McGill AirFlow LLC

System Pressure Testing for Leaks

An enterprise of United McGill Corporation —
Family owned and operated since 1951

LTK-4 Leak Detective Test Components

LTK-8 Leak Detective Test Components

Optional Smoke Delivery Components

No duct system is airtight; all leak to some degree. If controlled, duct leakage can be less than 1 percent of the total system cfm. To protect building owners against leakage and the resulting increase in operating costs, engineers are indicating the leakage parameters and are requiring verification testing in the specifications.

To help determine if duct leakage is within specifications, McGill AirFlow offers Leak Detective® test cart and components for both supply and exhaust systems. It is the purpose of this manual to properly instruct the user in how to set up the components, conduct leakage tests, and evaluate the results.

Equipment

McGill AirFlow offers Leak Detective test components in 4-, 5-, 6-, and 8-inch tube diameters. Each contains a calibrated orifice tube with a certified calibration chart, fan with flow control damper and inlet/outlet guards that meet OSHA safety requirements, two U-tube manometers, connecting tubing, and flex duct with adapter and clamps. Any of these components can be purchased individually or as a complete unit mounted to a wheeled cart.

For more detailed information about equipment for various applications, refer to McGill AirFlow's **Leak Detective** sales brochure.

Figure 1

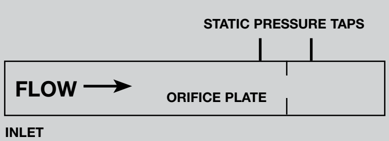


Figure 2

McGill AirFlow LLC

2400 Fairwood Ave.
Columbus, OH 43207
Phone: (614) 443-0192

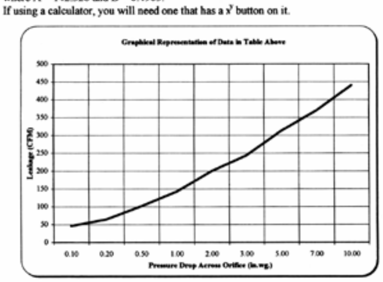
The table and graph below are to be used only for Tube No: 5091-5

This chart is for: Forward Flow

Instructions: Record the pressure drop across the orifice tube. Find the pressure drop in the table below and note the corresponding leakage rate

Pressure Drop Across Orifice (in.wg.)	Leakage Rate (cfm)	Pressure Drop Across Orifice (in.wg.)	Leakage Rate (cfm)	Pressure Drop Across Orifice (in.wg.)	Leakage Rate (cfm)
0.0	0.0	3.5	263.1	7.0	369.6
0.1	46.0	3.6	266.7	7.1	372.1
0.2	64.6	3.7	270.3	7.2	374.7
0.3	78.9	3.8	273.9	7.3	377.2
0.4	90.8	3.9	277.4	7.4	379.8
0.5	101.3	4.0	280.9	7.5	382.3
0.6	110.8	4.1	284.3	7.6	384.8
0.7	119.5	4.2	287.7	7.7	387.2
0.8	127.6	4.3	291.0	7.8	389.7
0.9	135.2	4.4	294.3	7.9	392.1
1.0	142.3	4.5	297.6	8.0	394.6
1.1	149.1	4.6	300.8	8.1	397.0
1.2	155.6	4.7	304.0	8.2	399.4
1.3	161.9	4.8	307.1	8.3	401.7
1.4	167.9	4.9	310.3	8.4	404.1
1.5	173.6	5.0	313.3	8.5	406.5
1.6	179.2	5.1	316.4	8.6	408.8
1.7	184.6	5.2	319.4	8.7	411.1
1.8	189.9	5.3	322.4	8.8	413.4
1.9	195.0	5.4	325.4	8.9	415.7
2.0	199.9	5.5	328.3	9.0	418.0
2.1	204.8	5.6	331.3	9.1	420.3
2.2	209.5	5.7	334.1	9.2	422.5
2.3	214.1	5.8	337.0	9.3	424.8
2.4	218.6	5.9	339.8	9.4	427.0
2.5	223.1	6.0	342.6	9.5	429.2
2.6	227.4	6.1	345.4	9.6	431.5
2.7	231.6	6.2	348.2	9.7	433.7
2.8	235.8	6.3	350.9	9.8	435.8
2.9	239.9	6.4	353.7	9.9	438.0
3.0	243.9	6.5	356.4	10.0	440.2
3.1	247.9	6.6	359.0	10.1	442.3
3.2	251.8	6.7	361.7	10.2	444.5
3.3	255.6	6.8	364.3	10.3	446.6
3.4	259.4	6.9	367.0	10.4	448.7

Leakage rate may also be calculated using $CFM = A(\text{orifice pressure drop})^B$
where A = 142.326 and B = 0.4903.
If using a calculator, you will need one that has a x^y button on it.



