button that can recalculate and zero the sensors. To do so, Stop the fan motor, then Click the "Zero Sensors" button at the Upper Right of the screen. This process takes 2 minutes and will show a countdown timer during the process.

2.2.3 Conversion tables

The Air-Care DLT-5 has all of the conversion tables and formulas embedded in the software and displays the results in real-time on the screen. If the Time Average is set to 4 seconds, the values will be recalculated and updated after each 4 second set of Data are taken.



2.3 Technical support

As with all Air-Care equipment, Technical support is just an email or free phone call away for as long as you own it. info@air-care.com or 800-322-9919

2.4 Calibration

The DLT-5 should be calibrated annually to maintain accuracy. If the DLT-5 is dropped or otherwise stressed beyond the normal operating conditions, it may be necessary to have the DLT recalibrated more often.

2.4.1 Field Calibration tests.

The field calibration is used to test the calibration in the field. If the DLT passes the field test, it does not need to be factory calibrated.

Set up for Field Calibration.

Attach the 10" diameter x 12 foot long hose to the OUTPUT end of the fan as it would be for Pressurization tests. Install the "Calibration Tool" in the other end of the 10" hose that is fully extended.
Attach the Green tubing to the "Duct Pressure" port on the panel and to the connector on the Calibration Tool. Install the Low Flow Ring on the fan Inlet.
Run a normal test with the default settings.

The test should stabilize between 118 and 132 cfm and approximately 20 sq inches of leak area. (Check your calibration sheet for exact CFM value for your particular machine.). If it is outside this range, call Air-Care.

Chapter 3
Air Duct Leakage Test Procedures

3.1 Pre-Test Procedures and System Preparation

Both terms, “Leakage” and “Tightness” are used to describe a test of the amount of air that exits or enters an air system unintentionally. The test can be performed by anyone who understands the process and follows the procedure, no certification is required to provide these numbers, however, some state and federal test protocols require training and certification in that protocol. Before you contract to perform the duct leakage test obtain the specific requirement you must fulfill for your client. If you have any questions regarding a particular protocol and you are unable to obtain local information, contact Air-Care for assistance.

3.1.1 Enter Customer Data on Computer.

The DLT software will not allow the test to be performed until the basic data is entered on the Set-Up screen. Also, you should also enter values for Total System air flow and Square footage of Conditioned Space entered on the “Meter” screen before the a test can be run (“1” is the default).

3.1.1 Check the operation of the air system before starting the tightness test preparation

If there are any non-operational parts of the system, record them and advise your client before you proceed.

3.1.2. Locate ALL intentional openings in the air system

Supply, return, and exhaust, humidifier and outside air openings in the air system MUST be identified so they can be sealed in a later step. If the location has more than one air system, test only one system at a time, but be sure the fan on the 2nd system does not run during the tests.

3.1.3 Turn the system off so the system fan remains off during the tests

Most of the time, turning the system off at the thermostat is sufficient. Some residential air systems cycle the system fan every 15 minutes or so regardless of the thermostat setting. This may require turning off the power at the breaker or unplugging the furnace.

3.1.4 Remove any air filters in the system

The filters must be removed during the test, but be sure to re-install all filters after the tightness testing is completed.

3.1.5 Determine the best place to attach the DLT-5 blower’s 10 inch hose and adapter plate.

For accuracy, the largest opening available should be used whether it is a central return, a large supply or an access door on the furnace. When attaching the 10” diameter adapter plate with the 14” x 14” square flange to an opening larger than 14” diameter, cut a piece of cardboard a few inches larger than the opening, tape it in place and attach the adapter to this cardboard with tape. Once in place, a hole can be cut in the center of the cardboard that is 10” or larger to fit over the hole in the adapter plate.

3.1.5.A 10” diameter hose and adapter plate

The 10” x 12 ft flexible hose and adapter plate can be attached to any opening in the system. Masking tape, cardboard and sheet metal screws can be used to attach the adapter plate to nearly any opening in the system.

<u>Note:</u> It is important to keep the Hose as straight as possible to insure accuracy. Stretching the hose to its full length is ideal, especially when measuring higher leakage in pressurization mode where the hose wants to “bulge out”.

3.1.5.B A large opening will allow good airflow for the leakage test

Often there is a large central return duct where the adapter can be connected, but a large supply can also be used.

3.1.5.C When accessible, the furnace provides a very good attachment point for the DLT hose

If the furnace is easily accessible, remove the cover over the blower and attach the hose with a cardboard cutout to match. Be sure that the furnace blower housing or other internal parts do not block the 10” opening in the adapter plate, as this will create “Back Pressure”. If this condition cannot be avoided, use a cardboard box approximating the size of the furnace door and 6” to 12” deep to create a plenum space for better air flow, and tape it to the furnace to prevent leaks.

3.1.6 Seal all the intentional openings in the air system

Seal all of the Intentional openings in the system so that the only place air will be flowing is through the unintentional openings – or an opening that was missed. The Tightness or Duct Leakage can be measured by Pressurizing or Depressurizing the duct system. Pressurizing is the most common, and it requires the sealing procedure to withstand this air pressure from inside the ducts pushing outward. It is important to inspect all of the sealed points to verify that they are in tact and indeed sealed before and after testing. When the ducts are depressurized, the pressure of the room is higher than the inside of the ducts, so the sealing materials are pushed toward the grills and in most cases maintain a good seal. Again, it is important to verify that the sealing of each opening is still in tact at the end of the test.

3.1.6.A Masking tape Kraft paper and cardboard to seal ducts

There are a variety of methods available to seal off the various types of grills and diffusers. The Poly Duct Mask Film is effective in most cases. 2” Masking Tape is very useful for textured surfaces and for attaching Kraft paper or sheets of cardboard over large ducts as well as to secure the edges of the Poly Film on rough surfaces. The grills can also be covered with brown Kraft paper or masking paper and tape. Ceiling, wall, and floor vents can be sealed by the above methods. Floor vents are somewhat easier to cover since gravity

helps hold the covering material in place, with or without added weight. Lifting up a floor vent, placing Plastic Wrap over the opening and reinstalling the grill can be an effective way to block off floor vents in houses and manufactured homes. If the floor grills have a flat surface, placing a newspaper or a towel with a weight may be all that is needed.

3.1.6.B Poly masking film to seal ducts

The Poly film roll is 8" wide and has a moderately sticky layer to hold it in place on smooth surfaces. Rolls come pre-perforated for convenience in tearing it off at various lengths. This material can be unrolled as it is being applied to the grill and smoothed into place. For vents wider than the roll, apply another sheet that overlaps the first by about 1". It is important to seal to the edges of the grills and any gaps around the sides of the grill if air is escaping. The escaped air is still reaching the intended occupied area, so it is not considered a "leak", but all escaping air should be sealed off for accurate testing. Be careful to not damage the surrounding walls, ceiling and floors while applying the tape or poly film. Be especially careful when removing the sealing materials that no paint or surface finish is damaged.

3.1.6.C Turn off all exhaust fans

Exhaust fans will change the pressure difference between the exterior and interior of the building and may affect the DLT duct leakage test results if left running during the test. Any other device that pulls air in or pushes air out of the building should be temporarily turned off also. This includes clothes dryers, standalone and window air conditioners, and evaporative coolers, etc.

3.1.7 Duct pressure Probe placement

The pressure in a leaky system is not uniform in all parts of the ducts or from room to room or interior to exterior of the building. Taking pressure data in the appropriate location or locations will determine the accuracy of the final test report.

3.1.7.A Single pressure Probe testing

A perfectly sealed duct system will have the same internal pressure everywhere. In these cases, the pressure sensor can be inserted almost anywhere in the system. The easiest placement would be to put the vinyl tubing through one of the grills then tape the tube in place to seal the hole into which it has been inserted. Even a system with moderate leakage in many areas should have relatively consistent pressure throughout. As a rule of thumb, if the DLT air mover is attached to a return, the pressure sensor should be inserted in a supply duct and vice versa. In a very leaky air duct system, there may be a high flow rate through the duct where the pressure probe is located. In this case the probe should be inserted through a small hole in the duct and the tubing attached to the end. The probe should be pointed upstream. Though this static probe is not always required, it can be used to for all of the duct pressure readings required in this test procedure.

3.1.7.B When to take multiple pressure readings

If one branch is responsible for the majority of leakage, it will require a much higher fan speed to attain 25 Pa of pressure than the other branches in the system. The closer the probe is to that leak the higher the measured leakage will be. The static pressure probe should be inserted in 2 or more locations in the duct and multiple tests are advised. The DLT-5 software will advise you when to alter the Test Configuration to reduce back pressure or attain the desired duct pressure. If that second pressure test point is the same as the first, you

may not need to do further tests. If the second pressure reading differs significantly from the first, it is advisable to take a third or forth reading and average the results.

