



Digital Minneapolis Blower Door™

Model 5 (M5)

Operation Manual – V1.0



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Safety Information

Read all safety information carefully before operating the Model 5 Digital Blower Door. Failure to follow these instructions may result in injury, equipment damage, or inaccurate test results.

Electrical Safety

- Connect the Blower Door fan only to a properly installed, grounded AC power outlet compatible with the fan's voltage rating.
- Insert the power plug firmly into both the fan receptacle and the wall outlet. A loose connection can cause the plug or receptacle to overheat.
- Do not use ungrounded outlets or adapter plugs. Never remove or modify the grounding prong.
- Do not operate the fan if the motor or any electrical connections are wet.
- In an emergency, disconnect the power cord from the wall outlet immediately. Always use the nearest accessible outlet and keep the area around it clear.
- Disconnect the power cord from the fan before inspecting or servicing the fan.

Battery Safety (Integral Battery Option)

- If the M5 fan is equipped with the optional internal battery. If you observe smoke, unusual heat, or flames from the battery, immediately carry the unit outside and away from flammable materials. Do not attempt to extinguish a lithium battery fire with water.
- Do not store or charge the battery in extreme temperatures. Battery charge range is from 32° to 122° F (0° to 50° C)
- Contact The Energy Conservatory if the battery shows signs of damage or swelling.

Fan Operation Safety

- Carefully inspect the fan before each use. If the housing, guards, blades, or cords are damaged, do not operate the fan until qualified repairs have been made.
- Keep people and objects away from the fan inlet and exhaust when the fan is operating.
- Do not expose fan to direct rain fall.
- If you notice unusual noise or vibration during operation, stop the fan immediately. If you cannot identify the cause, contact The Energy Conservatory before continuing.
- The fan motor is thermally protected. If the motor shuts down due to overheating, turn the fan OFF before the motor cools — this prevents an unexpected automatic restart.
- Wear hearing protection when working near the fan at high speed for extended periods.

Combustion Safety During Testing

⚠ WARNING: Depressurizing a building with combustion appliances operating can cause flame rollout from burners and dangerously elevated CO levels. Always disable combustion appliances before beginning a depressurization test.

- Adjust all combustion appliances (furnaces, water heaters, gas fireplaces) so they cannot turn on during the test.
- If attached spaces (e.g., townhouses) contain vented combustion appliances, disable those appliances or ensure those spaces are not depressurized during the test.
- Ensure all fires in fireplaces and woodstoves are completely extinguished before testing. Tape fireplace doors shut or cover ashes with damp newspaper to prevent ash from being pulled into the building.
- If combustion safety problems are discovered, immediately notify building occupants and owners. Do not perform air sealing work until existing combustion safety problems are resolved.
- The presence of elevated carbon monoxide (CO) in building air or combustion gases is a potentially life-threatening condition requiring immediate action.

CHAPTER 1

CH 1: Introduction

What Is a Blower Door?

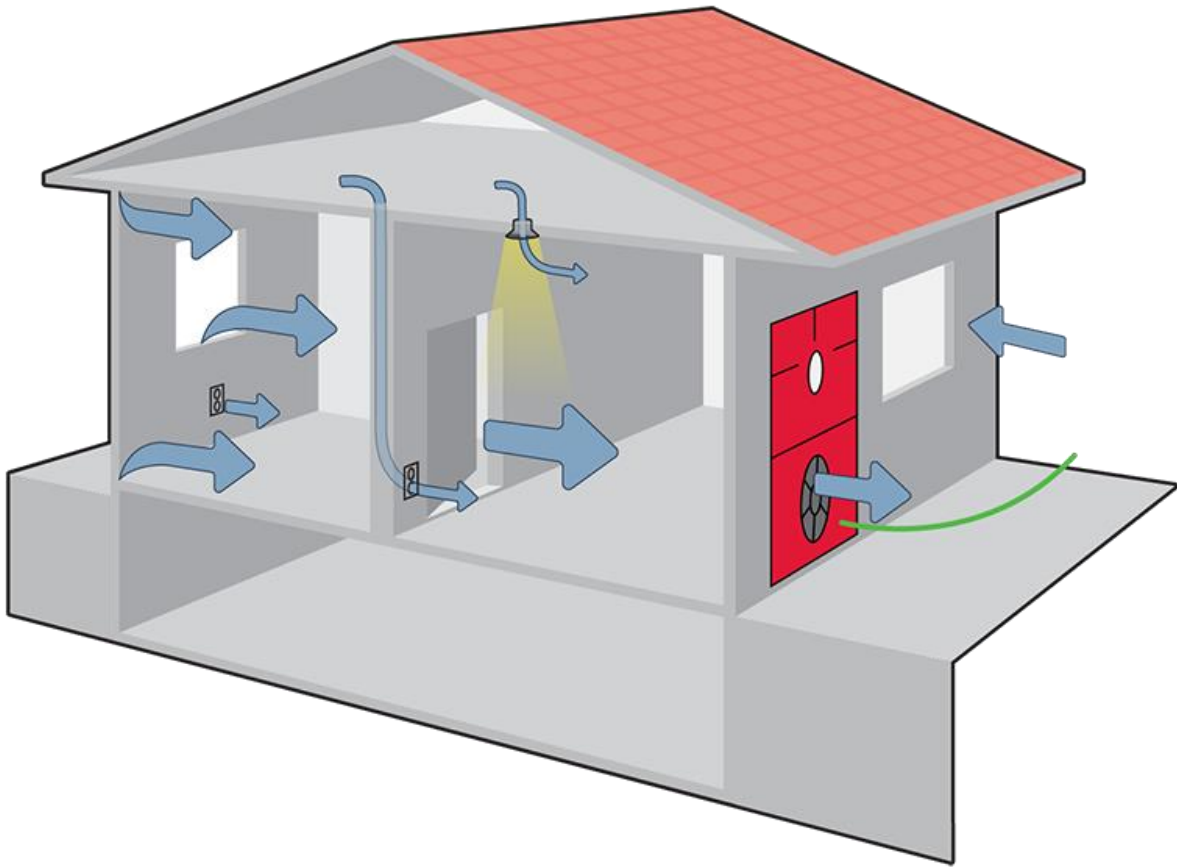
The Model 5 Digital Minneapolis Blower Door™ is a powerful, calibrated diagnostic instrument used to measure the airtightness of buildings. When used in conjunction with other diagnostic tools it can help locate air leakage sites, measure duct leakage to the outside and ventilation rates and investigate complex building comfort and performance issues. It consists of a calibrated fan temporarily sealed into an exterior doorway. The fan blows air out of the house to create a slight pressure difference between inside and outside — typically 50 Pascals (0.2 inches of water column). This pressure difference forces air through all penetrations in the building envelope simultaneously.

By measuring the airflow through the fan and the resulting change in building pressure, the Blower Door determines the total airtightness of the building envelope. A tighter building requires less airflow to reach the target pressure, which means fewer holes and less uncontrolled air leakage.

Blower Door tests are used to:

- Document the airtightness of new and existing buildings.
- Estimate natural air infiltration rates.
- Measure and document the effectiveness of air sealing work.
- Locate air leakage sites using smoke, an infrared camera, or touch.

A typical Blower Door setup and test takes approximately 20 minutes. Results can be used to assess ventilation needs, identify potential for combustion appliance back-drafting, and verify compliance with energy codes and green building programs. The results of a Blower Door test can be expressed in a variety of ways such as: CFM50, CFM50/Sq. Ft, ACH50, ELA/EQLA. Test Results are discussed in detail in Chapter 6.



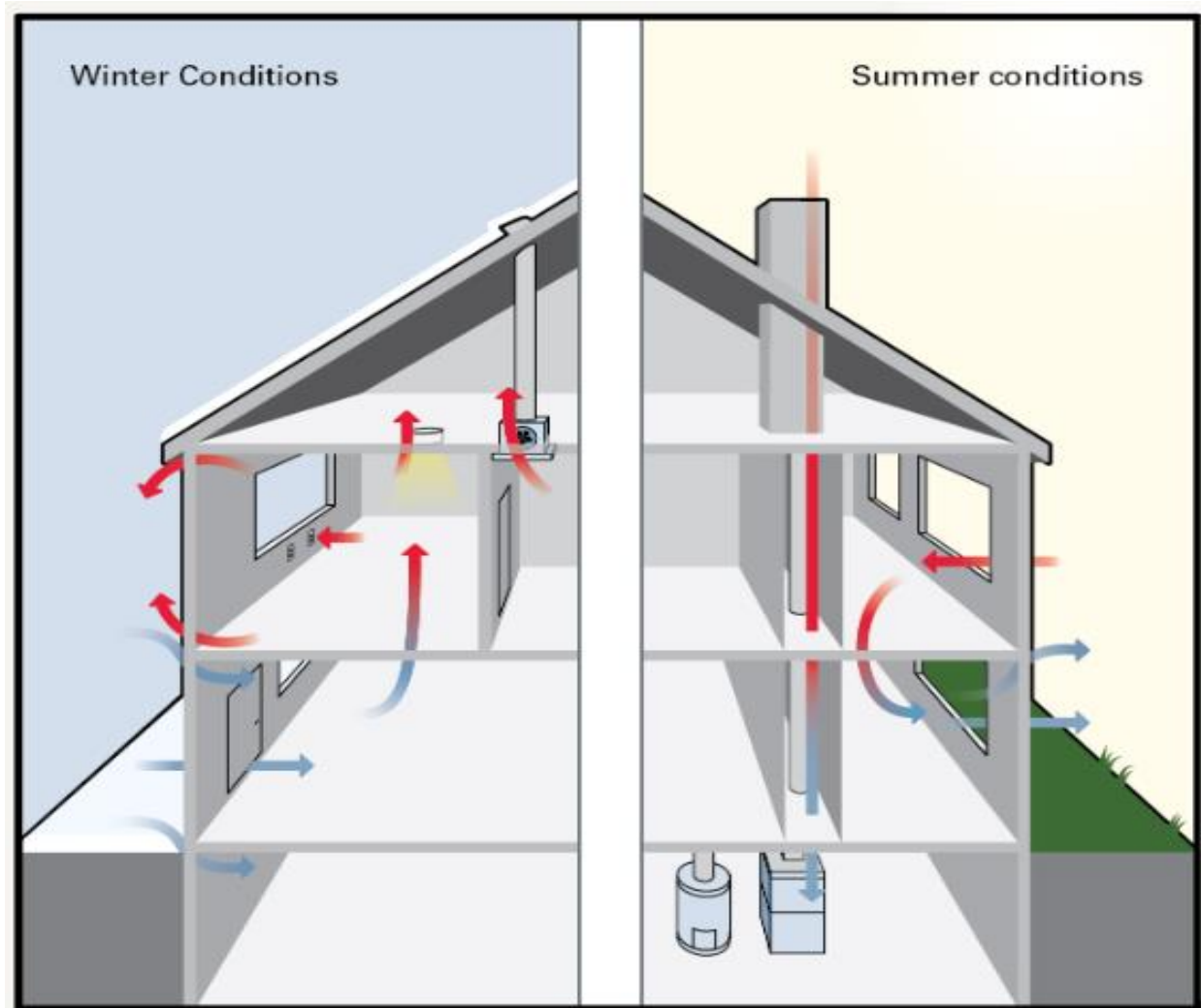
Air Leakage Basics

For air leakage to occur, two things must be present: a hole or crack in the building envelope, and a driving force to push air through it. Understanding what drives air leakage helps you use the Blower Door more effectively to diagnose performance and comfort issues and make better air sealing decisions.

