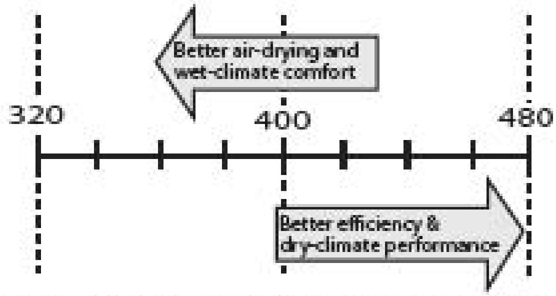
3.6 MEASURING AND EVALUATING SYSTEM AIRFLOW

Cooling efficiency is more dependent on airflow than heating efficiency. Also, refrigerant charge and airflow are interdependent and are best checked during the cooling season.

The correct airflow for a heat pump or air conditioner is usually expressed in cubic feet per minute per ton of cooling capacity (one ton equals 12,000 Btus per hour). When the heat pump or air conditioner is operating in the cooling mode, the acceptable airflow rate is 400 cfm ±20%, according to most manufacturers.

In dry climates, you may increase performance and efficiency by increasing airflow to 480 cfm per ton if noise and comfort allow. In wet climates, the recommended airflow per ton may be somewhat less than 400 cfm per ton to facilitate dehumidification by keeping the coil cooler and air moving slower across the coil.



Airflow and climate: More airflow per ton provides better efficiency and performance for dry climates, and less airflow provides better dehumidification for wet climates.

Airflow is often measured both before duct-sealing and after because duct-sealing may change the measured airflow. Tighter ducts may be more restrictive because duct leaks provide pressure relief through additional inlet and outlet area, which is lost when they are sealed.

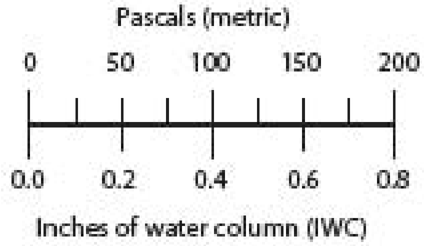
Technicians use a number of different airflow measuring techniques, depending on their equipment, training, and preferences. The type of air handler and ducts is also a factor when choosing an airflow-measuring method.

The most accurate and reliable methods for measuring system airflow are the duct-blower method and the flow-plate method. Measuring return airflow with a flow hood is also a fairly accurate and reliable method if the flow hood is properly calibrated and used according to manufacturer's instructions.

There are also a couple of airflow indicators, which are measurements of static pressure and temperature change across the indoor coil. These measurements won't give an accurate measurement of airflow, but they are used to detect inadequate airflow.

Airflow and blower speed

A blower in the air handler can have as many as five speeds. The first step in measuring airflow by any of the methods described here is to make sure that the blower is operating at one of the higher speeds, normally reserved for cooling. (Heating typically uses a lower speed.) Sometimes cooling is assigned a lower blower speed by mistake, so checking which blower speed is paired with cooling is a necessary preparatory step to airflow testing. If the blower speed isn't obvious when looking at the air-handler terminal block, clamp an ammeter around the color of wire corresponding to one of the higher speeds, in order to determine which blower speed is energized while cooling. It isn't necessary to operate the compressor and condenser fan in order to measure airflow.



Pressure in two measurement systems: Technicians and engineers use both Pascals (metric) and inches of water column (American) to measure duct pressures.

Preparing to measure airflow

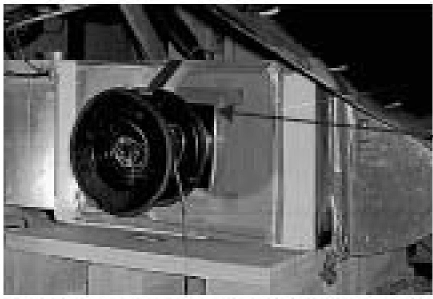
The idea behind the following preparatory steps is to solve any obvious large problems. We really don't need sophisticated test instruments to discover that filters, indoor coils, or blowers are packed with dirt or that the branch duct to the master bedroom is disconnected. Finding these problems before measuring duct airflow will speed up the commissioning process. The following steps precede airflow measurements.