3.1.7.C Where to take multiple pressure readings

The DLT has vinyl tubing that is 15 ft (red and green) and 25 ft long (clear) and barbed plastic couplers to connect them together for a total of over 50 feet. One end of the tubing is connected to the Duct Pressure Manometer and other end can be taken to any supply or return within 50 feet and inserted through the sealing material and taped in place. If the first pressure reading was in a supply duct, move the probe to another supply duct on the other side of the building for a second pressure for comparison. This comparison of the first supply duct leakage and the second supply duct leakage may indicate which supply duct should be repaired first.

3.1.7.D Eliminate pressure differences between rooms in the building

If the building being tested is relatively tight, there could be a pressure difference between the area where the DLT is set up and the exterior of the building. To neutralize this condition, open a door or window to the outside during the tests. The same is true of rooms in the building, open doors to all areas with ducts. If ducts run through the basement or an attic space, open the access doors to these areas during the test to equalize the pressure in all parts of the structure. If it is windy outside, the pressure in the building may change from minute to minute. The operator can run the test with Manual Mode with a higher Averaging time and press Save when it appears "Stable Enough". In extreme cases, it may be advisable to postpone the test until the wind gusts diminish and pressure readings stabilize.

3.1.8 Prepare the DLT to run the test.

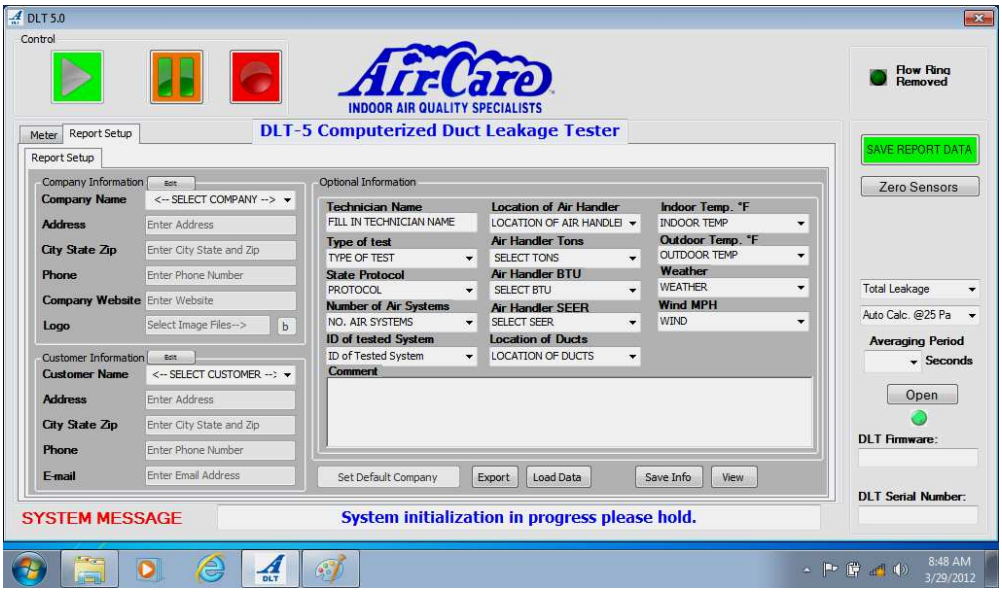
The Air-Care DLT-5 is designed to provide simple set up. The key components are combined into a single unit with only the power cord, 10" duct and duct pressure probe and tubing connections to be made in order to begin testing a duct system with sealed registers.

3.1.8.A Plug in to a 115-V AC outlet

The Air Care DLT air mover requires 115-volt AC power for the Air mover fan and the electronic package. The computer can run on its batteries or plugged in the Auxiliary socket on the panel. You can now attach the power cord to the panel (Standard Computer type connector) and plug it into a wall outlet. Turn on the power switch then the computer.

3.1.8.B Set up for Testing

Click START, then click on the DLT icon "**DLT**" and the Duct Test program will load, test the hardware, and auto-zero itself. The default settings will be adequate for most test protocols, Auto Fan control for 25 Pascals (0.100" WC), 4 second time average, **"@25 Pa Duct Pressure"** which will calculate CFM even if the fan cannot reach 25 Pa in a very leaky duct system. If special settings are required they can before the test is started .Click on the "**REPORT SET UP**" tab at the Top Left of the screen. This is where you enter your company information and Logo if it has not already been entered. Next enter the Client name and Air System info that will be added to the test data and calculated results for a Detailed and a Summary report that will be generated. This information will not affect the test data but identify the test location, client name and make it possible for the software to calculate the Efficiency loss due to the Duct Leakage measured.



There are 2 boxes in the Lower right of the Test Screen that you must fill in with the Total System Air Flow and the Total conditioned space in square feet. This will allow the software to calculate the Percentage leakage by system air flow or building square footage as required by the state or federal standards in your area.

The percentage of duct leakage will be calculated by comparing the leakage to the total flow of the air system. The rule of thumb to estimate the total airflow is approximately 400 cfm per ton and most residential units are between 2 and 5 tons. Heating airflow is approximately 400 cfm per 18,000 Btu/hr

3.1.9 Test procedure

The following procedure will provide the data and results that are generally required of a Duct Tightness or Duct Leakage test. There are other protocols generated by various state, federal governments and local utility companies that may have some variance from this procedure.

3.1.9.A Click on "RUN" on the test screen.

Watch the Central Dial as it slowly increase the Duct pressure to 25 Pa with increasing Fan speed. The reading may drift up and down slightly, but the reading should be between 20 and 30 Pascals. The software will calculate the air flow accurately, even it the actual pressure is only close to 25 Pa

3.1.9.B Save the test data.

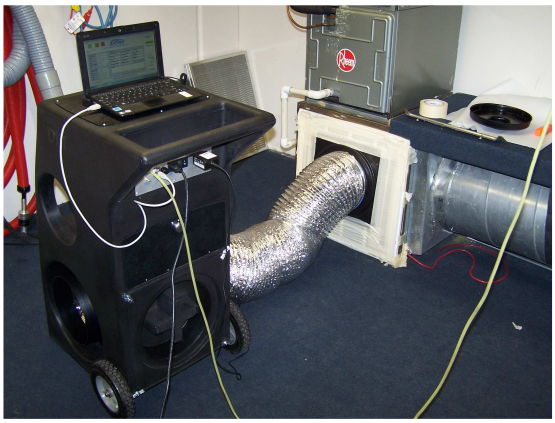
The Test is complete when the Duct pressure and fan motor have stabilized to the point that the readings remain constant, or only have a small variation up and down over a period of 30 seconds. Once the data is stable, click on "View and Save Report Data" at the Upper Right to save the Data and calculated values. Now Click on "EXPORT to PDF" to save the data in .pdf format as a Summary Report and a Detail Report that can be printed, emailed, or copied to a flash drive, and end the test. On a day with gusty winds, the pressure may not stabilize, if this happens, you may want to use a longer "Time Average" or even go to manual motor

control mode for the test. Once the pdf files are created, you can return to the Meter Screen by closing the report screen.

3.3 Pressurization verses Depressurization test procedures

The DLT can perform either procedure by moving the 10" flexible hose from the exhaust to the inlet end of the air mover. The AC4 will automatically change modes.

To change from Depressurization test configuration (Shown Below) to Pressurization configuration, the 10" Mylar hose and collar are moved from the suction end of the Air Mover Housing to the Blowing end. The Instruments will calculate the airflow.



Depressurization

Pressurization

3.3.1 Pressurization is the more common test

Pressurization and depressurization tests of the same duct system will yield results that are very similar. Pressurization is the more common procedure. Locating leaks with a theatrical smoke generator is generally easier when pressurizing the duct system to 50 Pa; especially new construction while the ducting is still visible.

Pressurization

3.3.2 Supply ducts

Supply ducts are pressurized during normal system operation, so pressurization testing for duct leakage would be most closely duplicating normal operational conditions.

3.3.3 Return ducts

Return ducts are depressurized during normal system operation, so depressurization duct leakage testing would be most closely duplicating normal operating conditions in the return duct system.