Print Date: 3-May-07
Calibration Date: 31-Aug-05

LTK-5CA Leak Detective Test Component Assembly with optional smoke kit

Orifice Tubes

The orifice tube provides an easy way to measure airflow. A cutaway view of a typical orifice tube is shown in **Figure 1.**

When air flows through the tube, there is a dynamic pressure loss generated across the orifice which varies approximately with the square of the air velocity. This differential pressure can be measured by connecting a manometer across the static taps on either side of the orifice. Each McGill AirFlow orifice tube is individually calibrated and has its own unique calibration table. Calibration table lists airflow leakage versus the differential pressure (**Figure 2**).

The orifice tube is one of the most rugged of all flow measurement devices, and the calibration should not change as long as the orifice plate, tube, and pressure taps remain clean, undamaged, and unaltered. Recalibration of an undamaged tube is recommended every 5 years, but no longer than 10 years. McGill AirFlow maintains a record of the calibration chart for all its orifice tubes for up to 10 years.

Standard McGill AirFlow orifice tubes are certified and traceable to NIST standards.

Fans

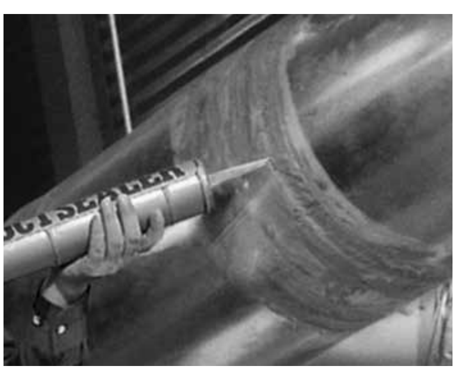
The fan in the 4-inch leakage test kit will operate on 110-volt, single-phase, 50- or 60-cycle current, or can be ordered for 220-volt operation.

The 5-inch fan will operate on 110-volt, single-phase, 60-cycle current, but can be wired for 220-volt operation. The 5-inch fan can be ordered for 50-cycle applications.

The 6- and 8-inch kits use a 220-volt, single-phase, 60-cycle, fan that is equipped with a L6-30 turn-lock plug required for 30-amp service. The fan can be ordered for 50-cycle applications but is not available for 110-volt operation.

All three standard fans come with a flow control damper and inlet/outlet guards that meet OSHA safety requirements.

Step 2



Step 3

Procedures

It is always recommended that a contractor perform a leak test on the first several hundred feet of duct installed. This is especially important when an untrained labor force or a new and unfamiliar sealant or assembly technique is being used. This initial test warns the contractor of any installation problems that are likely to be encountered and allows the proper adjustments to be made before other duct sections are assembled.

The following procedure describes the proper method of conducting leakage tests:

Step 1 — Check the specifications to determine the allowable leakage and leakage test pressure. Determine which segment(s) of the system will be tested (see “Suggested Leakage Specifications” at the end of this booklet).

Step 2 — Carefully seal all openings of the section to be tested (except the one where the Leak Detective test components will be connected). Various methods of sealing openings have been used, including:

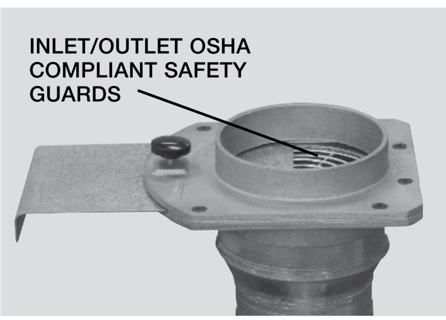
a. Plastic bags sealed with duct tape (for small openings)
b. Sealed chipboard disks or cardboard
c. Tapered paper or plastic food containers
d. Metal caps, sealed and/or welded
e. Inflated balloons (for small openings)