There are five main causes of air leakage in buildings: Stack Effect, Wind Pressure, Point-Source Exhaust and Supply Devices, and Duct Leakage to Outside.

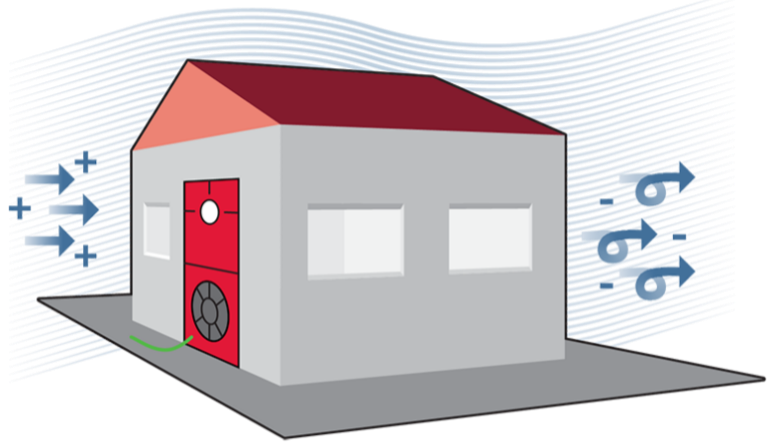
1. Stack Effect

Stack effect is the most common cause of air leakage. Warm air is buoyant and rises, escaping through holes near the top of the building. As warm air leaves, it is replaced by colder outside air entering at the bottom. In winter, this creates slight positive pressure at the top of the building and negative pressure at the bottom. Stack effect is strongest in cold weather and accounts for the largest share of air infiltration in most buildings. In summer, when outdoor air is warmer than indoor air, the process reverses.



2. Wind Pressure

Wind striking a building pushes outside air in on the windward side and pulls building air out on the leeward side. Wind-driven leakage varies with wind speed and direction, and is most significant in exposed, less-sheltered locations.

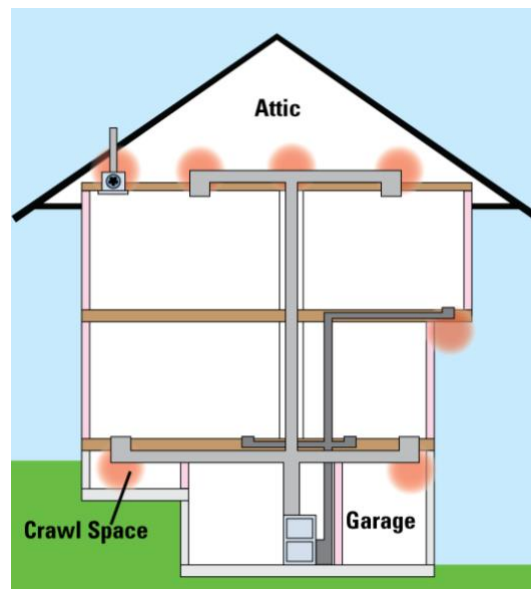


3. Point-Source Exhaust and Supply Devices

Exhaust devices — chimneys, kitchen range hoods, bath fans — push air out of the building, creating negative pressure that draws outside air in through holes and cracks. Supply devices deliver air into the building, which forces indoor air to leak out. These localized pressure imbalances can be significant when exhaust equipment is running.

4. Duct Leakage to the Outside

In forced-air duct systems, leaks to the outside create building pressure imbalances that increase air infiltration. Leaks in supply ducts cause negative building pressures; leaks in return ducts create positive pressures. Even small duct leaks can have a significant effect because of the high pressures found in duct systems during operation.



5. Door Closure Coupled with Forced Air Duct Systems:

Research has shown that in buildings with forced air duct systems imbalances between supply and return ducts can dramatically increase air leakage. For example, a study conducted in Florida showed that infiltration rates in many homes were doubled whenever the HVAC system fan was operating due to pressures caused by door closures. In the Florida houses closing a bedroom door created large duct imbalances by effectively cutting off the bedroom supply registers from the central return registers located in the main part of the house.

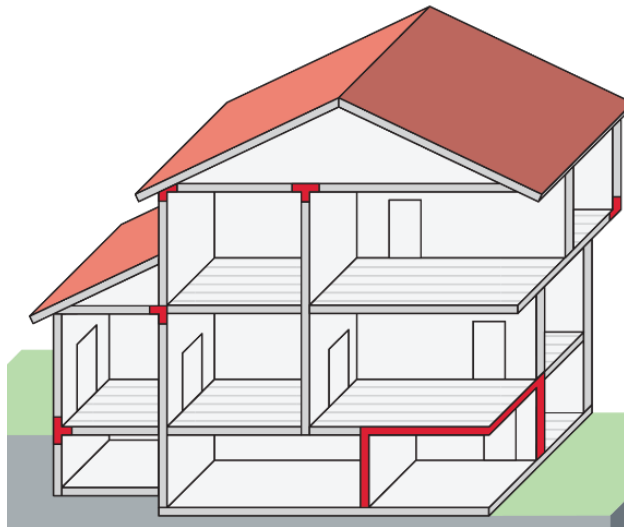
Common Air Leakage Sites

Air leakage sites occur through cracks and holes in the building envelope, via hidden construction details, and in forced-air duct systems.

Because warm air rises due to stack effect, the most important leakage sites are at the top of the building, where positive pressure is greatest and condensation risk is highest. Air sealing work typically begins at the top.

The bottom of the building is subject to the largest negative pressures, pulling cold air in through gaps in the lower level. Important: If natural-draft combustion appliances are present, do not seal lower-level leaks until attic and upper-level leaks have been addressed. Sealing only the bottom while large leaks remain at the top can create enough negative pressure to cause back-drafting of combustion appliances.

Hidden construction details — attached porches, cantilevered floors, overhangs — can also be major leakage paths. Densely blown cellulose or other barrier-type techniques at these junctions often produce dramatic reductions in air leakage.



Common air leakage locations include:

- Top plates of interior and exterior walls
- Electrical boxes and plumbing penetrations through the air barrier
- Attic hatches and pull-down stairs
- Knee walls and cantilever floors
- Attached garage and porch connections
- Duct connections, plenums, and filter access doors

CHAPTER 2

CH 2: System Components and Features

The Model 5 (M5) Digital Minneapolis Blower Door is a significant advancement over previous generation systems. The fan, speed controller, and pressure module are integrated into a single unit eliminating external tubing connections to the fan and reducing overall weight by approximately half compared to legacy systems. The M5 also has a ring detection system that allows the fan and connected devices to know which flow ring is installed on the fan to ensure accurate results.

Feature	Benefit
Less Weight	The M5 is approx. half the weight of a legacy system — easier to carry and set up.
Tubeless	An embedded Bluetooth flow sensor eliminates tubing between fan and gauge.
Cordless	The integrated speed controller means no external controller box - and the optional internal battery eliminates the need for a power cord.
Wireless	The M5 connects via Bluetooth to the DG-8, DG-1000 or to the TEC AutoTest app on your mobile device.
Ring Detection	The M5 detects which flow ring is installed, eliminating operator errors.
Precision Control	An absolute encoder knob provides both course and fine-tune speed adjustment.
Calibration Interval	6-year calibration interval with field-swappable digital pressure module.

M5 System Components

The complete Model 5 Digital Minneapolis Blower Door system consists of the following components:

1. Model 5 Digital Blower Door Fan

Includes an integrated fan speed controller with coarse and fine adjustment modes, a pressure module that allows the fan to measure its own flow rate, flow ring detection, and an optional internal battery.



2. Digital Gauge

The M5 can be purchased with either a 2-channel DG-1000 (Pressure & Flow) or a single channel DG-8 (pressure only). It can also be purchased without a gauge if you already have one of these TEC Bluetooth gauges. Both gauges can be connected to the fan via Bluetooth or USB-C to measure leakage.

The M5 fan is compatible with two TEC digital gauges:

Gauge	Description
DG-1000	• Full-featured Pressure & Flow gauge • Displays CFM50 directly on CH B, supports Bluetooth connection to M5, and runs automated cruise-control tests from the gauge. • Can connect to AutoTest App for automated testing and report generation.
DG-8	Pressure-only gauge. Displays building pressure but not fan flow directly on gauge. Connects to Model 5 automatically to support single point testing via M5 “Test from Fan” feature. Can also Bluetooth connect to AutoTest App along with M5 fan for automated testing and report generation.

3. Frame & Panel

Adjustable Aluminum Door Frame with lock and cam system and upper cross bar. Nylon Panel with opening for the M5 fan, two lower convenience taps for outside reference tube and a built-in zipper door for access through the panel when installed. Includes a secure mounting hook for easy fan installation.