3.4 If the standard test pressure of 25 pascals cannot be reached

In a very large air system or a normal system with excessive leakage, the DLT air mover may not be able to maintain a standard reading of 25 pascals in the ducts. A test may still be conducted by using the "@25" feature in the DLT-5 that uses the results from the low-pressure test data and normalize it to the equivalent of a 25-Pa test. This is the default setting. The greater the difference between 25 Pa and the actual duct pressure, the more likely the accuracy will be degraded. If the Fan goes to Maximum without reaching 25 Pa, it will shut down after 30 seconds unless it is switched to manual mode and adjusted to less than 90.0.

3.4.1 Testing parts of the air system separately

One way to re-run the test at 25 pascals is to only test a portion of the system at a time. It is not uncommon to test the return side separately from the supply side, and indeed, the return side can be tested with Depressurization to simulate normal operational conditions, and then the supply ducts can be tested with Pressurization to simulate their normal operating conditions. The air handler cabinet can also be temporarily isolated from the ducts by blocking the return and supply ducts at the air handler. In extreme cases, individual duct runs can be tested. In these cases, it is likely that there has been a catastrophic breech in only one duct run. The total leakage of the system is the total leakage of the separate tests.

3.5 After testing is complete; restore system to normal operating conditions.

3.5.1 Review all recorded data

After the test is completed, review the data for obvious errors and omissions. It is much easier to repeat a data point while the DLT is still setup and the duct openings sealed than it would be to schedule a return trip, shut down the air system and prepare it for testing.

3.5.2 Shutdown, disconnect and repack the DLT for the next test.

3.5.2.A Turn off power

First be sure your test data has been saved, with the “Save View Report Data”, then use the “STOP” button at the top of the screen to be sure the motor is stopped. When the Motor is stopped a message will say, “Motor Stopped, Data Not saved”, which only means that you should have saved the data with the “View, Save Report Data” button first. The software can now be closed, and the power can be turned off.

3.5.2.C Disconnect flex hose

Remove the hose clamps on both end of the 10” flexible duct and disconnect the duct from the air mover and the adapter plate. Place the hose center storage area of the Cart, and the adapter plate in the rear. The ¼” tubing and test probe can be stored in the rear area.

3.5.2.E Uncover ducts

Remove all the tape, poly film, paper and other materials used to block off the air duct openings. Reinstall any diffusers, access doors, filters and any other parts removed for the test.

3.5.2.F Test air system operation

Turn the air system on and test to be sure it is operating as it was prior to the testing.

Chapter 4
Additional Test Configurations

4.1 Testing supply ducts only

Before beginning repairs to an air system that exceeds the permissible leakage, it may be useful to determine which of the components are tight and which are responsible for most of the leaks. One supply duct connection has come lose and one simple repair will put the system into compliance with the test protocol.

4.1.1 Supply duct leak testing procedure

To test a portion of the duct system is accomplished with essentially the same procedures as those used for the whole system test.

4.1.1.A Prepare the system for testing; seal the vents

If you have just tested the whole system, the supply vents should still be sealed. If they are not, seal all the openings with procedures in Chapter 3.

4.1.1.B The DLT must be attached to the supply side ONLY

The adapter plate can be attached to one of the larger supply vent openings or to the main supply duct at the furnace plenum if it is accessible. The duct pressure sensor must also be installed in the supply duct at a reasonable distance from the DLT air mover adapter plate.

4.1.1.C Isolate the supply ducts from the rest of the system

It is important to seal off the supply ducts from the rest of the system. This will require a main supply duct to be blocked between the furnace and the first supply vent. This can be accomplished with cardboard, and tape or sealing film. The exact location depends on the access available to each area. If the Plenum box can be opened, the blockage can be located at the furnace. If the furnace has a place for a filter where the return duct connects to the furnace, wrap the filter in sealing film and insert it back into the furnace. This will isolate the Supply ducts from the return, but not the furnace itself, so check the furnace for leaks during this test.

4.1.1.D Run the Test with Default settings

Click on “RUN”
Allow time for the Duct Pressure to stabilize and Save the test data.

4.2 Testing return ducts only

4.2.1 Return duct leak testing procedure

This is the same procedure as for the Supply Ducts, but the DLT and probe will be installed to the Return Ducts.

4.2.1.A Prepare the system for testing; seal the vents

If you have just tested the whole system, the return vents should still be sealed. If they are not, seal all the openings with procedures in Chapter 3.

4.2.1.B The DLT must be attached to the return side ONLY

The adapter plate can be attached to the return opening or to the main return duct at the furnace, if it is accessible. The duct pressure sensor must also be installed in the return duct at a reasonable distance from the DLT air mover adapter plate.

4.2.1.C Isolate the return ducts from the rest of the system

It is important to seal off the Return ducts from the rest of the system. This will require a main Return duct to be terminated at the furnace. This can be accomplished with cardboard, and tape or sealing film or by attaching the DLT 10" adapter plate to the return at the furnace. If there is a place for a filter where the Return Duct connects to the Furnace, you can remove the filter, wrap it in sealing tape and reinstall it. The Return duct is now isolated from the rest of the air system.

4.2.1.D Run the test with default settings

Click on "RUN".
Allow time for the Duct Pressure to stabilize and Save the test data.

4.3 Test for Duct Leakage to Exterior only.

4.3.1 Procedure and Equipment Required

This is a very useful test because it measures the leakage to the exterior of the conditioned space of the building. This test requires a Blower Door to Pressurize or Depressurize the conditioned space. Air-Care does not sell a Blower Door unit. The DLT-5 must be adjusted to pressurize the Ducts to the same pressure the Blower Door supplies to the conditioned space. With the building pressure the same as the duct pressure, the only air flow in the ducts will be through leaks to the Exterior of the conditioned space. Install the Blower Door but DO NOT RUN it until the DLT is connected to the system, turned on and has completed its initialization and auto Zero routine. Select "Auto Calc @25" and "Leak to Exterior" test modes, but do NOT start the test until the instructed to do so below.

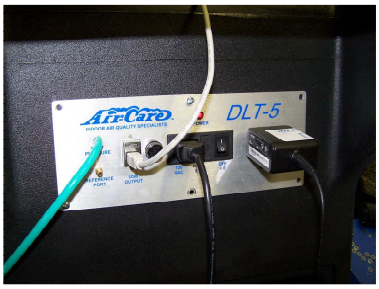
4.3.1.A Prepare the system for External Leak testing; equalize room pressure

If you have just tested the whole system for total leakage, the vents will still be sealed. If not, you must seal them now.

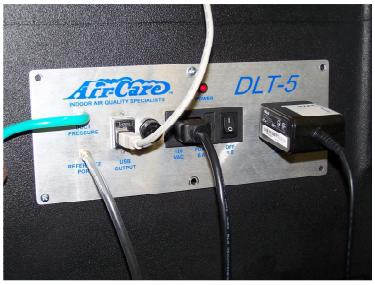
4.3.1.B Connect the Sensors in "External Leakage" configurations. (External Ref or Balanced)

The Duct Pressure sensor will be connected to the Duct Pressure Port on the panel just as it was for whole system testing, but the Reference Port below it must be connected to a tube that leads outdoors so that the DLT-5 has an External reference for the External Leakage test. The Blower door may have a reference to outdoors that can be connected with a TEE to the DLT Duct Reference port and select "Auto Calculate @25 Pa".

The alternate method is called the "Balanced" method and DOES NOT require a reference pressure from outdoors. Select "Balanced" in place of "Total Leakage" or "Leak to Exterior". In this configuration the Fan speed must be adjusted manually and the Duct Pressure Maintained at Zero (Balanced with the Blower Door pressure) and the Mode Selected as Pressurization or Depressurization by clicking on the Green button at the bottom of the gauge on the screen, Left for Depressurization, Right side for Pressurization.



Balanced



External Reference

4.3.1.C Connect the 10" hose to the DLT-5.

The 10" hose connection is the same for the "External Leakage" test as it is for the total leakage test. For Pressurization, connect it to the blowing end of the air mover, and be sure the Blower door is pressurizing the interior of the building by blowing into the building. For Depressurization testing, connect the hose to the suction end of the air mover and be sure the Blower Door is set up to depressurize the building by blowing outside.

4.3.1.D Test Procedure.

The DLT-5 must be connected, turned on and completed its Initialization and Auto Zero routines before running the Blower Door.

Start the fan in the Blower Door and set it for 25 Pa. Do not start the DLT-5 test until the building pressure is at 25 Pa. In some cases this test may be required at 50 Pa, the procedure is the same except the Blower Door and DLT must be set for testing at 50 Pa.