1. Ask the customer about comfort problems and temperature differences in various parts of the home.
2. Based on the customers comments, look for disconnected or restricted ducts.
3. Inspect the filter(s), blower, and indoor coil for dirt. Clean them if necessary. If the indoor coil isn't easily visible, a dirty blower is a fair indicator that the coil may also be dirty.
4. From the nameplate, note the cooling capacity in tons. Tons = Btu/hour ÷ 12,000. The ideal airflow is around 400 cfm per ton.
5. Notice moisture problems like mold and mildew. Moisture sources, like a wet crawl space, can overpower air conditioners by introducing more moisture into the air than the air conditioner can remove.

Duct-blower airflow measurement

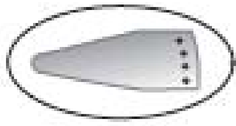
The duct blower is a fan mounted in an aerodynamic housing and equipped with a precise pressure-sampling tube. The duct blower is the most accurate airflow-measuring device currently available.

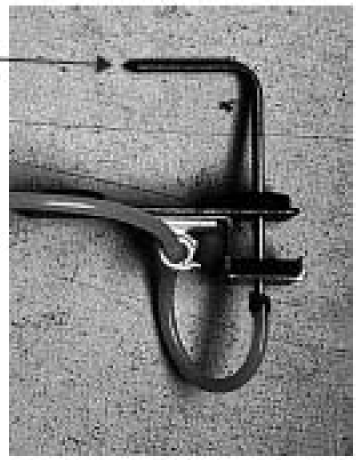
During this airflow test, all return air is routed through the duct blower where the airflow can be measured. The return air traveling through the duct blower is moved by the air handler's blower aided by the duct blower.



Main return is disconnected and the air handler is sealed.

Duct blower mounted to air handler: The best way to measure airflow with a duct blower is to connect the duct blower to the air handler and seal the main return.





Static pressure probe: Tiny holes near the tip sense static pressure from airflow perpendicular to the holes.

1. Set up a static pressure gauge to measure the duct pressure in the supply plenum, or a few feet away from the supply plenum, in a main supply. Tape the static pressure probe to hold it in place. The point of the probe should face into the oncoming airflow with the probe's static-pressure openings perpendicular to the airflow direction.
2. Make sure all supply registers and return grills are open. Leave filters installed.
3. Turn on the system and measure static pressure from the probe installed in Step 1.