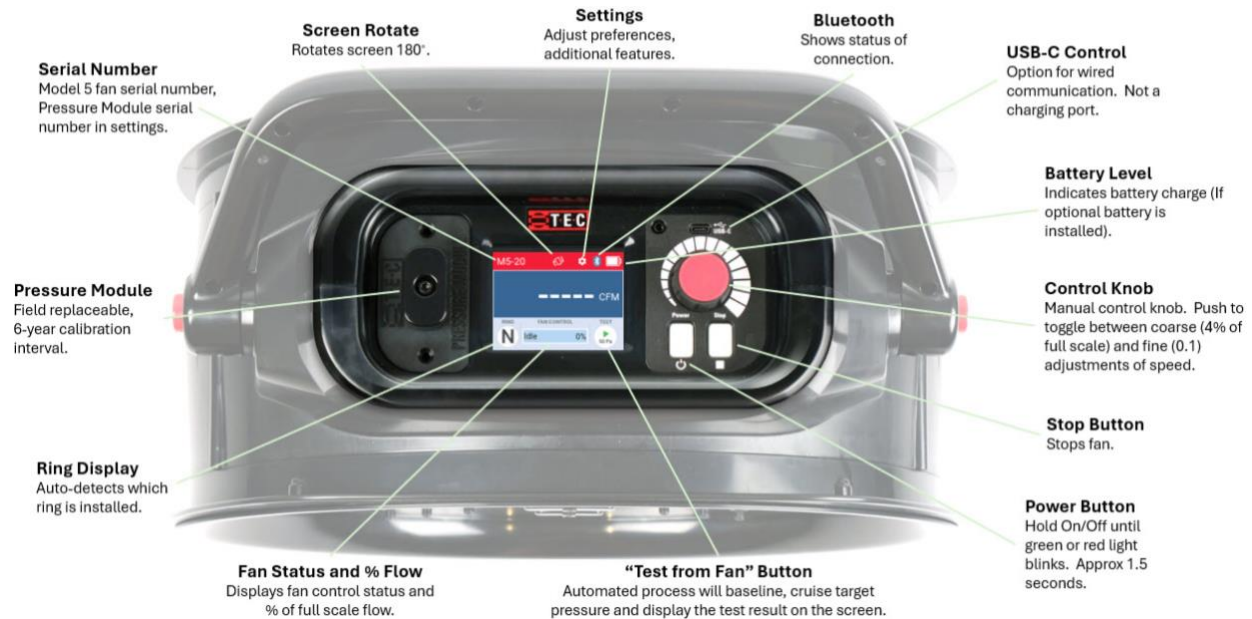


4. Accessory Bag

Includes a secure mounting hook for easy fan installation, power cord, USB data cable, Flow Rings A/B/C and No-Flow Plate and Wind-Tee.



Model 5 Fan Controls



Options for Running Tests Using the Model 5 Fan

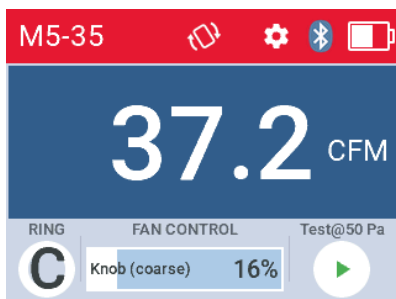
There are three main approaches to running a test with the Model 5 fan:

- “Test from Fan” – ideal for quick single point measurements.
- Connect to TEC Auto Test – ideal for multipoint tests and automatic report writing.
- Manual test using knob – ideal for quick checks. The details of these options are provided in chapter 5

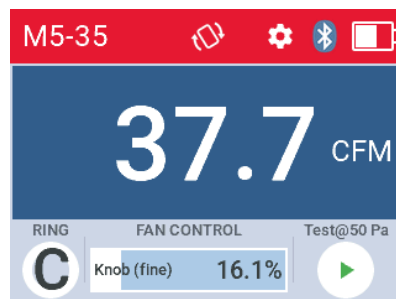
Control Knob Function

The M5 fan speed can be controlled by the encoder knob on the fan control panel. The knob can be used in two modes - coarse and fine. The mode is displayed on the screen and can be toggled between the two by pushing the knob down.

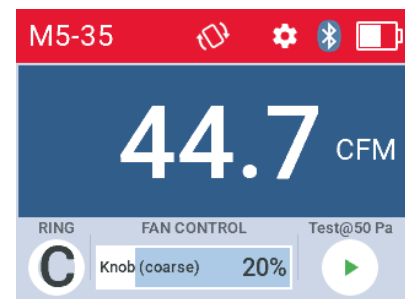
- Coarse mode — rapid speed changes (increments approx. 4% of full scale)
- Fine mode — precise adjustments (increments approx. 0.1% of full scale)



Fan set at 16% of flow with knob in coarse mode



Fan in fine adjustment mode turned up one increment (16.1%).



Fan in coarse adjustment mode turned up one increment (20%).

M5 Flow Rings

The M5 fan measures airflow accurately across a wide range using a set of calibrated Flow Rings that attach magnetically to the fan inlet. The standard kit includes Flow Rings A, B, and C. Optional Ring D extends the low-flow range for very tight buildings.



Flow Ring ranges at 50 Pa:

Configuration	Maximum Flow	Minimum Flow
Open Fan	3125	1415
Ring A	1602	415
Ring B	469	100
Ring C	139	22
Ring D (Optional)	26	2.4

Note: When taking measurements, stand at least 12 inches from the side of the fan inlet. Standing directly in front of the inlet may obstruct airflow and produce inaccurate readings.

CHAPTER 3

CH 3: Installing the Blower Door for Testing

Choosing the Installation Location

Select the installation doorway carefully — it affects both ease of setup and measurement accuracy.

- Install the Blower Door in an exterior doorway of a large, open room whenever possible.
- Avoid doorways where stairways or major obstructions are within 5 feet of the fan inlet — nearby obstructions can restrict airflow and affect accuracy.
- If the doorway leads to a porch or garage, open garage doors and windows to connect that space to the outside before testing.
- The door frame is almost always installed from the inside of the building. It may be installed in place of the primary door, the storm door, or anywhere between them.
- Open the interior door and the outside storm door as fully as possible during the test to prevent airflow restrictions.



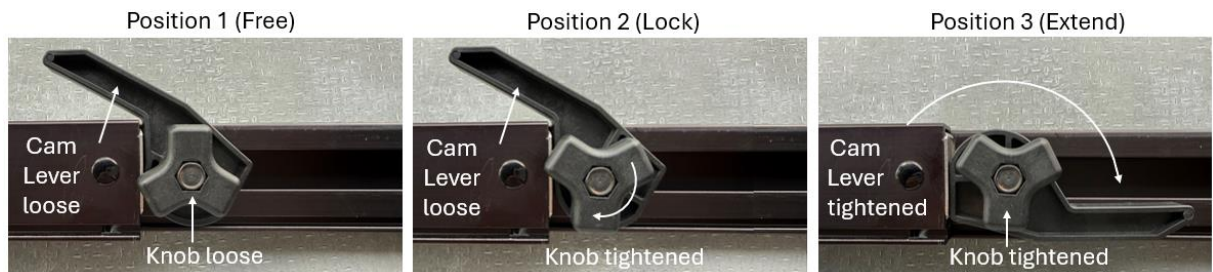
Assembling the Aluminum Door Frame

The door frame ships in six pieces stored in a cloth frame case.

1. Remove one long and one short exterior frame piece from the case.



2. Ensure all cam levers and knobs are in Position 1 (Free).

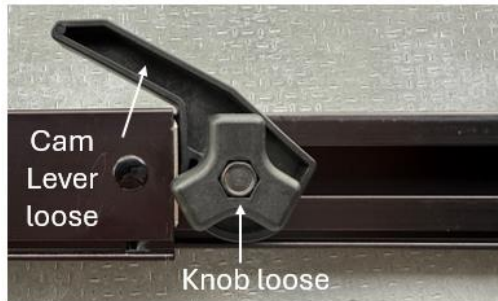


3. Snap the two pieces together by sliding one end of the short piece over the corner block on the long piece. Press the button on the corner block as you slide — the bullet will snap into the hole on the short piece.
4. Assemble all four sides in this manner. Keep all cam levers on the same side of the frame.

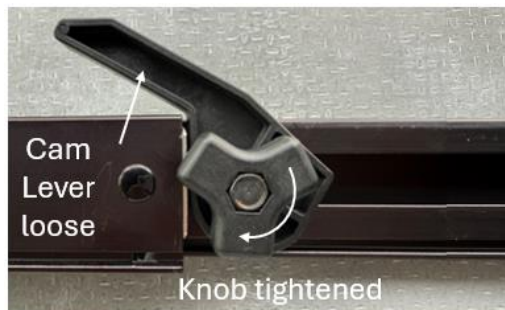


Fitting the Frame in the Door Opening

1. Fit the assembled frame in the door opening with all cam levers and knobs in Position 1 (Free). The weatherstripping should touch the door jamb sides but remain easily removable.



2. Extend the frame to the correct height, hand tighten the cam lever knob clockwise on the vertical frame piece to Position 2 (Lock). The knob should be snug but not over tightened.



3. Extend the frame horizontally to fill the door opening. With your foot hold the lower frame piece in the corner and press the remaining vertical frame piece up to make a tight fit and then turn the remaining levers to Position 2 (Lock).
4. Remove the extended frame from the opening and lean it against a wall.



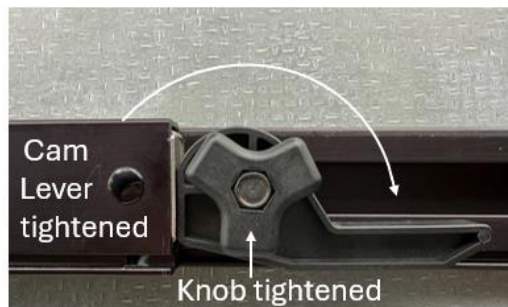
Attaching the Nylon Panel

1. Remove the nylon panel from the accessory case. Lay it on the floor or drape the top edge over the top frame piece.
2. Use the long Velcro strip at the top of the panel to hold the panel over the top frame piece.
3. Use the two Velcro tabs at the bottom of the panel to secure the panel around the bottom frame piece. Readjust the top Velcro strip to remove slack.
4. Pull both sides of the panel tightly around the frame and secure it with the four side Velcro tabs. The frame and panel should be taut with no wrinkles.