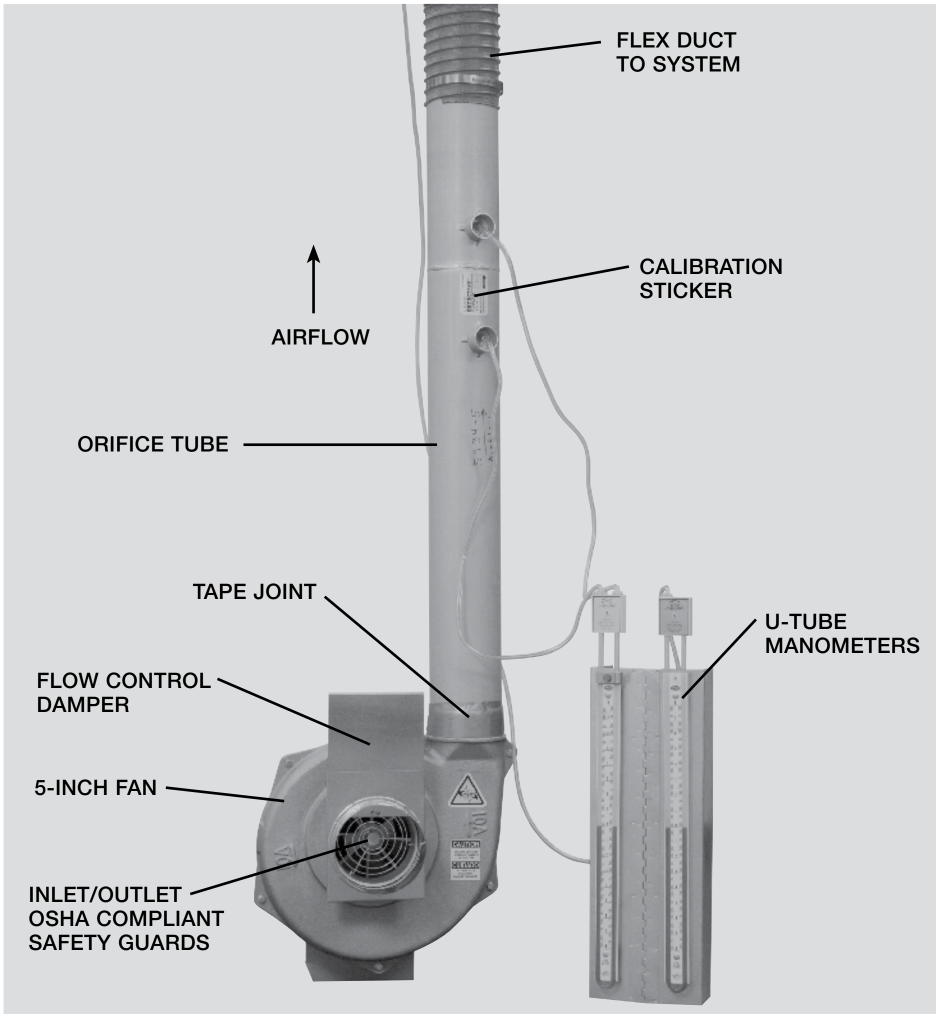
Step 3 — Systems should not be pressurized until all duct sealant has had at least **48 hours** to cure. Some products may require more time, so be sure to check the manufacturer’s instructions.

Step 4a — Typical Positive Pressure Testing: Connect one end of the orifice tube to the duct system using a short piece of single-wall flexible duct. The arrow on the calibration sticker shows direction of flow.