In the "External Reference" configuration, the DLT must be in "Auto @25 Pa" and "External Leakage" mode. Click on "RUN" and the DLT will adjust and maintain 25 Pa (Default). If the Blower door has automatic pressure adjustment (a.k.a. Cruise Control) it will maintain the room pressure, but the Blower Door without this feature will need to be adjusted to get a stable 25 Pa. in the building. It may take several minutes for both blowers to stabilize the pressures in the room and the ducts. Once both the room pressure and duct pressure are stable near 25 Pa the DLT-5 Click "Save & View Report Data" to record the data, You can now stop the fans.

In the "Balanced" configuration, there is no tube connected to the "Reference Port". When the Room Pressure has stabilized with the Blower Door, select Manual Motor speed (the screen "Switch"), "External" mode and "Balanced". The Motor speed must be manually adjusted by with "Click and Hold" on the Up or Down arrow at the bottom of the Manual Motor speed screen display. You must input the type of test as Pressurization or Depressurization by clicking on the Greet buttons at the bottom of the Round Gauge. If the Blower Door is pressurizing the building by blowing air into it, Select "Pressurization", if the Blower Door is Depressurizing the building by blowing air Outside, select "Depressurization. Now you can start the Blower door and adjust the room pressure.

When the building pressure is stable, start the DLT fan. As the DLT motor speed increases, the needle on the gauge will move toward Zero. If the needle goes past zero in either direction, Slow the fan down. As the DLT fan changes speed, the Blower Door fan must be monitored to assure that the pressure remains at the correct level. Most Blower Doors have automatic controls for this, but if it does not have auto control, you must adjust it to the correct pressure, then adjust the DLT for "0" pressure, then recheck the blower door again. You must repeat this until both pressures are near the correct settings, then save the data.
You can now stop the Blower Door Fan.

Chapter 5
Interpreting Results

5.1 Purpose of the duct leakage test must be determined prior to testing

If the DLT testing is performed to a specific protocol, i.e. California Title 24, or EPA Energy Star, there is not much room for interpretation of the data. The Title 24 protocol establishes the desired acceptable limits from the data gathered during the test. If the client is requesting an estimate of the cost of energy that may be saved over a five year period, there may be a great deal of interpretation of the data, since local climate, building insulation, and the projected cost of energy must be factored into the calculations. Air-Care DLT-5 software makes these calculations based on some common assumptions, data collected from the customer in addition to the actual Duct Test Data.

5.1.1 Some quick ballpark estimating rules of thumb

The raw data and calculated CFM from the DLT must be linked to the particular building being tested. A leakage rate of 400 CFM is meaningless unless it can be related to the size of the air system with either total system CFM or total building square footage. Washington State uses the area of the conditioned space to determine acceptable duct leakage percentage, while California use total system CFM.

5.1.1.A Total CFM of a building is approximately the same as its square footage

As a rule of thumb for older buildings, the total CFM of an air system is approximately equal to the total square footage of the building. For newer, tighter buildings with more efficient Air Systems, 500 or more square feet may be served by 400 CFM. To estimate the percentage of duct leakage in an older building that is 2 stories and is 3,000 square feet per floor, divide the measured leakage (400 CFM) by the total CFM of the building (3000 sq ft/floor x 2 = 6,000 sq feet and approximately 6000 CFM) then multiply by 100.

$$\frac{\textbf{400 CFM Leakage}}{\textbf{6000 CFM Total}} \textbf{ X 100 = 6.7\% Rate of Leakage}$$

The same 400 CFM leakage in a 10,000 square foot one story office building **"A"** or a 2,000 square foot 2 story townhouse **"B"** would be:

"A"

$$\frac{\textbf{400 CFM Leakage}}{\textbf{10,000 CFM Total}} \textbf{ X 100 = 4\% Rate of Leakage}$$

"B"

$$\frac{\textbf{400 CFM Leakage}}{\textbf{2000 CFM Total}} \textbf{ X 100 = 20\% Rate of Leakage}$$

5.1.1.B Each ton is has approximately 400 CFM

Another rule of thumb to estimate total system cfm is based on the rated cooling capacity or heating capacity of the system. ASHRAE guidelines assume that most air systems provide 400 CFM of airflow for each ton of capacity. Similarly, 18,000 Btu/hr of heating is approximately 400 CFM. Most homes have 2-ton to 5-ton furnaces, which means approximately 800 to 2,000 CFM. In most cases a home that requires a furnace larger than 5 tons will have a second or third separate system installed to meet the demand. Each system

must be tested individually for duct leakage, but they will still have a total CFM of approximately 400 CFM per ton of cooling and 21.7 CFM per kBtu/hr of heating.

5.1.1.C Leakage to outside

Another important value is the estimated energy wasted or lost to the outside due to duct leakage. Unfortunately, this calculation requires a large number of measurements that are difficult to measure accurately, however, a very close approximation can be calculated using some assumption that these values fall within a predictable range. If you have a "Blower Door" and can pressurize the building to 25 Pa (or 50 pa in some states), the DLT-5 can be used to measure the duct leakage to the exterior directly without the need for complex assumptions.

5.1.1.D Wind and Cold can affect duct leakage test

Extreme weather, such as high winds or below freezing temperatures, can cause the duct pressure to jump up and down during the test. It is recommended to postpone the test until conditions are more stable to provide accurate results, but if rescheduling is out of the question for some reason, and the client agrees to a close approximation, the readings can be averaged over time. A good rule of thumb is to run the test in Manual Mode for1 minute or 5 minutes, then record the readings every 10 to 15 seconds and average them. It is important to record the deviations, the readings and the fact that they have been averaged. This information may not be of interest to the client and does not need to be in the Summary report, but it should be included in the comments section so it will be in the Detailed report with the data.

5.2 Finding the duct leaks

If duct pressure and leakage were taken at multiple locations, the data can be used to learn more about the air system. When the DLT is connected to the supply ducts, the pressure in the return ducts may be close to the same as the supply ducts if a system is reasonably tight. If there is significant leakage, the pressure will be lower in the ducts with more leakage. If that leakage is in the return ducts, there will be a lower pressure in the return ducts than in the supply side. This will result in HIGHER leakage readings for the ducts with the most leakage.

5.2.1 Compare the leakage data for each duct measured

It will become apparent which ducts have the higher leakage and need to be repaired first. It may be useful to move the DLT air mover to the opposite side of the system, take readings there and compare the second set of leakage data to first. This can be particularly useful when the ducts are not easily accessible for visual inspection. By identifying the worst leaks in this way, the client can reduce the cost by limiting the amount of demolition required to access the larger leaks for repairs.

Summary Report

Test Date: 4/15/2012 **Technician Name:** Wayne

Test Performed by: Michaels Air Balance
3868 East Post Road
Las Vegas, NV 89120
702-454-5515

Customer: Janice Doe
12345678 Ninth Street
Henderson, NV 89052

Test Results:

Measured Duct Leakage	:	31.07
Equivalent Leakage Area	:	7 SqIN
Duct Leakage as a Percent of Total Conditioned Space	:	1.4
Duct Leakage as a Percent of Total system Flow	:	1.6
Pressurization/ Depressurazation	:	De-Pressurization
Actual Duct Pressure	:	25.0
Type of Test	:	Exterior Leakage Only
Protocol	:	CA

Property Info:

Total System Airflow	:	2200 CFM
Total Conditioned Floor Area	:	2600 SQ FT

Equipment Info:

DLT Model	:	1.0.0.2
DLT Serial Number	:	F50000156C584501

Estimated Efficiency Loss from Duct Leakage:

Comments:

Detail Report

INDOOR AIR QUALITY SPECIALISTS

Test Date: 4/15/2012
Test Performed by: Michaels Air Balance
3868 East Post Road
Las Vegas, NV 89120
702-454-5515

Technician Name: Wayne
Customer: Janice Doe
12345678 Ninth Street
Henderson, NV 89052

Test Results:

Measured Duct Leakage	31.07
Equivalent Leakage Area	7 SqIN
Duct Leakage as a Percent of Total system Flow	1.6
Duct Leakage as a Percent of Total Conditione	1.4
Pressurization/ Depressurazation	De-Pressurization
Actual Duct Pressure	25.0
Type of Test	Exterior Leakage Only
Protocol	CA

Property Info:

Total System Airflow	2200 CFM
Total Conditioned Floor Area	2600 SQ FT

Equipment Info:

DLT Model	1.0.0.2
DLT Serial Number	F50000156C584501

Equipment Settings:

DLT Fan Sensor Reading	-14.8 Pa
Auto/ Manual Fan Speed	Manual Fan Speed
Mode	Manual test Performed
Averaging Time	4.0 Sec

Estimated Efficiency Loss from Duct Leakage: 1.6 %

A. Annual System Effiency Loss :

B. Estimated Impact on Equipment Efficiency Rating :

Air Conditioner SEER		Air Conditioner Tonnage		Heat Pump HSPF		Furnace AFUE	
Rated	Actual	Rated	Actual	Rated	Actual	Rated	Actual
16	15.74	2	1.97	8.5	8.36	95	93.48
14	13.78	3	2.95	8.0	7.87	90	88.56
12	11.81	4	3.94	7.5	7.38	85	83.64
10	9.84	5	4.92	7.0	6.89	80	78.72
8	7.87	10	9.84	6.5	6.40	75	73.80

Chapter 6
Locating Leaks

6.1 Leakage testing does not necessarily include locating the leaks

If this service is offered, it must be quoted separately. Leakage testing requires visual access to most, if not all, of the ducts in the system. As discussed in Chapter 3 on Procedures, testing the supply ducts, the return ducts or the air handler separately can identify the ducts that have the worst leaks and which are the tightest, but those procedures cannot pinpoint the cracks and breeches that need to be sealed. Often locating the leaks and sealing them is left to an HVAC contractor. Having said that, let's discuss the methods to mark the leaky areas once they are visually accessible.