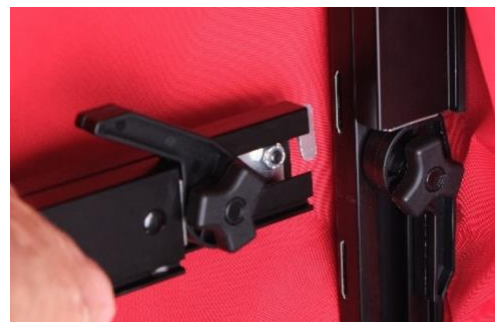


Securing the Frame in the Door Opening

1. Lift the assembled frame and panel and insert it into the doorway, pressing it firmly against the doorstop.
2. If needed readjust the panel by releasing the top Velcro strips and four side Velcro tabs to pull the panel tight.
3. Move all cam levers to Position 3 (Extend) to lock the frame tightly against the door jamb.



4. With the lower cross bar in Position 1 insert the silver clip into the second from the bottom slot in the vertical frame and extend it and secure it on the other vertical frame piece. Then turn the knob to lock it and turn the cam lever to extend it. Repeat the process for the upper cross bar using any slots on the top half of the vertical frame pieces.



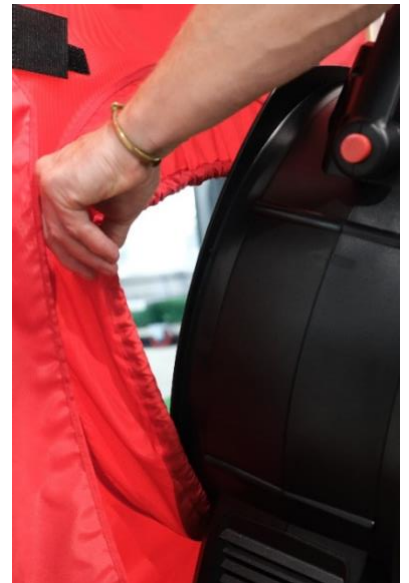
Installing the Outside Building Pressure Tubing

Run one end of the Green tubing through one of the patches at the bottom corner of the nylon panel to the outside. The outside end must be placed away from the fan exhaust stream. When using an M5 fan, no tubing is connected to the fan, so the gauge can be moved to the most convenient location to get an envelope measurement. On a windy day, this would be the leeward side of the building.



Installing the M5 Fan in the Panel

1. Clip the fan mounting bracket to the center of the lower cross bar.
2. With the Flow Rings installed on the fan, align the fan with the hole in the nylon panel. The exhaust side of the fan faces toward the panel (and outward) for depressurization, inward for pressurization.
3. Tip the fan forward with one hand and stretch the elastic panel collar over the exhaust flange. The collar should sit snugly between the exterior flange and the M5 panel.
4. Lift the fan so the Blower Door handle rests inside the mounting bracket.
5. Alternatively, you can secure the fan to the lower cross bar with the Velcro strap in place of the mounting bracket.



Fan mounted with handle in the carrying position



Handle clicked into the screen view position

Tubing Connections for Running Tests

The M5 system has a built-in flow measurement and does not require a tubing connection to the fan.

The building envelope pressure is measured with a DG-8 or channel A of a DG-1000 by running a tube, which crosses the envelope to connect the outside, to the reference port on the DG-8 or CH A of the DG-1000. The tubing can be run through the fan panel, or any location where it is convenient and the wind will have minimal impact on the envelope pressure reading.



DG-1000 Manometer

Connection Point	Purpose
Channel A	Building Pressure: Green tubing connects through panel to reference outdoor pressure or to input for indoor pressure.
Channel B	M5 Fan Flow: Fan connected via Bluetooth. Displays fan flow (CFM50). No tubing required.

DG-8 Manometer

Connection Point	Purpose
+ / - taps	Building Pressure: Green tubing connects through panel to reference outdoor pressure or to input the indoor pressure.
Fan Flow	M5 Fan Flow: Displayed in TEC AutoTest app via Bluetooth — not shown on the DG-8 gauge directly.

Electrical Connection

Insert the female plug from the power cord firmly into the receptacle on the bottom of the M5 fan. Plug the other end into a compatible AC outlet.

⚡ CAUTION: Push the plug completely into the receptacle. An incomplete connection causes the plug or receptacle to overheat and may damage the equipment.

CHAPTER 4

CH 4: Setting Up the Building for Testing

After installing the Blower Door, prepare the building before starting the airtightness test. The preparation steps below apply when the test purpose is to assess retrofit air sealing potential, weatherization effectiveness, or to estimate natural infiltration rates.

i NOTE: The setup procedures in this chapter are recommended by The Energy Conservatory and generally conform to ASTM E779-10 and CGSB-149.10-M86. However, if you need to meet a specific code or rating standard (e.g., RESNET-380, EN 13829), obtain the applicable standard and follow its specific setup requirements.

Adjustable Openings

- Close all storm and prime windows.
- Close all exterior doors and interior attic or crawlspace hatches connected to conditioned spaces. Close exterior crawlspace hatches and vents if they are normally closed most of the year.
- Open all interior doors to conditioned rooms. The goal is to treat the entire building as one conditioned space so that all leaks are subjected to the same pressure. Basements that are conditioned should be included.
- Tape plastic over window air conditioners if they appear to be air leakage sources and are typically removed for part of the year.

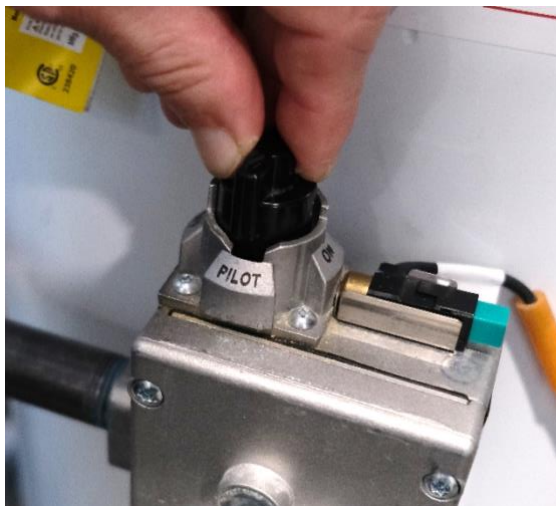




Combustion Appliances and Exhaust Devices

⚠ WARNING: If combustion appliances turn on during a depressurization test, flames can be drawn out of the combustion air inlet (flame rollout) a serious fire hazard that can also cause dangerously elevated CO levels.

- Disable all combustion appliances so they cannot turn on during the test. Common methods: turn off the power to the appliance or set it to the Pilot setting.



- If attached spaces (e.g., connected townhouse units) contain vented combustion appliances, disable those appliances or ensure the attached spaces are not depressurized during the test.

- Ensure all fires in fireplaces and woodstoves are completely extinguished. Tape fireplace doors shut, clean out ashes, or cover ashes with damp newspaper.
- Turn off all exhaust fans, clothes dryers, attic fans, ventilation system fans, and air handler fans.



Testing New Construction

For Blower Door tests are being performed to document compliance with building energy codes, follow the building setup requirements of the applicable code. The 2012 International Energy Conservation Code (IECC), for example, specifies the following:

- Exterior windows, doors, fireplace and stove doors — closed but not sealed beyond their intended weatherstripping.
- Dampers (exhaust, intake, makeup air, backdraft, and flue) closed but not sealed beyond intended infiltration control measures.
- Interior doors, if installed — open.
- Exterior doors for continuous ventilation systems and heat recovery ventilators — closed and sealed.
- Heating and cooling systems, if installed — turned off.
- Supply and return registers, if installed — fully open.

i NOTE: If you are testing under a different standard (e.g., RESNET, ENERGY STAR, PHIUS), obtain a copy of that standard and follow its specific setup requirements. The Energy Conservatory's set-up recommendations may differ from those standards in some respects.

CHAPTER 5

CH 5: Conducting an Envelope Airtightness Test

The following instructions assume the Blower Door system and building have been set up as described in Chapters 3 and 4. This chapter covers selecting the test procedure and how to complete the two most common tests - an automated single point test (via M5 fan screen) and an automated multipoint test (via TEC AutoTest App). Additional test procedures are provided in the Appendix.

Choosing a Test Procedure

Single-point or Multi-point Test

Test Type	Description
Single-point Test	A single measurement of building leakage at 50 Pa. Fast and straightforward. Appropriate when a quick airtightness measurement is needed. Does not require a smartphone or tablet.
Multi-point Test	Building leakage is measured at 5 to 10 different pressures between approximately 10 and 60 Pascals. Improves the reliability of the test by making it easy to detect changes in the building during the test, such as temporary seals that come loose. It also permits calculation of the pressure exponent, which may help diagnosis of leaks, and provides better averaging in windy conditions. Requires TEC AutoTest app for calculations and to create a report.

Pressurization and/or Depressurization Test

Blower Door airtightness tests are most often performed with the building depressurized — the fan exhausting air out. Under certain conditions, however, it is necessary or preferable to pressurize the building instead. Common reasons to pressurize include:

- Known pollutants (mold, contaminants) might be drawn into building during depressurization.
- The test protocol requires both depressurization & pressurization results to be averaged

Pressurization tests produce results that are similar to depressurization tests, but usually slightly higher due to backdraft dampers being pushed open by the pressure.

Test Type	Description
Depressurization	Place the M5 fan with the inlet (the side with the rings) inside the building to exhaust air to the outside. This will depressurize the building with reference to outside. You will use the DG-8 or DG-1000 Channel A to monitor the building pressure with respect to (WRT) the outside.
Pressurization	Place the M5 fan with the inlet (the side with the rings) outside the building to push air into the building. This will pressurize the building with reference to outside. You will use the DG-8 or DG-1000 CHA to monitor the building pressure with respect to (WRT) the outside.

Selecting the Flow Ring to Start the Test

Independent of what test procedure you are following, as you start the test, you will need to decide what ring you will start with. If you are unsure which ring to start with:

- For large or older homes: start with Open Fan
- For newer homes built to modern airtightness codes: start with Ring A
- For very tight homes (passive house level or similar): consider Ring B or C

Note that the M5 automatically detects the installed ring size, and if your initial selection is not correct, it will quickly detect it and guide you to put on a smaller or larger ring and re-start the test.