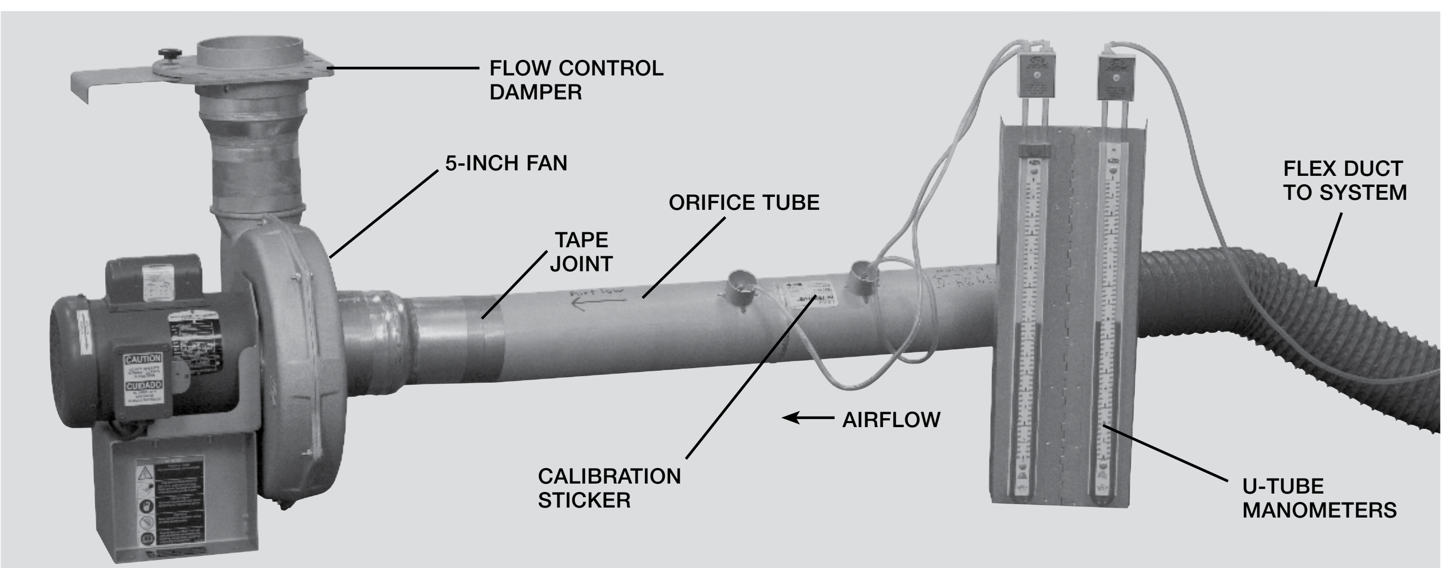
Step 4b — Typical Negative Pressure Testing: For all standard components except the 4-inch, two options exist for performing negative pressure testing.

1. Leave the orifice tube on the discharge side of the fan and hook up the flexible duct to the fan inlet. As long as there is no leakage at the fan inlet and outlet joints, this is an acceptable method of test. (**Note:** the fan motors have an internal fan to cool them, this is NOT test air leaking out.)
2. Put the orifice tube on the inlet side of the fan, making sure the air is flowing in the direction of the arrow on the calibration sticker.

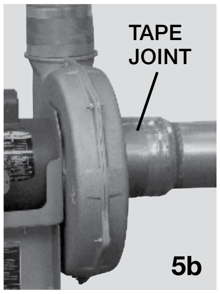




Step 4a — Typical Positive Pressure Testing Set-up using the Leak Detective 5-inch Test Components



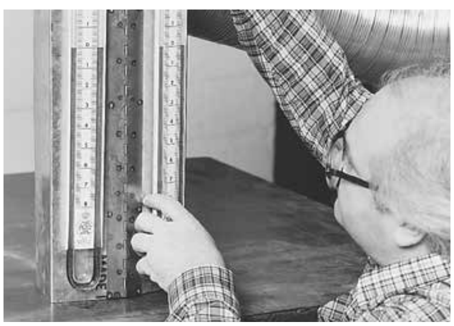
Step 4b — Typical Negative Pressure Testing Set-up using the Leak Detective 5-inch Test Components



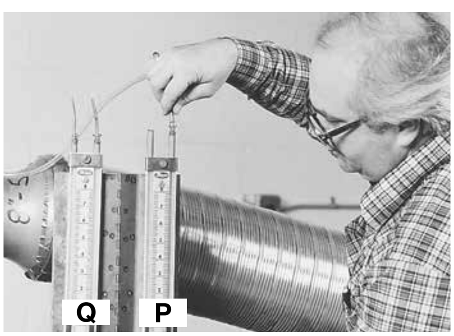
Step 5

Step 6a

Step 6b



Step 7



Step 8

Step 5 — For positive pressure tests (**5a**), the fan **discharge** should be connected to the orifice tube. For negative pressure testing (**5b**), the fan **intake** will be connected. With McGill AirFlow's 4-inch Leak Detective test components, the fan comes equipped with a tapered nozzle, which can connect to either the fan inlet or discharge and will mate with the tapered cone receiver on the orifice tube. The tapered nozzle should be cut off so only about **2 inches** are inserted into the orifice tube receiver. Be sure to firmly mount the fan and tape all connections to avoid leakage.