6.1.1 When the amount of leakage is documented, it is time to locate the leaks

There are several ways to locate duct leaks visually. There may be obvious disconnected or damaged portions of the ducts that can be easily spotted. It can be more difficult if there are a large number of small leaks throughout the whole duct system. That will call for some advanced techniques.

6.2 Using "smoke" to locate leaks

You must be able to observe the exterior of the ducts visually to detect where the smoke is coming out of the ducts for this system to work satisfactorily. Most new construction has the duct leakage tested before all the walls and ceilings are installed. This is the ideal condition for locating duct leaks with smoke.

6.2.1 Theatrical smoke machine

Theatrical smoke generators usually use a mixture of glycerin and water to produce a fine mist resembling smoke. This smoke can be introduced to the system through the DLT air mover set up for Pressurization testing. If the system is set up for Depressurization testing, the process is quite different.

Follow setup instructions on the smoke generator and locate it near the DLT air mover, and turn on the air mover.

Adjust the airflow to pressurize the ducts to a maximum of 50 Pa, then start the smoke generator and let the smoke be pulled into the air mover.

With the smoke pressurized in the ducts, the exterior of the ducts must be inspected along their entire length. If the whole system is being tested, all components of it must be inspected such as the furnace, fresh air intake, humidifier, etc.

As leaks are located, they must be marked and recorded for repairs. Record this information in a log, with the location and the suggested method of repair. This log can be very useful to the contractor who will do the actual sealing, or a guide to you if you are sealing them yourself.

6.2.2 Puffer bottle of smoke

Air Current test bottles usually have 2 smoke producing chemicals in a plastic bottle. One is sealed in a small glass vile that is to be broken by stepping on the outside of the plastic bottle. This smoke may be an irritant if directly inhaled and corrosive if left near metal instruments or tools, so follow

cautionary labeling. These bottles produce much less smoke than the theatrical smoke generators, so it may take considerably longer to locate all of the leaks.

The air system may be in normal operation when the smoke bottle is used. Squeeze the bottle to produce a small amount of smoke around all the duct connections and seams.

On the supply side the duct is pressurized and air will escape from a bad connection or leaky seem causing the smoke to dissipate as fast as it can be sprayed into the leaky area.

For the return duct leaks, which are depressurized, the smoke will be sucked into the holes in the ducts. Both of these smoke indications should be demonstrated for the building owner so they can see the invisible leaks are quite actively moving air into and out of the ducts in an uncontrolled and unintentional manner.

The DLT blower can be used to pressurize or depressurize the whole system to use the bottled smoke to locate duct leaks. It will require temporarily sealing of the duct openings; so running this test at the time of the duct leak test is advisable.

6.3 Infrared thermometer for locating duct air leaks

During normal operation of the furnace, the conditioned air will be warmer or cooler than the room, by 18 to 22 degrees F. By using an infrared thermometer with a laser pointer, the temperature of the supply grills can be checked for a consistent temperature. The ones that are significantly closer to room temperature or at room temperature probably have the largest leaks. If a disconnected boot is found, reinstalling it will significantly reduce the duct loss. If the first test could not reach 25 Pa with the duct disconnected hen the retest with the duct reconnected should easily be able to reach 25 Pa.

Chapter 7
Sealing Duct Leaks

7.1 Sealing of the duct system should be performed by a contractor licensed to do such repairs

The Certified company performing the initial leak test to find the leaks and the post repair leak testing to measure the improvement should not be the same company that is doing the repairs. This can have the appearance of a conflict of interest. It is OK for a company contracted to test and repair ducts to take before and after tests, but if a certification of compliance is required to meet a state or federal standard, a 3rd party post-test is a must, and sometimes both Pre-Testing and Post Testing requires Certified 3rd party reports. Check for state and local and federal procedures that apply in each individual case.

7.1.1 There are a variety of simple, common sense methods to seal most duct leaks

The method will depend on the type of leak being sealed, but cloth based so-called DUCT TAPE should NEVER be used to seal ducts. Studies have shown that this type of tape will degrade in a few years due the heat in the duct or heat in an attic or crawlspace in summer. Always use a product that is approved for use on ducts including Aluminum tape, Mylar duct tape, Mastics, and Caulks.

- Reattach loose flex ducts and secure per code
- Use metal tape on steel duct joints
- Use the appropriate caulking to seal panned-in ducts
- Replace severely damaged ducts
- There are computer-controlled systems with specially formulated sealing materials that are fogged into the duct while the DLT air is flowing with the ducts blocked. The tiny droplets of sealant collect in the leaks, cure there and seal the leaks.

Chapter 8
Energy Loss

8.1 The formula for calculating energy loss to a high degree of accuracy is complex

It requires data that is time consuming to acquire to the degree of precision that would justify its acquisition. Fortunately, most of those data stay within a predictable range and it is possible to calculate a very useful estimate by assuming typical values for them in the equation. This technique yields an "Energy Loss Factor" that multiplied by the actual heating or cooling bill to provide the building owner a dollar amount that was wasted due to that particular air system because the conditioned air escaped from the ducts to the outside environment. The air that escapes from the supply ducts or infiltrates the return ducts from inside the house has not been well studied as of this writing. It has been assumed that the inside leakage does not result in very much loss.

8.2 The energy loss calculations are performed by the DLT-5 software

The DLT-5 software makes all of these assumptive calculations very quickly and add the results to the detailed report it generates from the data entered for the duct leakage test and customer provided information. Using a Blower door and the "Exterior Leakage" test produce a more accurate set of data.

8.3 Duct leakage also degrades the specifications of the furnace

If a furnace is rated at 13 SEER and is 4 tons, it may service the building properly if a significant percentage of its capacity is leaking away. If the energy loss factor is 0.22, multiplying 1.0 minus 0.22 (or 0.78) times the unit SEER (13) and the tonnage (4) ratings will obtain the actual operating SEER of 10.1 and tonnage of 3.1. This illustrates that the cost of leaky ducts also results in lower performance which results in longer run times and degraded comfort levels. The cost of a 4 ton 13 SEER furnace is much higher than the 3 ton 10 SEER performance at which it is running.

8.4 Estimating Wasted Energy Costs

The DLT software estimates the cost of the Energy wasted by the Duct Leakage measured using some assumptions. Since most Energy bills do not separately list the amount of energy used for Heating and cooling from the total bill, the DLT estimates the Cost of the loss as dollars per $100 of Heating or cooling costs. This will give the Homeowner a way to estimate what is being wasted and the potential for savings if the leaks are sealed. The main assumption is that only about 50% of the total Duct Leakage is to the exterior. If the "Exterior Leakage" is calculated, the dollar amount wasted per $100 of Heating and cooling costs must be multiplied by 2, i.e. doubled.