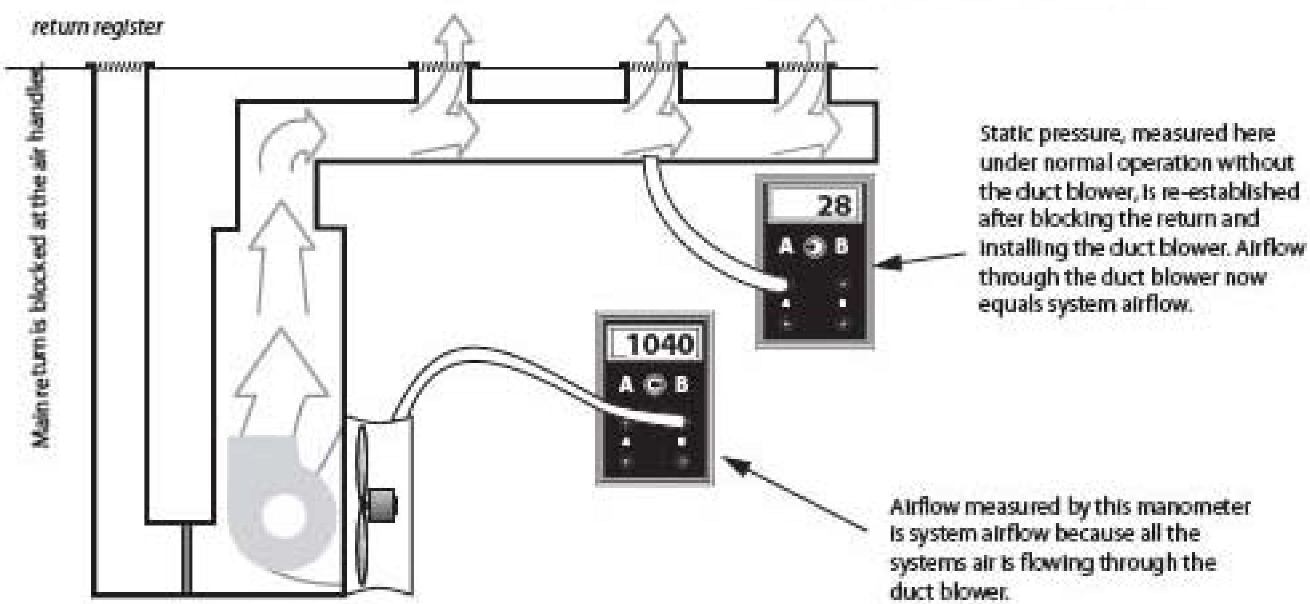
4. Shut off power to the air handler. Connect the duct blower to blow into the air handler at the blower compartment or the single return register, using one of the two options outlined below.

- **For single- or multiple-return systems:** The preferred method of connecting the duct blower is to block the return plenum's main return entry to the air handler. Filters are often installed in a good location to achieve this temporary blockage. Alternatively, you can support the main return and move it temporarily out of your way, while you seal the opening to the air handler with cardboard and tape. Then connect the duct blower to the blower compartment after removing the door.
- **Option for single-return systems:** Remove the grill at the single return register. Connect the duct blower through its flexible tube or else directly to the register, using cardboard to block off the excess area of the register. (Note: If there is significant return leakage, airflow measurement will be artificially high.)

Duct blower mounted to main return: With a single return, it's convenient to attach the duct blower to the single main return register. However, this option may result in an artificially high airflow reading.

All the return air should now come through the duct blower. If the duct blower is connected to an air handler, located outside the conditioned space, the door or access panel between the conditioned space and the air handler location must be opened. Now you are ready to measure system airflow.

1. Turn on the air-handler fan once again, making sure the air-handler fan is running at the correct speed for cooling.
2. Turn on the duct blower to blow into the air handler, increasing airflow until the manometer measuring supply-plenum static pressure reads the same as your original static-pressure measurement.



3. Measure and record the airflow through the duct blower. Refer to the duct-blower instruction book, if necessary, to insure that you know how to take the reading. The airflow reading you take directly from the digital manometer or look up in the manufacturer's table for converting pressure to flow is total system airflow in cubic feet per minute (CFM).

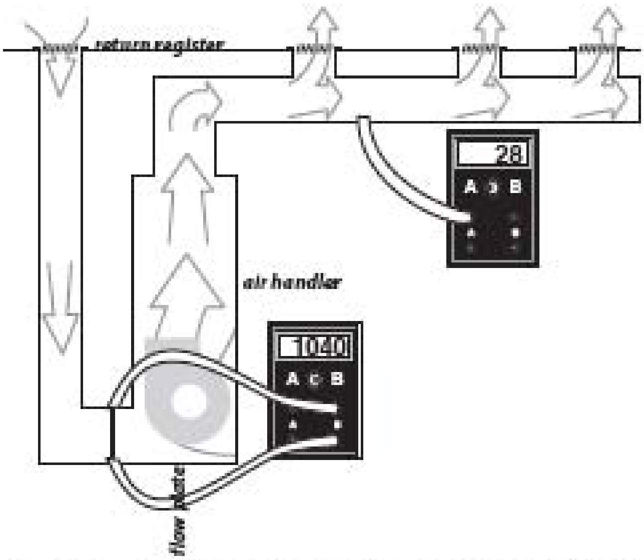
Flow-plate airflow measurement

The TrueFlow* air-handler flow meter, manufactured by The Energy Conservatory of Minneapolis, is relatively fast and easy to use. This flow meter is a plate with holes and sampling tubes that samples and averages velocity pressures and converts them into an airflow measurement.