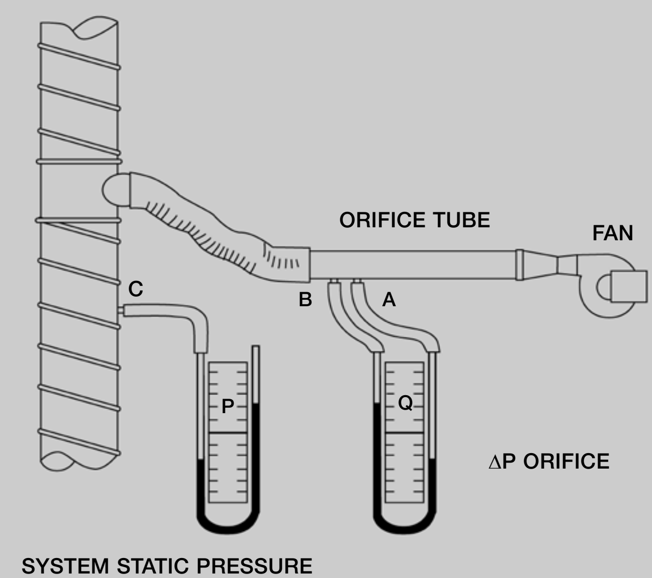
Step 6a — Drill a 5/16-inch hole in the duct system at a convenient location, at least 12 inches from the orifice tube connection.

Step 6b — Insert and securely tape one end of a piece of plastic tubing in this hole, making sure that no leakage will occur around the penetration. This will be used to measure system static pressure. **Do not use the orifice tube taps to measure the system static pressure.** It is convenient to have pressure taps designed into the system on ducts where leakage will be tested. Taps should have removable caps and be sized for tubing with a 3/16-inch inside diameter and 5/16-inch outside diameter.

Step 7 — Mount both manometers and adjust the water level to zero scale. Adjustments can be made by sliding the manometer's U-tube up or down on the scale as necessary. The manometer's adjustable valves must be opened at least 1/4 turn to assure proper measurement. Only water (distilled, if possible) should be used in the manometers; however a small amount of colored dye may be used to enhance the visibility of the fluid column.

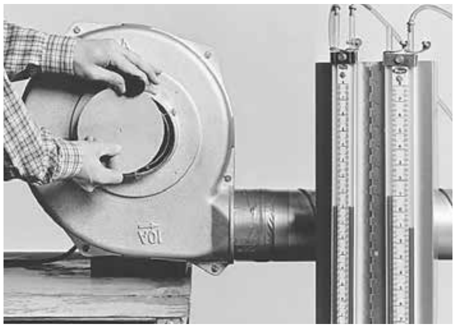
Step 8 — Connect one side of one manometer to the tubing installed in **Step 6b**. The other side of this manometer should be left open to the atmosphere. This will be manometer "P," as shown in **Figure 3.**

Figure 3



Step 9 — Using additional plastic tubing, connect either side of the other manometer to tap A, and the other side of this manometer to tap B on the orifice tube. This manometer, identified as "Q" in **Figure 3**, will measure the differential pressure across the orifice plate. Check the manometer's water level again and adjust it to zero, if necessary.

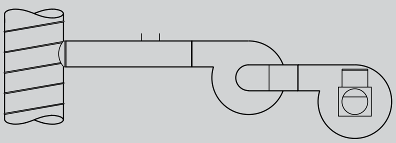
Step 10 — If your fan is not equipped with a variable inlet damper, you will need a square of heavy cardboard or other suitable material to cover the fan inlet. The inlet (or discharge, for negative pressure testing) should be completely covered before the fan is started.