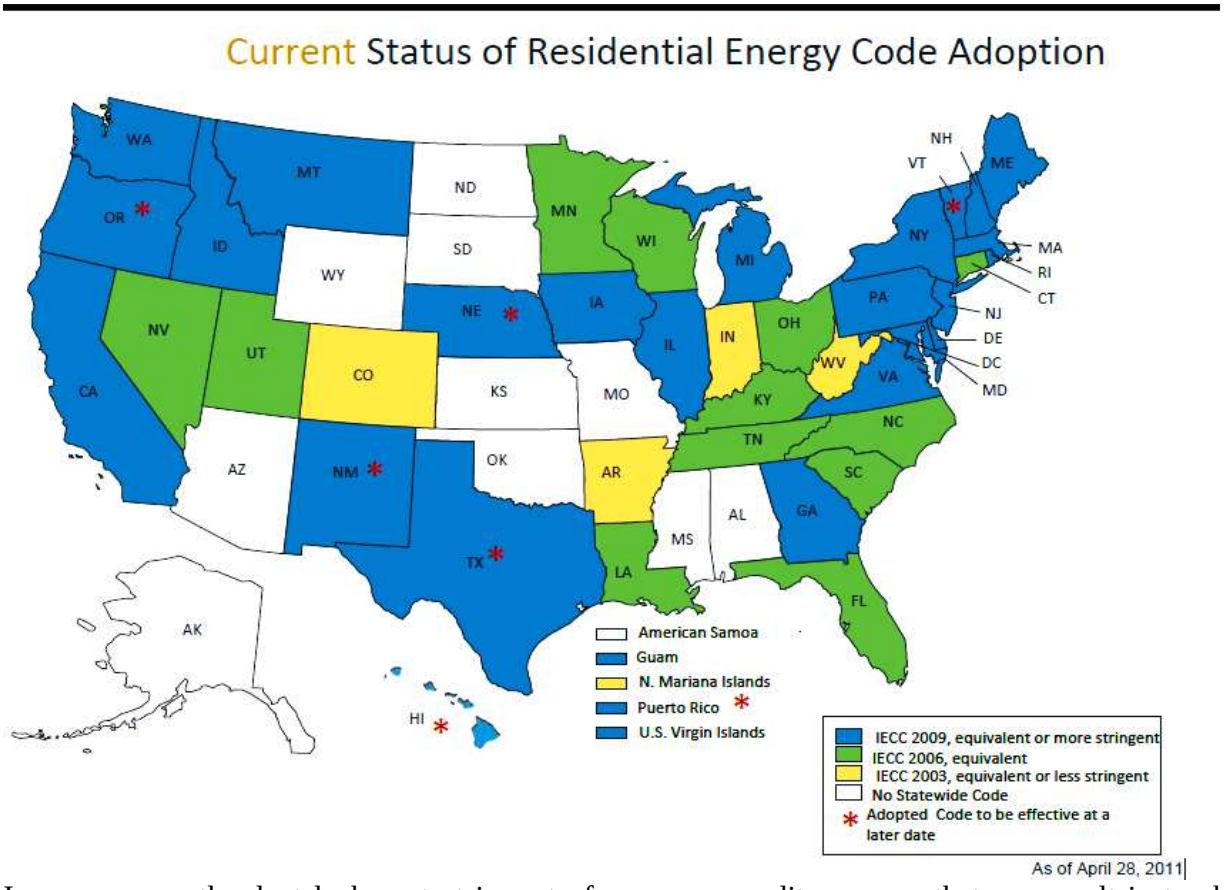
Chapter 9

Certification Requirements

Certification is not required to operate the DLT-5 or to test for duct leakage unless the test is to satisfy a protocol by an agency that requires certification. If you are called in as an independent 3rd party to test the leakage of a residential or commercial duct system, you must request the reason for the test and the protocol to be used to determine if you can meet the requirements of that protocol.

No certification is required if you are an HVAC contractor "pre-testing" your own duct systems before the drywall is installed so leaks can be sealed more easily. This is a good way to insure your air systems will pass an independent 3rd party test after drywall is up. The Air-Care DLT can be used by virtually anyone who follows the protocol in this book, or California Title 24 or Energy Star protocols to "pre-test" for duct leakage prior to the certified 3rd party testing company.

The Department of Energy's **2009 IECC (**International Energy Conservation Code**)** has been adopted by 40 states. This code covers all aspects of Energy conservation from Lighting to Insulation to Duct leakage, etc. State by State details Link: http://www.bpa.gov/Energy/N/Utilities_Sharing_EE/doc/BuildingCodesofTomorrow.pdf
Their guideline map is below.



In many cases the duct leakage test is part of an energy audit program that can result in tax benefits or rebates from utility companies. One company may provide all of the testing of appliances, insulation, lighting efficiencies, window and door sealing as well as duct leakage. These classes can be 8 hours/day and 10 days long. Some classes are specific to duct leakage testing with hands on program lasting one to three days and may cover new construction or remodeling of existing construction. The programs are

usually divided into residential and commercial categories as well. The cost can vary and some utility companies offer free training, sometimes co-sponsored by an equipment manufacturer.

Links:

Department of Energy:
http://www.bpa.gov/Energy/N/Utilities_Sharing_EE/doc/BuildingCodesofTomorrow.pdf

EPA
Energy Star: http://www.energystar.gov/index.cfm?c=home_improvement.hm_improvement_hpwes
Home Energy Audit: www.energystar.gov/index.cfm?c=home_improvement.hm_improvement_audits
Home Energy Yardstick: www.energystar.gov/index.cfm?fuseaction=home_energy_yardstick.showStep2
Energy Star (40 States): http://www.energystar.gov/index.cfm?c=behind_the_walls.btw_ducts

California Title 24 Air Duct Leakage requirements
Appendix ACM RC2005 (Procedures)
http://energy.ca.gov/title24/2005standards/residential_acm/2005_RES_ACM_APP_RC.PDF

Florida Department of Energy
http://www.fhba.com/index.cfm?referer=content.contentItem&ID=1270

Oregon State Department of Energy
http://www.cbs.state.or.us/external/bcd/committees/10cec/proposals/OSSC10-11.pdf

Texas State Department of Energy
http://austinaes.com/duct.html

Washington State University Extension, Energy Program
http://www.energy.wsu.edu/

HERS Certification Providers
CHEERS: www.cheers.org
CalCerts: www.calcerts.com

NARI, the National Association of the Remodeling Industry: http://www.nari.org/

Chapter 10
"Can't Reach" and "Back Pressure" Compensation

10.1 Estimating duct leakage at Duct Pressures other than 25 Pa.

There are times it may not be possible to obtain fan data in an accurate range at 25 pascals of duct pressure. If the system is very large or has a large amount of leakage, the air will escape faster than the fan can supply it. In a very small or very tight air system, the leakage may not be enough to register on the flow sensor.

In these cases, the "@ 25 Pa" setting will calculate the CFM of leakage as if it were at 25 Pa, even if the actual duct pressure is higher or lower than 25 Pa. This setting is the Default setting for the DLT-5. This method introduces a slight error that increases as the duct Pressure goes farther from 25 Pa. The DLT-5 will display a message if the calculation cannot be made with reasonable accuracy. This calculation is also performed for "@ 50 Pa" tests.

10.2 When Back Pressure prevents accurate results.

Back pressure can occur when there is a very large leak in one section of the duct system or when there is a restriction or large leak in the duct system between the DLT-5 air mover and the duct pressure probe. The DLT-5 monitors the back pressure and is able to compensate for it and calculate the correct results from these data in many cases. When the back pressure is excessive and accurate compensation is not possible, a warning message will appear at the bottom of the screen, "Excessive Back Pressure" or "Excessive Back Pressure, Remove Flow Ring". In the first case, the test results may still be valid for most conditions, but excessive internal duct restrictions may be introducing some error. For the second Message, the total leakage of the system is greater than the range of the DLT with the Flow Ring installed. Removing the ring will extend the range of the DLT into a Larger Leakage range, so an accurate measurement can be taken.

It is also possible that the current connection to the Air System is not ideal. Moving the Duct Pressure Probe to another location in the system may reduce the back pressure to manageable levels. If the 10" hose is not connected to the largest Duct or to the Furnace, this can also cause excessive back pressure. It is advisable to perform multiple tests with the Duct Pressure Probe in multiple locations and average the results in this situation to provide the most accurate test for this situation.

Chapter 11
Additional Computer and Communications Features

11.1 DLT-5 REPORTS, Viewing, Printing and Exporting as .pdf documents.

Air-Care has created a proprietary Measurement Software package for the DLT-5. The duct leakage-testing portion of the program lets the operator enter the customer name, and other data, plus system information and technical notes. The Duct Test data from the DLT-5 is collected with the customer data and your company information and stored as a Summary report and as a Detail Report in .rpt format.

The reports can be viewed or printed in this format, but it is highly recommended that you "EXPORT" the reports DURING THE TEST as .pdf format documents so they can be emailed, saved and printed on computers that do not have the DLT-5 software.