Testing Options Summary

The table below summarizes what testing capabilities are available with the Model 5 fan, depending on your gauge and whether you use TEC AutoTest.

Testing Option	Standards	How to test	Equipment Required
Single Point Test (CFM50) Often used in Weatherization, Builders	NA	M5 “Test from Fan”	M5, DG8 or DG1000
Single-point test Often used by Raters, Code Compliance	RESNET380	TEC AutoTest App	M5, DG8 or DG1000
Multi-point test Often used by Raters, Code Compliance	RESNET380, ISO 9972, ASTM E779, others	TEC AutoTest App (creates shareable PDF report)	M5, DG8 or DG1000, Auto Test App on mobile device

Automated Single Point Test from Model 5 Screen – “Test from Fan”

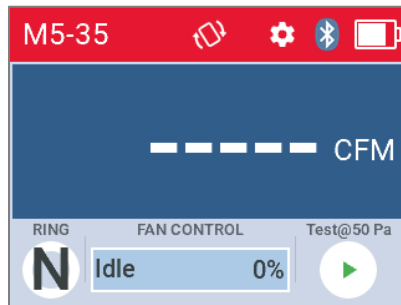
The M5 fan comes with a unique feature designed to produce an accurate, quick single point test result.

This automated process will complete the following four steps:

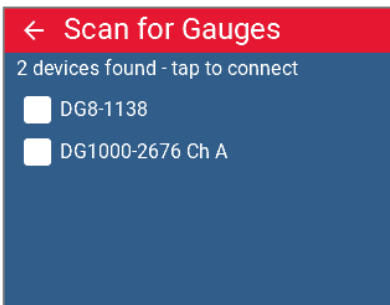
1. Capture baseline
2. Run test by cruising to target pressure*
3. Take a time averaged flow measurement
4. Display test results.

*If target pressure cannot be reached, fan will calculate CFM@50 using “can’t reach 50 factor starting at 10 Pascals of envelope pressure.

Model 5 Blower Door screen flow for “Test from Fan”



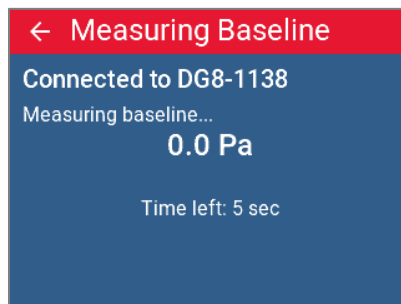
Press the play button on the Model 5 (M5) screen



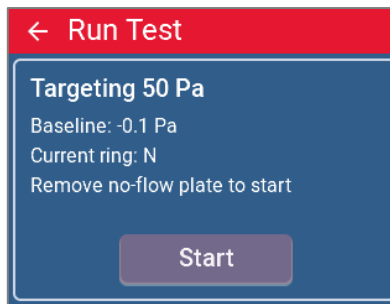
Select from list of available TEC gauges. Note: Future tests auto-connect to last gauge selected.



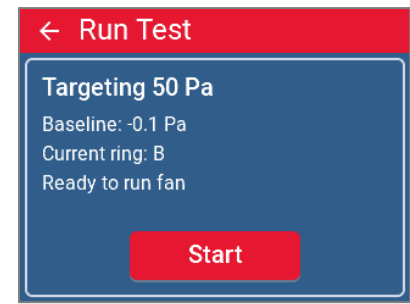
N ring (No Flow) installed. Press Start to take baseline.



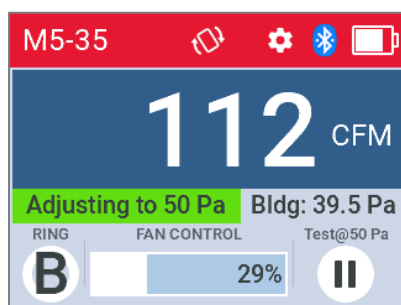
10 second baseline envelope pressure is measured and stored



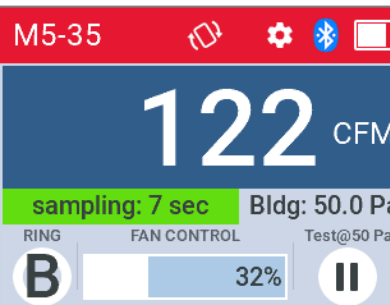
Fan displays baseline. Start not enabled when N (No Flow Plate) is installed.



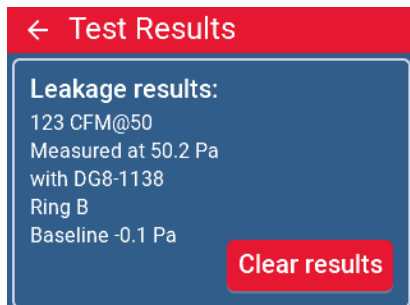
Start button is enabled when a different ring is detected



The M5 cruises 50Pa, displays flow & building (bldg.) pressure as it increases fan speed



Once 50Pa is achieved, the fan completes a 10 second sample of the cfm50 (Q50).



Completed test results are held so picture can be taken. Displays results, and details of system.

i NOTE: If 50Pa cannot be reached with the installed ring, the M5 will guide you to the next largest ring. If the M5 cannot achieve 50Pa in open fan it will provide a calculated cfm50/Q50 from the highest building pressure achieve and include that in the displayed results.

Automated Multi-point Test Using M5 with TEC AutoTest App

Multi-point testing is the recommended method when natural infiltration estimates, or high-accuracy, high reliability air tightness documentation are required.

Depending on your region, the requirements for multi-point tests are outlined by local authorities and typically reference either ASTM, RESNET, or ISO Standards. In some cases, these standards are referenced, but with modifications. You should confirm this by looking up the requirements for the region where you are testing.

With that said, many standards require or prefer multipoint tests. It is common to test five to eight target pressures between 60 Pa and 10 Pa. At each pressure, readings are allowed to stabilize and then the average building leakage is recorded. This can be done manually, but TEC AutoTest automates this process with data collection, curve fitting, and report generation for multi-point tests.

i NOTE: During an automated multi-point test, AutoTest collects hundreds of simultaneous measurements of building pressure and fan flow. This reduces the influence of wind fluctuations on test accuracy and makes it much easier to detect if something changes in the building during the test.

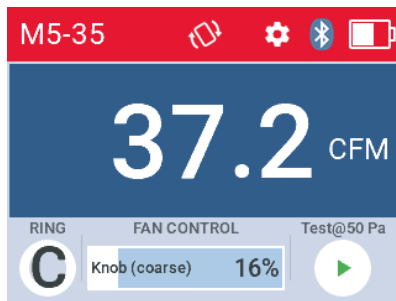
TEC AutoTest (iOS and Android) provides automated multi-point testing, real-time data collection, and report generation. It works with both the DG-1000 and DG-8 gauges.

i NOTE: Auto Test automatically corrects for air density, calculates leakage areas, estimates natural infiltration rates, and generates formatted reports — making it the recommended workflow for code compliance Blower Door tests.

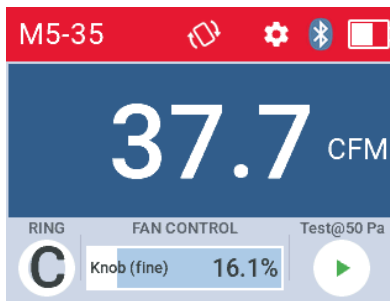
Manual Control Knob for Setting Fan Speed

The M5 fan speed can be controlled using the speed control knob on the fan control panel. The knob can be used in two modes - coarse and fine. The mode is displayed on the screen and can be toggled between the two by pushing the knob down.

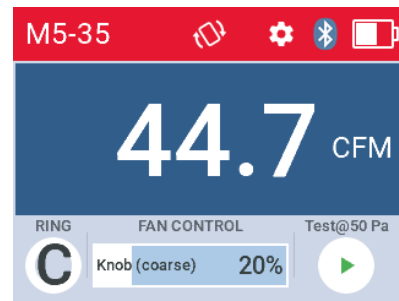
- Coarse mode — rapid speed changes (increments approx. 4% of full scale)
- Fine mode — precise adjustments (increments approx. 0.1% of full scale)



Fan set at 16% of flow with knob in coarse mode



Fan in fine adjustment mode turned up one increment (16.1%).



Fan in coarse adjustment mode turned up one increment (20%).

Manual control is appropriate for simple one-point tests. Note that manual testing does not provide automated baseline, control to a cruise pressure or pressure and flow averaging. For more accurate results, use “Test from Fan” on the screen from the M5 or cruise control via the DG-1000, TEC AutoTest.

Can't Reach 50 Pa — One-Point Tests on Leaky Buildings

If the building is too leaky to reach 50 Pa with Open Fan, the fan will calculate the estimated CFM50 from a single reading at a lower pressure using Can't Reach 50 (CRF) factors. The Smart Fan will begin providing the calculated CFM50 once the building pressure reaches 10 Pa. This is an approximation — accuracy is lower than a standard 50 Pa test. The lower the pressure you get, the more uncertainty.

Testing in Windy Conditions

In strong or gusty winds, building pressure readings can fluctuate significantly — 10 Pa to 20 Pa swings are common.

Under these conditions:

- Ensure your envelope measurement is being made in the quietest location. This is generally on the leeward side of the building, in the middle of the wall with the tap at ground level, next to the foundation. Using a wind tee also provides a small benefit.
- Use the time-averaging function to stabilize readings.
- Run an automated multi-point test with AutoTest, which includes the Wind Assistant feature to monitor baseline fluctuations and extend periods of record (POR's) to reduce the impact of wind-related variability.



Before Leaving the Building

Before leaving the site, confirm the following:

- Return the thermostat and water heater temperature controls to their original settings.
- Check that all pilot lights (furnace, water heater, gas fireplace) are lit. Re-light any that were extinguished during the test.
- Remove all temporary seals from fireplaces, woodstoves, and other openings sealed during the test.

Alternative Test Approaches in Appendix B

- Run single point test with DG-1000: for step-by-step guidance on how to run a test from a DG-1000 with the Model 5 fan, see appendix B.
- Running a single point test with TEC AutoTest
- Running a single point test with the TEC Gauge app.