One of two flow plates are inserted and sealed at their edges in the filter slot or bracket within the air handler. Then, the static-pressure drop across the flow plate is measured and airflow is found on printed tables supplied by the manufacturer or automatically by the digital manometer.

When used according to the manufacturer's instructions, which are summarized below, the accuracy of this method is better than the other tests described on these pages, with the exception of the duct-blower test. Refer to the manufacturer's instructions for the precise testing method. A summary follows.

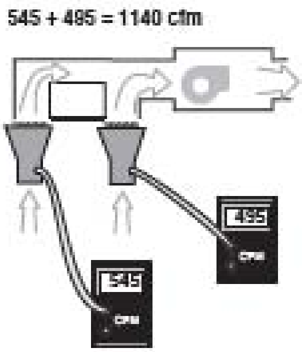
1. Measure and record the normal system operating pressure, with a standard filter in place, using a static pressure probe in the supply plenum or supply duct near the air handler.
2. Replace the existing filter with the flow plate. Seal the flow plate into the slot, according to the manufacturer's recommendations.
3. Measure and record the system's operating pressure with the flow plate in place, at the same location as when the filter was in place.
4. Measure the flow through the TrueFlow Meter using the digital manometer supplied by the manufacturer. Obtain flow from the numerical table or the digital manometer itself.
5. Calculate a correction factor from the measured operating pressures (using a correction table) and multiply by the measured flow to get the original flow rate, moving through the air handler when the first measurement was taken.



True Flow* Meter: The True Flow* flow plate installs in a filter slot and measures system airflow almost as accurately as the duct blower.

Flow hood airflow measurement

This test measures the fairly laminar airflow at return registers. Measuring supply-register airflow isn't as accurate as measuring return airflow because supply air is more turbulent and because floor supply registers close to walls don't allow the flow hood to be centered over them. The flow-hood inlet must be larger than the return grills, although 10 percent of the register may be blocked with tape to allow the flow hood to cover that reduced opening.



Measuring return air with a flow hood: This method provides an estimate of system airflow. It can significantly underestimate airflow because return duct leakage bypasses the measurement.

This test works best on systems with one to four return grills located in areas where a flow hood can cover the grills and be centered over them. Keep in mind that the return airflow will appear low if the return ducts are very leaky. A low reading may mean that the system is drawing some of its return air from a crawl space, attic, or attached garage.

1. Turn on the air handler to run at the higher fan speed, normally used for cooling.
2. Center the flow hood over the return register, covering it completely. If the register is larger than the flow hood, seal up to 10 percent of the register with tape before covering it.
3. Read and record the airflows through the return registers. Add the measured airflows of the return registers together to get the total system airflow.

Measuring total external static pressure

Total exterior static pressure (TESP), created by the duct system, gives a rough indicator of whether airflow is adequate. TESP is the sum of the absolute values of the supply and return static pressures. The supply and return static pressures by themselves can indicate whether the supply or return or both are restricted. The greater the TESP, the lower the airflow.

The TESP test can estimate airflow if the manufacturer's table for static pressure versus airflow is available. The ducts, registers, and a coil mounted in the ducts (if present) create the system's resistance measured by static pressure in inches of water column (IWC) or pascals. The return static is negative and the supply static is positive. The positive or negative signs are disregarded when adding supply static and return static to get TESP.

1. Attach two static pressure probes to tubes leading to the ports of the manometer. For analog manometers, attach the high-side port to the probe inserted downstream of the coil or air handler.
2. Take the readings on each side of the air handler to obtain both supply and return static pressures separately. Disregard positive or negative signs given by a digital manometer when performing addition.
3. Consult manufacturer's literature for a table, relating static pressure difference to airflow for the blower or air handler. Find airflow for the static pressure measured above.