To VIEW the Reports, Click on "View and Save Report Data". You will be taken to the Summary Report (A) shown below. To see the Detail Report, Click on the Detail Button (B).
To Export both reports as .pdf Documents, click on the "EXPORT TO PDF" box ©

The Summary Report (sample on page 21) has the essentials required for most Tests.
The Detail Report (Sample on Page 22) contains customer data about the size configuration of the air system tested and additional calculations for leakage and energy efficiency as well as projected cost of energy losses per $100 of heating or cooling costs due to duct leakage that can be of interest to the customer or the contractor working on the project,

11.2 **Computer features**

The Notebook Computer included with the DLT-5 is a fully functional, Wi-Fi equipped computer. If you supply your own Laptop Computer, you will receive a copy of the software required by the DLT-5. If you have technical questions, please call Air-Care Free Support line. 800-322-9919

Air Care DLT Parts List

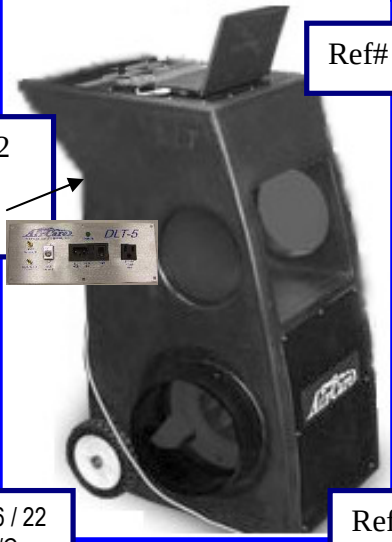
Ref#	Description	M1 P/N
	Air Care DLT-5 (Duct Leakage Testing System (complete assembly) with Netbook	FG0124
	Air Care DLT-5 (Duct Leakage Testing System (complete assembly) without Netbook (Software on CD or USB Flash Drive)	FG0151
1	DLT-5 in cart without accessories or Netbook	SADLT0025
2	NetBook with Windows 7 starter edition and DLT-5 Software	SAO0285
3	Tape, Masking, 2" wide, 1 roll	DLTC0001
4	Tape, Duct Mask Register, 12” wide with perforations, 1 roll	DLTC0002
5	Hose, Mylar 10"(Nominal) x 12.5 ft	DLT0011
6	Hose Clamps, 10” to 12”	DLTC0014
7	Adapter for 10" Hose Collar with 14” x 14” Adapter Plate	SADLT0012
8	“TEE”, 1/8 x 1/8” x 1/8” for tubing	DLTC0011
9	“Coupling” 1/8” x 1/8” for tubing	DLTC0012
10	1/8” ID x ¼” OD vinyl tubing, Green	COM0189
11	1/8" ID x ¼” OD vinyl tubing, Red	COM0191
12	1/8” ID x ¼” OD vinyl Tubing, Clear	COM0192
13	Pressure Probe, 90 Degree	DLTC0010
14	Field Calibration Tool	SADLT0020
15	Flow Ring for Low Flow conditions	DLTC0031
16	Wheels, 8” diameter for ½” Shaft	DLTC0030
17	Software for DLT-5 (Not Shown) Specify CD or USB Flash Drive. Customized for each DLT-5 and cannot be used on other DLT-5 without customization.	SADLT0046
18	Axle, ½” (Not Shown)	DLTC0045
19	Front Cover	SADLT0024
20	Top Cover, Desk Top for Computer (Cover Only, does NOT include Electronic Board)	SADLT0017
21	Board, Electronic for Motor Speed and Pressure Sensing (Not Shown)	DLTC0023
22	Power Panel, Complete	SADLT0015
23	Power Cord, 15 ft, 3 conductor with Computer type connector (Not Shown)	EC0012
24	Wheel Caps for Axle	COM0095
25	Rear Storage compartment Door, Panel Only (Not Shown)	SADLT0023
26	Storage Door Catch (Not Shown)	DLTC0031
27	Storage Door Knob (Not Shown)	DLTC0032
28	Latch, Double Wing, Turn for 14” x 14” Adapter Plate (Not Shown)	DLTC0033
29	USB 2.0 Cable, Male Type A to Male Type B, 3 ft long (Not Shown)	DLTC0009

Air-Care DLT-5
(Duct Leakage Testing System)

- DLT-5 Cart with Blower, Electronics, Computer desk, Storage for all accessories,
- Low Flow Ring
- Adapter Plate to attach 10” hose to Ducts
- Field Calibration Ring
- Ref #1, without accessories, NetBook shown on Desk Top

Ref# 20 Desk top

Ref# 22 Power Panel



Ref# 16 / 22 Wheel /Cap

Ref# 19 Front Cover

Ref#3, Tape, Duct Mask Register, 12” wide with Perforations

Ref#9, “Coupling” 1/8” x 1/8” for tubing

Ref#8, “TEE”, 1/8” x 1/8” x 1/8” for tubing

Ref#4, Tape, Masking, 2” wide

Ref#13, Pressure Probe

Ref #14 Field Calibration Tool

Ref#5, Hose, Collapsible

Ref#7, Adapter for 10” hose

Ref#2 Netbook Computer

Ref #15 Low Flow Ring

Ref#6 10” Hose Clamps

Ref#10, 1/8” x 15’ vinyl tubing, Green

Ref#11, 1/8” x 15’ vinyl tubing, Red

Ref #12 1/8” x 25’ vinyl tubing, Clear

Not shown

DLT Specifications

Air Mover:	
Fan Type	12” Axial Backward Inclined
Motor	PSC Built into Center of Blower Wheel
Case Construction	Rotational Molded
Speed Control	Digital, feedback controlled
Maximum Airflow: Free Air	880 Free Air
Maximum Airflow: 25 Pa	625 w/ Duct attached
Power Required	115 Volt AC @ 2.2 Amps
Instrumentation:	
Duct Pressure Sensor	90 Deg tube w/ Magnetic base
Duct Pressure Measurement	Digital Transducer with Multiplex signal processor
Air Flow Sensor	Tri-Port Digital transducer
Air Flow Measurement	Firmware averaging and Software data recording
Back Pressure Measurement	Differential Pressure transducer
Range of Measurement	15 to 625 cfm @ 25 Pa
Dimensions:	
DLT-5 Cart with all accessories installed	17.5” L x 14” W x 38” H
Notebook Computer	9” W x 4” D x 1.8” Thick 10.1 In. Screen
Weight:	
DLT-5 Cart with all accessories installed	58 lbs
Notebook Computer	2 lbs
Shipping Weight	69 lbs
Warranty:	
Duct Leakage Tester, DLT-5	One Year

Maintaining and Calibrating the Air Care DLT

M.1 Maintaining the DLT is simple, check calibration, and keep it clean

M.1.1 Keep the DLT clean

A daily wiping with a clean damp cloth will usually maintain the exterior of the DLT. Vacuum any dust that builds up on the inlet grill. If tape is used to secure the Mylar hose to the DLT, it may be necessary to use an adhesive cleaner to remove residual tape adhesive before it hardens.

M.1.2 The DLT is factory calibrated

The manometer and flow sensor have been calibrated at the factory and will maintain their accuracy for 1 year unless damaged by misuse or rough handling. It is a good practice to field check the calibration before & after each test. It is recommended practice to verify that the "Duct Pressure" Port and the "Reference" display the same reading (Except with a minus sign) with a stable pressure measurement.

M.2 Check for leaks in the 10" Mylar hose and the vinyl tubes

Check the plastic tubing for possible damage or leaks regularly before each test is recommended. This can be done with a small syringe by drawing a vacuum with the syringe on one end of the tubing while holding you finger over the other end of the tubing. The vacuum should hold for at least 30 seconds to a minute. DO NOT APPLY ANY PRESSURE TO THE TUBES WHILE THEY ARE CONNECTED TO THE MANOMETER OR IT WILL BE PERMANENTLY DAMAGED.

Inspect the 10" dia. Mylar hose for holes and tears. When in doubt, connect the 10" hose to the Pressure side of the fan and hold the other end to a flat surface to seal it off. Turn on the fan at middle to high speed and listen and feel for a hole. If you moisten you hand, you it will be a sensitive leak detector. Of course, if you have a smoke generator, it can be used to locate leaks in this hose.