CHAPTER 6

CH 6: Basic Envelope Airtightness Test Results

After completing a Blower Door airtightness test, the result is the fan flow required to maintain a specific building pressure — most commonly 50 Pascals. This chapter explains how to interpret and present those results, how to normalize them for building size, and how air density corrections improve accuracy. For more comprehensive analysis including multi-point curve fitting, leakage area calculations, and natural infiltration estimates, use TEC Auto Test.

Basic Airtightness Test Results

Airtightness results are expressed in several standard formats:

- Volumetric air flow
 - Fan flow needed to create 50 Pa pressure difference from baseline
 - CFM50 — cubic feet per minute needed to create 50Pa
 - n_{50} — cubic meters per hour M3/hr needed to create 50Pa
- Volumetric air flow per area of envelope
 - Fan flow needed to create 50 Pa pressure difference per area of envelope
 - CFM50/Sq Ft - cubic feet per minute of fan flow needed to create 50 Pa of pressure difference divided by the area of the envelope
- ACH50 — air changes per hour at 50 Pa
 - Fan flow needed to create 50 Pa pressure difference per volume of building
 - $ACH50 = CFM50 \times 60 / \text{Building Volume (ft}^3\text{)} = \text{Air changes per hour at 50 Pa}$
 - $ACH50 = M3/hr / \text{Building Volume (m}^3\text{)} = \text{Air changes per hour at 50 Pa}$
- Equivalent area of leakage — EqLA or EfLA
 - These are an estimate of the total equivalent hole size in the building envelope at a reference pressure, also called Equivalent Leakage Area (EqLA) or Effective Leakage Area (ELA). See Chapter 6 for detailed calculation methods.

Airtightness test results can be expressed in several standardized formats. Each serves a different purpose.

CFM50 — Air Leakage at 50 Pascals

CFM50 is the airflow in cubic feet per minute that the Blower Door fan must supply to maintain a 50 Pascal pressure difference across the building envelope. 50 Pascals is roughly equivalent to the pressure created by a 20-mph wind blowing uniformly on all sides of the building simultaneously.

CFM50 is the most widely used single-number measure of building airtightness. When you conduct a one-point test at exactly 50 Pa, the fan flow reading is your CFM50 directly.

i NOTE: CFM50 can also be expressed as liters per second (L/s) or cubic meters per hour (m³/h) at 50 Pa. TEC Auto Test can display results in any of these units.

Percent Reduction in CFM50

Measuring CFM50 before and after air sealing work lets you quantify the improvement. This is one of the most direct ways to document the effectiveness of a weatherization project.

$$\% \text{ Reduction} = [(CFM50 \text{ before} - CFM50 \text{ after}) \div CFM50 \text{ before}] \times 100$$

Reductions of 40–50% are common in high-level weatherization programs working on very leaky houses. Document both the before and after results at the time of the test.

Normalizing Air Leakage for Building Size

A raw CFM50 number is hard to compare across buildings of different sizes. Normalizing the result for building size allows meaningful comparisons — between buildings, against program standards, or over time.

ACH50 — Air Changes per Hour at 50 Pascals

ACH50 expresses how many times per hour the total volume of conditioned air in the building would be replaced if the building were subjected continuously to a 50 Pa pressure difference. It is the most widely required metric in building energy codes and rating systems.

$$ACH50 = (CFM50 \times 60) \div \text{Building Volume (cubic feet)}$$

i NOTE: If the basement was included in the Blower Door test (interior door open), include the basement volume in your calculation.

Example of ACH50 requirements per IECC Code since 2009

Climate Zone	2009 IECC	2012 IECC	2015 IECC	2018 IECC	2021 IECC	2024 IECC
0 to 2	7	5	5	5	5	4
3 to 5	7	3	3	3	3	3
6 to 8	7	3	3	3	3	2.5
Requirement	Test or visual inspection	Blower Door Test Required	Blower Door Test Required	Blower Door Test Required	Blower Door Test Required	Blower Door Test Required*

* - Sampling allowed in Multifamily units with more than 8 units.

CFM50 per Square Foot of Envelope Area

This metric divides measured air leakage by the envelope area of the building and is generally seen as a better metric than ACH for comparing the airtightness of buildings that vary significantly in size. Envelope area typically includes the surface area of all 6 sides of the building.

$$\text{CFM50/ft}^2 = \text{CFM50} \div \text{envelope Area (square feet)}$$

Correction for Air Density

Fan flow measurements can be corrected for differences in air density caused by temperature differences between inside and outside. During a depressurization test, the Blower Door measures the air leaving through the fan — but what matters is the air flowing back in through the building's leaks. When inside and outside temperatures differ, these two flows differ due to air density. In extreme weather conditions, the difference can be as large as 10%.

i NOTE: TEC Auto Test automatically applies air density corrections. Manual corrections are only needed when calculating results by hand.

Additional Test Results (TEC AutoTest)

TEC AutoTest calculates additional results that require multi-point test data and mathematical modeling. These are summarized below.

Leakage Areas: EqLA and ELA

Leakage area estimates give a physical sense of the total "hole size" in the building envelope — useful for reporting, for comparing before-and-after results, and as inputs to infiltration models.

Metric	Definition
Equivalent Leakage Area (EqLA)	Defined by the Canadian National Research Council as the area of a sharp-edged orifice that would leak the same amount of air as the building at 10 Pa. Used in the AIM infiltration model (HOT2000). Typically, about twice as large as ELA.
Effective Leakage Area (ELA)	Developed by Lawrence Berkeley Laboratory. Defined as the area of a nozzle-shaped opening that leaks the same amount of air as the building at 4 Pa. Used in the LBL infiltration model.

★ **IMPORTANT:** EqLA is recommended for documenting physical changes in building airtightness (e.g., before and after air sealing). EqLA tracks closely with actual changes in hole size — for example, opening a 50 square-inch window increases EqLA by approximately 50 square inches.

Estimated Natural Infiltration Rates

The Blower Door measures leakage under controlled high-pressure conditions — not the actual infiltration occurring under real weather. AutoTest uses the ASHRAE Standard 136 procedure to estimate the average annual natural infiltration rate from the leakage area measurement. This estimate is used to evaluate indoor air quality and the need for mechanical ventilation.

⚡ **CAUTION:** Annual infiltration estimates are averages. Actual daily and seasonal rates vary dramatically with wind and temperature. For an individual house, estimates may vary by a factor of two compared to tracer gas measurements. Do not use these estimates for peak pollutant calculations or precise energy loss modeling.

Key assumptions in the ASHRAE 136 model:

- Leakage is distributed: $\frac{1}{4}$ in the ceiling, $\frac{1}{4}$ in the floor, $\frac{1}{2}$ in the walls.
- Leaks are uniformly distributed across each surface.
- The model is designed for detached single-family dwellings only.
- Duct leakage is not included — buildings with duct leakage will have higher actual infiltration rates than the model predicts.

Mechanical Ventilation Guideline

When airtightness improvements reduce natural infiltration below levels needed for acceptable indoor air quality, mechanical ventilation becomes necessary. Whole-building ventilation should be considered. In the US, the ventilation rate is based on ASHRAE Standard 62.2.

NOTE: ASHRAE 62.2 also includes requirements for local kitchen and bathroom exhaust. Consult the full standard for ventilation system design guidance and exceptions.

CHAPTER 7

CH 7: Finding Envelope Air Leaks

The Blower Door is most powerful as a diagnostic tool when combined with leak detection techniques. By pressurizing or depressurizing the building, you amplify air movement through every hole in the envelope simultaneously — making leaks much easier to find than under natural conditions.

Air leaks in buildings rarely follow a simple direct path to the outside. They often travel through wall cavities, attic bypasses, and other hidden construction details before exiting the envelope. The goal of air leak detection is to find where the leakage path crosses the exterior envelope — not necessarily where you can feel the draft inside.

Run the Blower Door at a building pressure of 20 Pa to 30 Pa (rather than 50 Pa) when searching for leaks with your hand. This pressure is more comfortable for extended scanning and still creates enough flow to locate significant leaks. Get in the habit of always using the same pressure so you develop a sense of what constitutes a large versus a small leak.

Using Your Hand

A simple and common leak detection method is to depressurize the building and walk the interior, feeling for airflow with your hand. The back of the hand is more sensitive to moving air than the palm.



An effective room-by-room technique: stand just outside a closed interior room and leave a one-inch gap at the door. A strong blast of air through the gap indicates significant leaks between that room and the outdoors. This lets you quickly triage which rooms warrant detailed scanning.

Focus on:

- Top plates of interior walls (accessible from the attic)
- Electrical outlets and switch plates on exterior walls
- Plumbing and wiring penetrations through the floor or ceiling
- Attic hatch frames and pull-down stair perimeters
- Recessed light fixtures in insulated ceilings
- Band joist areas in the basement

Using a Fog Puffer™



A handheld Fog Puffer (smoke generator) makes air movement visible, which is especially helpful in attics, crawlspaces, and other areas where you cannot feel airflow directly. With the building depressurized and the attic or crawlspace access door closed, direct small puffs of smoke toward suspected leak sites from within the attic or crawlspace. If smoke is drawn into the leak, it will disappear rapidly. A flexible extension tube attached to the puffer allows you to reach deep corners and tight spaces.

The Fog Puffer is also essential for finding duct leakage squirting smoke near supply and return registers while the building is pressurized quickly shows which registers are connected to significant outside duct leaks.

Using an Infrared Camera

Combining a Blower Door with an infrared (IR) camera is the most powerful leak detection technique available. The procedure involves two interior scans:

1. Take a baseline IR scan before turning on the Blower Door.
2. Allow the Blower Door to depressurize the building for 5 to 10 minutes.
3. Take a second IR scan. Areas where air is infiltrating will show a temperature change — cooler in winter (cold air entering), warmer in summer (warm air entering).



Cold air from an attic being drawn into a wall assembly by a blower door cooling down the wall near the top plate.