Air handlers deliver their airflow at a TESPs ranging from 0.30 IWC (50 Pascals) and 1.0 IWC (250 Pascals) as found in the field. Manufacturers maximum recommended static pressure is usually a maximum 0.50 IWC for standard air handlers. TESPs greater than 0.50 IWC indicate the possibility of poor airflow in standard residential forced-air systems.

The popularity of pleated filters, electrostatic filters, electronic air cleaners, and high-static high-efficiency evaporator coils, prompted manufacturers to introduce premium air handlers that can deliver adequate airflow at TESP of greater than 0.50 IWC. Premium residential air handlers can provide adequate airflow with TESP up to 0.90 IWC. TESPs greater than 1.00 IWC indicate the possibility of poor airflow in these premium residential forced-air systems.

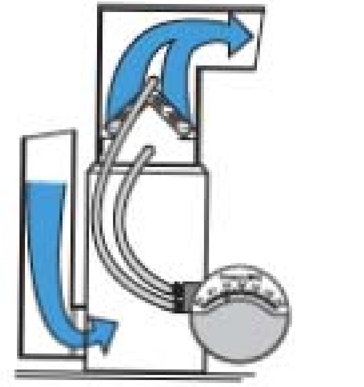
Total external static pressure (TESP): The positive and negative pressures created by the resistance of the supply and return ducts produces TESP. The measurement shown here simply adds the two static pressures without regard for their signs. As TESP increases, airflow decreases. Numbers shown here are for example only.

Table 3.6.1: Total external static pressure versus system airflow

TESP (IWC)	0.3	0.4	0.5	0.6	0.7	0.8
CFM	995	945	895	840	760	670

Static-pressure drop across coil or filter

Measuring static pressure drop across a coil or filter can give a fair estimate of airflow when the filter or coil is new. Manufacturers often provide a table showing airflow through the filter or coil under different static pressures. Static pressure can vary widely from point to point within the measurement area, especially when ducts take an abrupt change of direction near the air handler. Access to both sides of the coil for testing static pressure can be difficult. Drilling test holes requires care and planning to avoid damaging the indoor coil if it is located in a duct.



Static pressure drop across coil: The more static pressure applied to a new clean coil, the greater the airflow will be through it. Manufacturers often provide data for both dry and wet coils. Numbers shown here for example only.

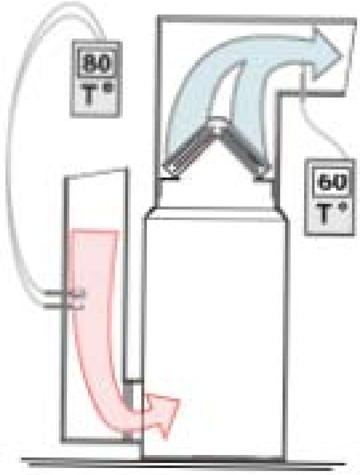
Table 3.6.1: Static-pressure drop versus airflow through coil

S.P.	.23	.27	.31	.36	.41
CFM	1000	1100	1200	1300	1400

Carrier® temperature-split method

Carrier Corporation uses dry-bulb supply temperature as an indicator of whether airflow is adequate. This method requires measuring the return-air wet-bulb and dry-bulb temperatures. From these temperatures, the recommended dry-bulb temperature is determined from a slide rule provided by Carrier. If the measured dry-bulb temperature is lower than the listed value, the airflow is probably too low. If the temperature is higher than the listed value, the airflow is probably higher than 400 cfm per ton, which is usually no problem.

For recommendations on improving duct-system airflow, see *Section 3.6.*



Carrier temperature-split method: First measure return wet-bulb and dry-bulb temperature. Check the chart below for the suggest supply dry-bulb temperature. Then measure the actual dry-bulb supply temperature. If the measured temperature is lower than suggested, the airflow is too low.