M.3 Factory calibration:

Annual factory calibration is recommended for the DLT-5. Field Calibration checks are possible. For details on calibration services, call Air-Care 800-322-9919

DLT-5 Messages

Message	Action Needed
Auto Run at 25 Pascal Started, Please Wait	Advisory that the test has been started, but the DLT has not reached test pressure in the duct yet.
Test Running Fan Speed being Adjusted	Wait until fan speed is stable for 30 seconds, then Press View and Save Data to end test
Data Files have been Saved	Advisory, that data has been saved
Enter Total System air flow or Square Footage of Conditioned space	On the Test Screen, at the Lower Left, there must be values for the Square Footage of the Conditioned space and the Total air flow of the system (usually 400 CFM for each Ton of Air Conditioning or 23.76 CFM for 1000 BTU/Hr of heating)
System Initialized, Ready for Auto / Manual Test	Advisory that the "RUN" button can be clicked to start the test.
Stopping Automatic Process	Advisory that the "Stop" button has been clicked.
M1 High: Fan Speed at Maximum	Advisory that the Fan is at Maximum and if the Leakage data looks stable, it should be SAVED. The Maximum motor speed is 90 on the Automatic side or 900 on the Manual side of the vertical indicators.
Duct Pressure could not be reached, check that the 10 inch hose is properly connected. It may be necessary to change the hose location or the Duct Pressure Probe location.	The test failed and the Fan was probably turned off. The main causes of this are a VERY leaky system, the Duct where the pressure probe is located is disconnected from its duct, or the 10" hose from the DLT-5 has come loose.
DLT-5 Initializing, Please wait	Board Powered ON, Software Loading
Sensors being Zeroed, Please Wait	At Startup, this is a 15 second process. When Manually selected, it requires 120 seconds to run, and a "Count Down Timer" will be displayed.
DLT-5 Initialized, Auto / Manual can be Started	All Basic Startup tests completed, and ready to start the test
Enter Company information	One of your company names must be entered as the Testing company on the Set Up page
Enter Customer information	The Customer and test location must be entered before the test can be started.
Test Started, Please Wait	"RUN" button Pressed in @25 or @50 modes, Duct Pressure UNDER 10 Pa _(+/-) "Test Running, Fan Speed being adjusted" "@ 25 Pa" or "@50 Pa" Duct Pressure Blank Boxes for Calculated Values
"Test Running, Fan Speed being adjusted"	"RUN" button Pressed in @25 or @50 modes, Duct Pressure over 10 Pa _(+/-) "Test Running, Fan Speed being adjusted" "@ 25 Pa" or "@50 Pa" Duct Pressure. . Estimated Values in Boxes for Calculated Values, CFM and Leak Area.
Duct Pressure could not be reached, Remove Flow Ring.	Duct Pressure could not be reached with Flow Ring Installed, Please Remove Flow Ring.
MANUAL MODE	Manual Mode. Fan speed must be adjusted with mouse to set DUCT PRESSURE to ZERO for Balanced Flow Measurements
P1: Excessive Duct Pressure, Stop Test,	Test in progress, but Duct Pressure excessive. Stop Motor, End Test and reload the Program. If test still does not run properly, Call Air-Care for technical assistance.
Excessive Back Pressure, reconfigure connection	Test in progress but there is excessive back pressure that will affect accuracy. To save data anyway, Click "Save and End". Verify 10" hose is as straight as possible, Move Duct Pressure sensor to a new location, or Attach the DLT to a larger opening in the air system.
DLT-5 In PAUSE Mode.	The Pause Button has been pressed. Test values can be changed, the RUN button can be pressed to start the test.
Excessive Back Pressure, Remove Flow Ring	Remove the flow ring to provide greater air flow and less back pressure for this test.

Bibliography

Development of a Practical Method for Estimating Thermal Efficiency of Residential Forced Air Distribution Systems, EPRI, Palo Alto CA, January 1997

ASHRAE Standard 152P, Method for determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems, ASHRAE, Atlanta GA, May 1999

US Department of Energy, International Energy Conservation Code, 2009

Improvements to ASHRAE Standard 152P, Paul Francisco and Larry Palmer, Ecotope, Seattle WA, June 1999

California State Energy office, Title 24, ACM Appendix RC

HERS Home Energy Rating System,

ASHRAE American Society of Heating, Refrigeration and Air Conditioning Engineers

AMCA Air Movement and Control Association

AABC Associated Air Balance Council

Land Air Balance Services

Energy Conservatory

Dwyer Instruments

Glossary

Air Conditioner	Device to cool room air by the refrigeration method.
Air Flow	The volume of air moving past a point in the air system in a set time frame, usually Cubic Feet per Minute, CFM
Air handler unit	The part of an air system that contains the fan and moves the air through the system, also AHU or A/H or "Unit"
Air System	The complete system to heat or cool air, distribute it through a structure and recycle it to maintain temperature and sometimes humidity and sometimes exhaust stale air and pull in outside air.
Back Pressure	Resistance to the main air flow often caused by a restriction or an excessive leak at the far end of the Ducts.
Balanced Pressure Test	A method to determine air flow by connecting a calibrated fan to an air duct that is adjusted to match the pressure of the air system fan to read a pressure of Zero.
BTU	British Thermal Unit, used to measure Heating capacity
CFM	Cubic Feet per Minute, a measure of Air Flow volume
Depressurization	Duct Leakage test that exhausts air from the ducts or Depressurizes them during the test.
Duct Leakage	Air flow that escapes the duct in places that were not intended, i.e. NOT the normal supply registers.
Duct Pressure	The pressure difference between the room and the interior of the ducts while the Air handler is running
Duct Pressure Probe	The probe placed in a sealed duct system during a Duct Leakage test so the pressure can be set for the test.
Energy Star	An EPA Program that sets standards for the current state of the air Energy Efficiency in buildings and protocol for verifying buildings meet these standard before they are given the "Energy Star" rating.
Exterior Duct Leak	Air flow that escapes to the exterior of the building envelope
Filter	The device that collects dust and debris from the air before it returns to the air handler.
Furnace	This can include the Heating or the Cooling mechanism and the Fan in the Air Handler that conditions the air.
Grill	A diffuser at the end of a supply or return duct. Sometimes the Filter is mounted in the Return Grill area.
HERS	Home Energy Rating System. A home using NO energy rates "0", the best. Duct leakage, insulation value, building orientation and many other factors are used.
In WG	A unit of low pressure. One inch of water gauge is what it takes to suck water 1" above the surface into a straw
Leak area	The estimated total leak area of a duct system if all the area of all the small holes were located in one place
Pascal or Pa	A unit of very low pressure. 249 Pascals equal one inch of water Gauge.
Pressurization	Method of testing an air duct system by forcing air into the sealed duct system to simulate normal operating pressure
Reference Pressure	In Duct Testing, the pressure in the area that will be used as the base for other pressure readings, such as the duct.
Register	A grill or diffuser where conditioned air is supplied to a room, at the end of a Supply Duct.
Return Duct	The duct that collects air from an area and conveys it back to the Air Handler
SEER	Measure of an Air Systems efficiency, Seasonal Energy Efficiency Ratio.
Supply Duct	The Duct that takes conditioned air from the Furnace/Air Handler to the conditioned rooms in the building.
Title 24	The California Air Duct Leakage Protocol
Ton	A unit of measure of Air Conditioning cooling capacity
Total Duct Leakage	All of the air flow that leaks out of a duct system, both external to the building envelope and internally.

INDOOR AIR QUALITY SPECIALISTS

LIMITED WARRANTY

DLT-5
Duct Leakage Tester

Air-Care warrants this product to be free from defects in materials and workmanship to the original purchaser for a period of Two (2) years from the date of purchase. Components listed below are excluded from this Two year period and are covered for periods described below:

Blower Assembly	1 Year
Circuit Board	1 Year
Wheels	No Warranty

Warranty covers both parts and labor (labor is to be performed at Air-Care's facility located at 3868 E. Post Road; Las Vegas, Nevada).

Individual components included with this equipment, including but not limited to the Notebook Computer are only warranted to the extent of that product manufacturer's warranty.

Warranty is extended to the original purchaser and is **not** transferrable.

This warranty does not extend to any damage to a product caused by or attributable to freight damage, abuse, misuse, improper or abnormal usage. Warranty is also void if the product has been modified or altered in any way.

The purchaser is responsible for the cost of shipping the equipment to Air-Care's facility for evaluation. If found to be defective and covered by the terms of this warranty, Air-Care will pay FedEx ground shipping charges on the repaired or replaced item back to the purchaser's location. Any additional expedited service charges for quicker shipping shall be born by the purchaser. If the product or component is not found to be a warranty issue, the purchaser will be responsible for return shipping charges.

Air-Care is not responsible or liable for indirect, special, or consequential damages arising out of or in connection with the use of performance of the product; damages with respect to any economic loss, loss of property, loss of revenues or profits, loss of use, or other incidental or consequential damages of whatsoever nature.

The warranty extended hereunder is in lieu of any and all other warranties, and any implied warranties of any type.

This warranty gives you specific rights. These rights and others vary from state to state.

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