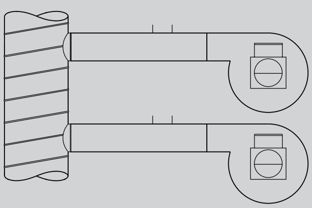
Q P

Step 11

Figure 4



Increases Static Pressure



Increases cfm

Step 11 — Start the fan on low speed and gradually open the inlet by adjusting the damper or shifting the cardboard. Carefully observe the system's static pressure (manometer P) and slowly increase the fan inlet opening until the desired test pressure is reached, or until the inlet is completely exposed. But be careful not to blow out the manometer fluid. IMPORTANT: The pressure indicated by a U-tube manometer is **the difference in the height** of the water columns. **This is usually double the reading on the manometer scale.** Note that manometer P depicted in **Step 11** indicates a static pressure of **2 inches wg**.

Step 12 — When the specified test pressure is reached, secure the inlet damper in position and allow the fan to run for at least one minute to make sure that the system pressure indicated on manometer P remains stable. If the inlet damper has been completely opened and the pressure has not yet reached the desired system test pressure, close the damper and switch the fan to a higher speed (small fan only). Repeat **Steps 11-12**. If still unable to reach test pressure at the maximum fan speed, refer to the "Troubleshooting" section.

Step 13 — When the system pressure reading is steady, the air entering the system is exactly balancing the air escaping from the system. A measurement of the air flowing through the orifice and into the system will indicate the air leakage out of the system. This airflow can be determined from the pressure drop across the orifice, as read on manometer Q.

Step 14 — The leakage rate in cubic feet per minute (cfm) can be determined from the orifice tube calibration table. A sample calibration table is shown in **Figure 2**. Locate the pressure drop across the orifice in the table (as indicated on manometer Q), and note the corresponding leakage rate. This is the air leakage in cubic feet per minute of the system under test. Each McGill AirFlow calibration table also has a unique equation which allows calculation of cfm, given the orifice pressure drop as indicated on manometer Q. **Note:** in **Figure 2** the equation for orifice tube number 5091-5 is 142.326 (orifice pressure drop) $^{0.4903}$.

Step 15 — If the leakage is in excess of the engineer's specifications (see "Suggested Leakage Specifications"), you will have to locate sources of leakage and attempt to eliminate them. For some helpful suggestions, please refer to the "Troubleshooting" section. Sources of leakage may be located by using a McGill AirFlow Leak Detective Test Cart with the optional smoke delivery system.

Step 16 — Two or more Leak Detective fan components can be operated simultaneously when the individual Leak Detective fan component has a lower capacity than is required to successfully test the duct system (see **Figure 4**). **Series** operation of two or more fans supplying a single orifice tube **will boost the maximum static pressure** that can be achieved. The use of **parallel** Leak Detective components (multiple fans and orifice tubes) **will boost the maximum volume** and therefore increase the measurable air leakage rate (at a given duct system static pressure). The air exiting each orifice tube is fed into the test section, either through individual taps or through a manifold. All fans need to be operated simultaneously to prevent airflow "short-circuiting" back through inoperative units. It is best to damper the parallel fans so each is delivering approximately the same airflow. After the duct system is pressurized to the required test pressure, the total amount of air leaking out of the duct section is the **sum** of the cfm measured through all orifice tubes.

Troubleshooting

Here are some typical problems encountered when leak testing duct systems, and some suggested solutions to these problems.

A. Erratic or unresponsive behavior of the system pressure manometer

This is probably a problem with the manometer itself. Check to make sure that one end of the manometer is open to the atmosphere, the other end is securely connected to the tubing leading to the duct system pressure tap, and there are no cuts or slits in the tubing. Also, make sure that the U-tube and connecting tubing are clean and not partially blocked with dirt, oil, etc. The internal parts of the adjustable valves located on the end of the manometer's U-tube should be inspected for debris or malfunctions. To assure proper operation and measurement, the adjustable valves must be open. To open the valves, turn the valve's tubing adapter counterclockwise 1/4 to 1/2 revolution.

B. Constant buildup of system pressure

In very tight systems, the fan inlet damper occasionally admits more air than can leak out of the duct. If this happens the pressure will increase. Close the inlet damper on the fan until the pressure stabilizes, or if the inlet damper is completely closed, make sure there is a tight seal against the fan inlet. If the situation continues and you are testing a small portion of the system, you may want to test a larger section. The increased leakage should allow you to stabilize the system pressure.