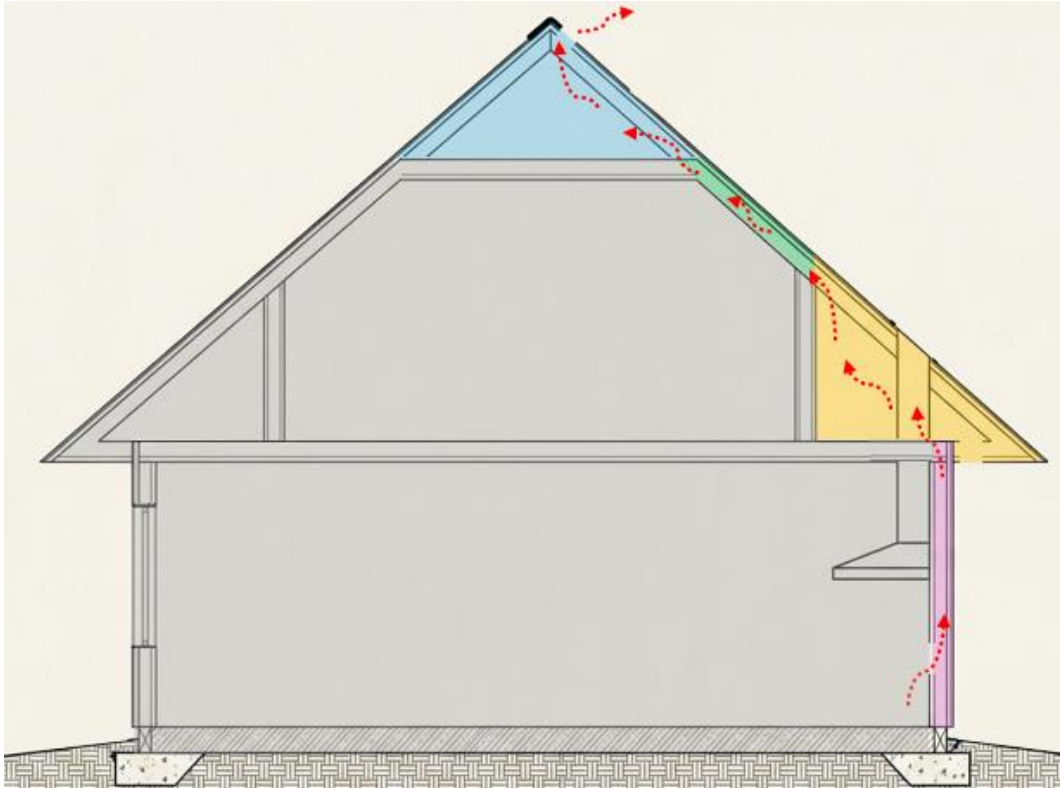
A temperature difference of as little as 5° to 10°F between inside and outside is sufficient to reveal significant leaks. Even when outdoor air temperature is similar to indoor temperature, solar-heated attic surfaces or ground-cooled crawlspaces can create enough of a gradient to expose important leakage paths.

Pressurizing the building and scanning from the outside is also effective — particularly useful for identifying leaks in the exterior cladding, window frames, and roof connections.

i NOTE: IR scanning with a Blower Door often reveals leaks without requiring physical access to attics or crawlspaces — saving significant time on complex buildings.

Diagnosing Series Leakage Paths

Many of the most important leaks in a building are not direct paths to the outside. Air often travels through intermediate unconditioned zones like attics, crawlspaces, garages, or wall cavities before exiting. These are called series leakage paths.



Air leaving the house first passes through the wall to a ceiling boundary, then through two attics to reach the roof boundary. Both boundaries must be leaky for infiltration to occur, but the relative resistance of each boundary determines how much air leakage occurs.

Zone Pressure Diagnostics (ZPD) is the standard method for quantifying series leakage (See Chapter 9). ZPD combines Blower Door results with pressure measurements taken in the zone being tested, both before and after creating a temporary opening in one surface of the zone. This lets you estimate how much of the measured building leakage is attributable to each zone boundary.

TEC offers a ZPD Calculation Utility — available free at www.energyconservatory.com — that implements the improved ZPD methodology published by the Energy Center of Wisconsin. The utility guides you through 7 calculation steps using data collected with any TEC digital pressure gauge.

Appendix A: Running a Multi-point Automated Test with TEC AutoTest

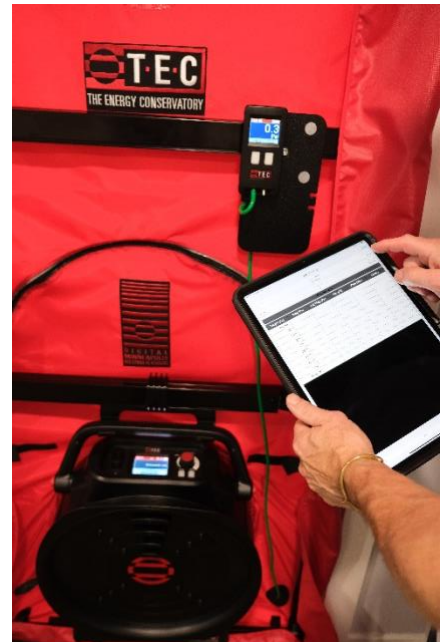


TEC Auto Test is an automated building envelope and duct system airtightness testing app for mobile devices. The TEC Auto Test app allows the user to wirelessly connect with a TEC Smart Fan and Bluetooth gauge to conduct an automated airtightness test of a building or duct system. The app creates pdf test reports with pass/fail test results by collecting the measurements from the connected devices and manually entered building and customer information. Project files can be geotagged using location services on your mobile device.

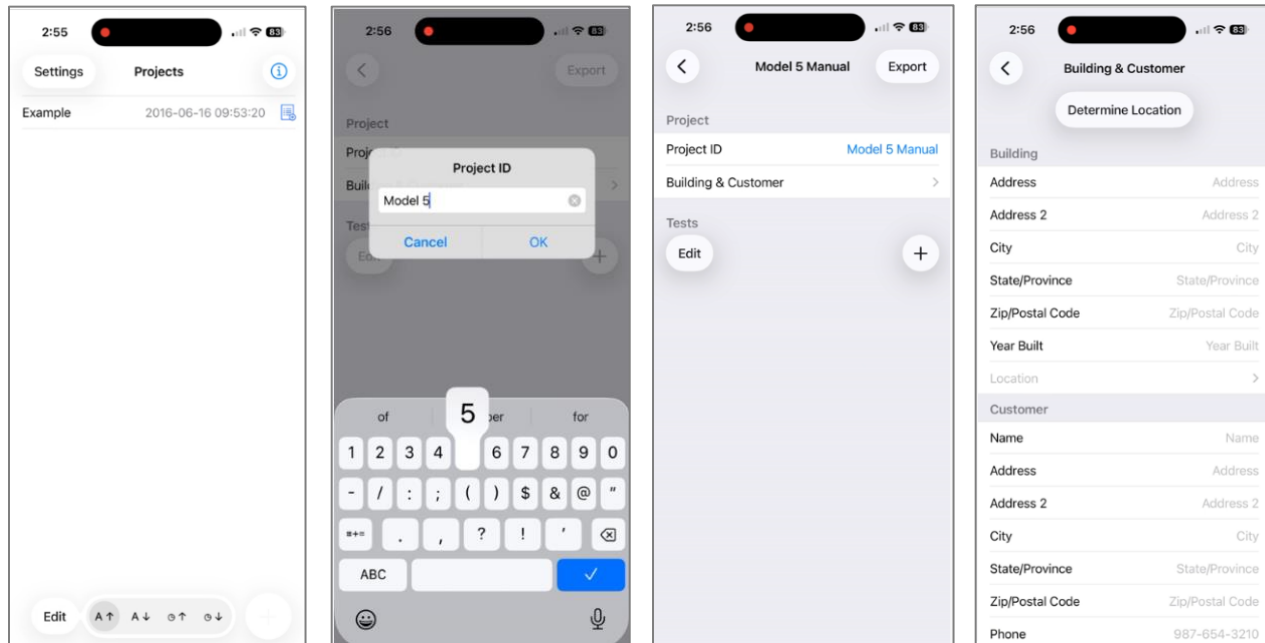
The app creates PDF test reports that can be viewed and exported using email or cloud sharing apps installed on your mobile device (e.g. Google Drive, Dropbox). Users can also export Project files that contain all test and building data within the Project. Exported Project files are in an XML file format. The app supports multiple airflow units including cfm, m³/h and l/s. The new Wind Assistant™ feature can detect windy weather conditions and automatically adjust the envelope test settings to improve test accuracy and repeatability. The Wind Assistant has multiple settings and is user configurable.

Key Features:

- Available for both Apple IOS (Apple store) and Android (Google playstore) devices.
- Supports building envelope and duct system airtightness tests
- Convenient Bluetooth communication with TEC Digital Products. Can also connect to digital gauges via WiFi.
- The Wind Assistant™ feature can detect windy weather conditions and automatically adjust the envelope test settings to improve test accuracy & repeatability.
- Project files can be geotagged and time stamped
- Creates a PDF report which can be exported using cloud sharing apps.
- Complete XML Project files can also be exported.
- Contains multiple default test protocols that define the type of tests and code compliance/test settings that the app uses when conducting a test.
- Protocols can be edited, deleted, and new protocols created.
- Project and test files can be copied to speed up data entry for large production situations
- Standards supported: ASTM E779 multi-point standard, RESNET 380 Multi-Point standard, RESNET 380 One-Point standard, two variations of the ISO 9972 Multi-Point standard, and two variations of the CGSB 149.10 Multi-Point standard. In addition, the app includes one duct leakage test standard: RESNET 380 Total Duct Leakage and Duct Leakage to Outside