C. Not possible to build up desired test pressure with fan inlet damper wide open

This is probably the most common problem encountered in leakage testing. It indicates excessive system leakage, or at least a leakage rate higher than the volume capacity of the Leak Detective test component. However, before you begin hunting for leaks, check the following:

1. Are all openings in the test section tightly sealed? Be especially wary of any temporary end cap or blankoff installed strictly for the leakage test. Generally duct tape by itself will not give a tight enough closure. Also, remember that large blankoff sections exposed to even moderate test pressures can become lethal if they blow off during testing.
2. Are the Leak Detective test components properly connected and tightly sealed?
3. Is the anticipated leakage of the section under test well within the volume capability of the Leak Detective test component?
   If you try to test an installation of duct so large that its **allowable** leakage is beyond the capacity of the Leak Detective test components, it is possible that leakage is within acceptable limits but the fan can't supply the total leakage cfm. For example, a 50,000 cfm system with a 1 percent (of total volume) allowable leakage specification could leak 500 cfm. If the Leak Detective test components has an effective delivery of 100 cfm, they cannot possibly pressurize the entire system. The solution is to obtain a larger fan, use multiple fans in parallel (add cfm), or segment the system into multiple sections, each of which should have a leakage rate **less than** the fan cfm at the required test pressure (see "Suggested Leakage Specifications").
4. For 4-inch Leak Detective test components, check the fan nozzle and make sure it is only 4 to 5 inches long. If it is too long, it may be constricting the flow. You may have to cut the nozzle to shorten its length.
5. Make sure you are reading the difference between the two manometer fluid levels, **not** the height of either leg from "zero." See **Step 11**.
6. If none of the above items apply, then you must begin checking the system for leaks. Here are some hints you may find helpful:
   a. Major leaks can generally be felt and/or heard. Leakage locations should be marked in a highly visible manner. After all leakage points have been marked, the fan should be turned off and **temporary** repairs made (usually duct tape will suffice for this). It should be noted that leakage points cannot generally be found from the ground. Ladders and/or movable scaffolding must be used to get close to the installed duct and fittings. Retest to see if you can meet specifications, and if so, use a quality duct sealant product to make permanent repairs at the leakage points. A final test should be made after the permanent repairs are completed, but remember to wait approximately 48 hours, or until all sealant has cured.
   b. Suspect any system component of being a source of excess leakage. Fire dampers, smoke dampers, and access doors are notorious leakers. Although leaks from these components may be hard to hear or feel, significant amounts of air can leak from the total roll-formed seam length and contribute large amounts of leakage when pressurized.
   c. Check all joints to make sure they are assembled properly and that the joint is completely sealed with a quality duct sealer. Be sure to check the areas you can't see easily since they probably were difficult to reach.
   d. If you still can't locate the leakage source, try to identify the general area by breaking the system into smaller sections and testing them. A smoke machine delivering non-toxic smoke is an especially useful way to locate major leakage sources. McGill AirFlow offers a smoke delivery system using FDA approved smoke fluid.
   e. Soap bubble testing is **not recommended** for HVAC duct systems. People become unduly alarmed at the presence of small soap bubbles and waste a lot of time and money sealing areas that are not major leakage sources.

D. No reading of pressure drop across the orifice

This indicates that there is no airflow through the orifice tube and probably means you have forgotten to open the fan inlet damper. On rare occasions, it could also mean that the system is so tight that there is essentially no leakage. If you open the inlet damper slightly and observe no pressure drop across the orifice, be sure to watch the **system pressure manometer** and do not allow the system pressure to exceed the specified test pressure. When the inlet damper is fully open for the 4-inch Leak Detective test component, it could quickly pressurize a tight system to upwards of 15 inches wg. One other reason may be that the manometer parts are not open or the plastic tubing is not attached between the orifice tube and manometer.

E. Water is blown out of the manometer

This happens occasionally, indicating that you have applied too much pressure by opening the fan damper too suddenly. Refill the manometer, zero the scale, and start again.

F. Manometer fluid is frozen

Since the manometer fluid is water, it must be kept above freezing. Do not add anything to the water to depress its freezing temperature, as this will affect the density and therefore affect your readings. If this is a problem, you must warm up the area where the testing is being done so that the water will not freeze. Also, adding the water immediately prior to running the test will probably keep it from freezing until you have made your readings.

Table 1 Allowable Leakage Rates

Type of System	Minimum Test Pressure[5]	Maximum Allowable Leakage
Fractional horsepower fan system; fan coils, small exhaust/supply fans	0.50-inch wg	2%
Small systems; split DX systems — usually under 2,000 cfm	1-inch wg	2%
VAV and CAV boxes and associated downstream duct[1]	1-inch wg	2%
Single-zone, multi-zone, low pressure VAV and CAV systems[2], return ducts, and exhaust duct systems	2-inch wg	2%
All constant volume ducts in chases and concealed spaces, main return ducts on VAV and CAV systems, main ducts on exhaust or supply systems	3-inch wg	1%
Supply ducts for VAV and CAV systems	4-inch wg[3]	1%
High-pressure induction system	6-inch wg[4]	0.5%

Notes
1. It is assumed that the box damper is on the inlet side of the box. If the box damper is on the outlet side of the box, then the box should be included in the upstream leakage testing. Series boxes should not be included in the test since they operate at neutral pressure.
2. When low-pressure VAV and CAV systems are used, the total allowable leakage should not exceed 2 percent, including the box and downstream ductwork. The box and downstream ductwork should be tested at the lower 1-inch wg static. This is the minimum for most systems currently used in today's design practices.
3. It is recommended that the pressure rating of the duct be equal to the fan shut-off pressure if the possibility of fan shut-off exists either in the VAV systems or in systems with smoke/fire damper control. In a VAV system, the pressure may be selected at the intersection of the minimum box total cfm and the maximum fan RPM.
4. Large induction systems may have higher-pressure requirements, i.e. 10-inch wg.
5. Test pressure should not exceed the pressure rating of the duct.

Suggested Leakage Specifications

McGill AirFlow maintains that lower allowable leakage rate specifications, as related to HVAC duct system designs, are essential in meeting the demand for lower energy costs. McGill AirFlow recommends designers of HVAC duct systems incorporate the American Air Balance Council's (AABC) *2002 National Standards for Total System Balance* — "Duct Leakage Testing" (refer to Chapter 35) for allowable leakage rates (refer to **Table 1**) in obtaining LEED qualified and sustainable energy efficiency. McGill AirFlow further recommends specifying that the entire system, which includes all ductwork and system components (VAV boxes, fire/smoke dampers, etc.), be leak tested at the maximum system operating pressure in order to ensure conformance to the lower allowable leakage rate specifications. Under no circumstances should systems be pressurized above the maximum design operating pressure.

The entire installation or any part of it shall be subject to inspection and leakage testing by an independent agency (not affiliated with the installing contractor).

The scope and timing of leakage testing shall be determined by the engineer, and this information may be withheld until testing begins. For bidding purposes, it should be assumed that the entire system will be tested.

Partial disassembly and sealing of segments of the system may be necessary for compliance with test requirements.

Procedures for conducting a leakage test shall be in accordance with McGill AirFlow's publication, **System Pressure Testing for Leaks.**

Equipment for conducting leakage tests shall be the Leak Detective test component, cart, or Leak Detective Test Station as manufactured by McGill AirFlow, or an approved equivalent product. Leakage from non-duct components (fire dampers, smoke dampers, volume control boxes, etc.) is an integral part of overall system leakage, and these components shall be included in the duct leakage tests. Manufacturers of these components shall be responsible for any remedial efforts directed at their products in order to bring the system or section into compliance with leakage specifications.

The inspecting agency shall provide the engineer with a report on the leakage test(s). This report shall give an accurate description of the test procedure and results, including recommendations for any remedial action that is needed.

Remedial action is indicated if the system or any portion of it fails to meet the criteria set forth either by the surface area method or when tested in accordance with other provisions of this section.

Copies of certified calibration data for leakage test apparatus shall be provided as part of the test report.

McGill AirFlow LLC

An enterprise of United McGill Corporation —
Family owned and operated since 1951

One Mission Park
Groveport, OH 43125-1149
614/829-1200, Fax: 614/829-1291
E-mail: marketing@mcgillairflow.com
Web site: mcgillairflow.com

Form No.: SPT Rev. 16 5/14