Step-by-Step Process for Running Automated Multi-Point Test with TEC AutoTest

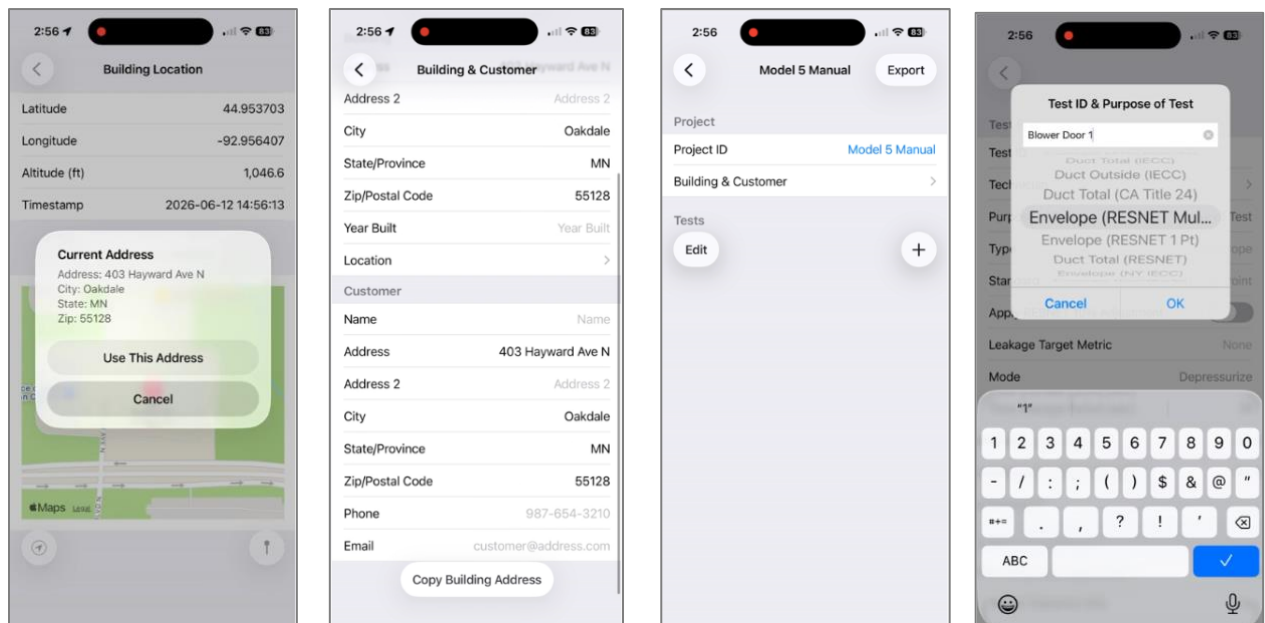


Open AutoTest, add a new project by clicking + in bottom right corner.

Enter the Building Name or Location in the Project ID Field

Click on “Building & Customer”

Click “Determine Location” to geo-locate

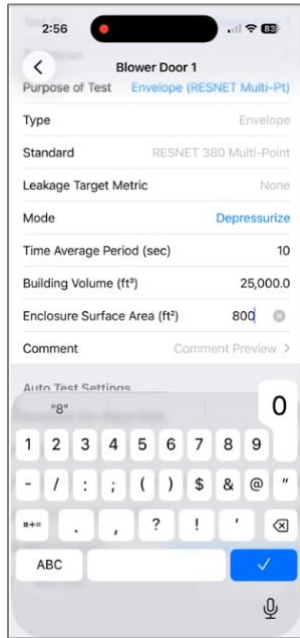


Use Current Address

Enter in Customer Name and address. If same as building can be copied

In the project, push + button to add a specific test

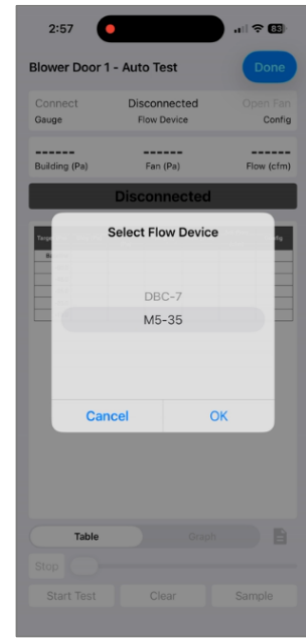
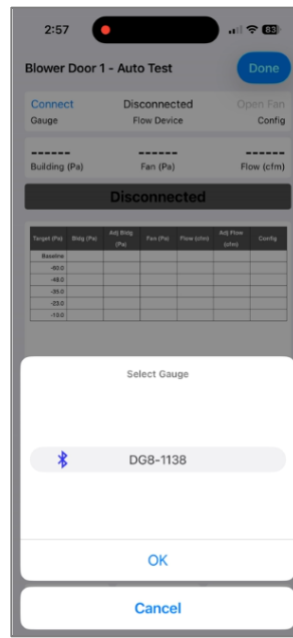
Enter the name of the test and the purpose of test (type of test)



Enter Volume and/or enclosure area if “Pass/Fail” results are needed on report. Click OK.



From the test screen, press the blue connect to connect to the Gauge that will be used. The gauge must be powered up. Future connection to this gauge will be automatic.



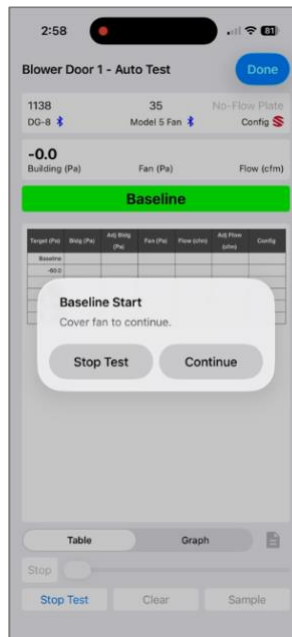
Then select the digital fan.



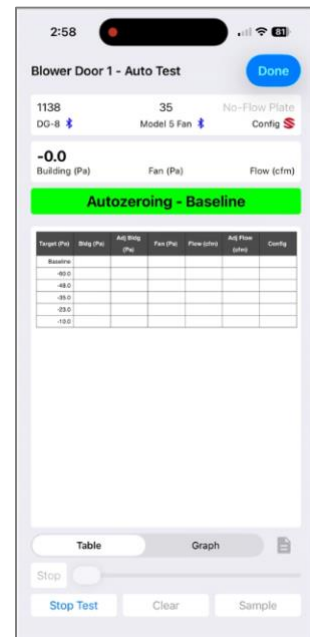
With both Devices connected, “Start Test” button is enabled.
Note current ring is detected and displayed in top right.



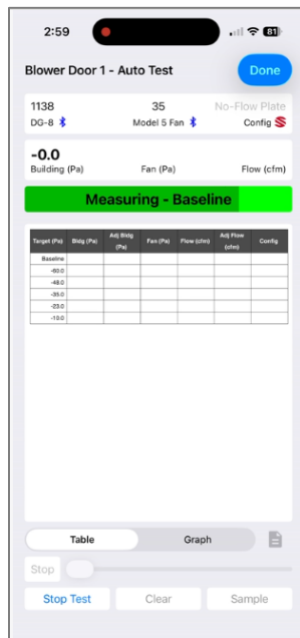
Enter environmental conditions. Altitude will be auto filled if geo-location was done.



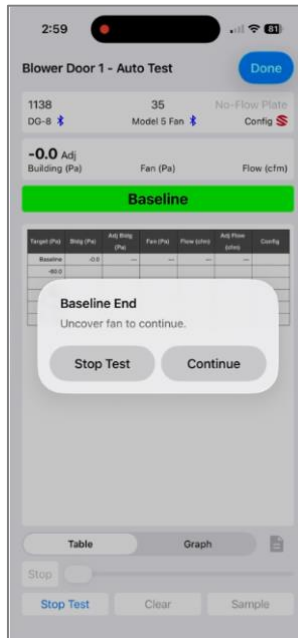
Ready for baseline. Fan must detect “No Flow Plate” to enable proceed button.



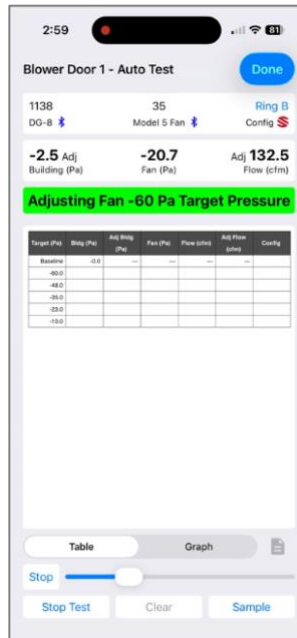
Gauge measuring envelope pressure is autozeroed.



Baseline is measured and stored



Remove No Flow Plate and place ring for test.



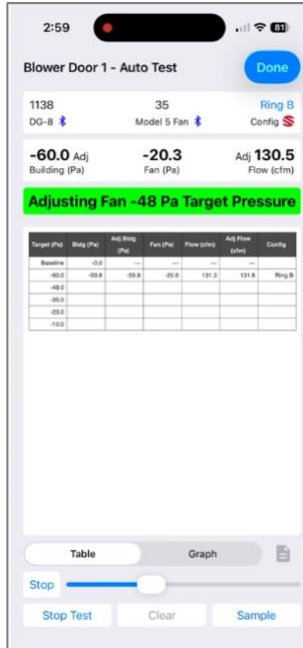
Fan initiate's test. Example of multi-point. Single point can also be selected.



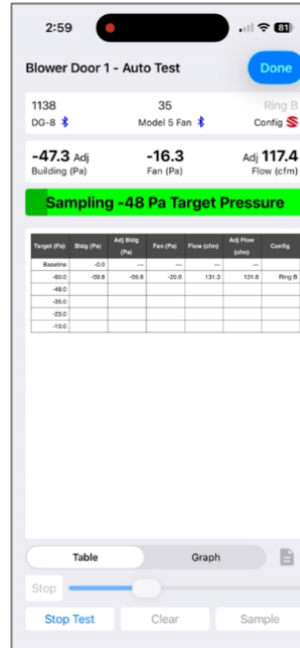
Pressure stabilizes, gauge autozero's prior to measurement



Flow & pressure sampled for period of record



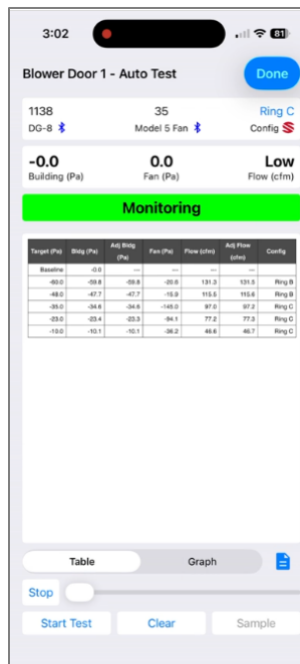
Records first results and automatically moves to next test pressure



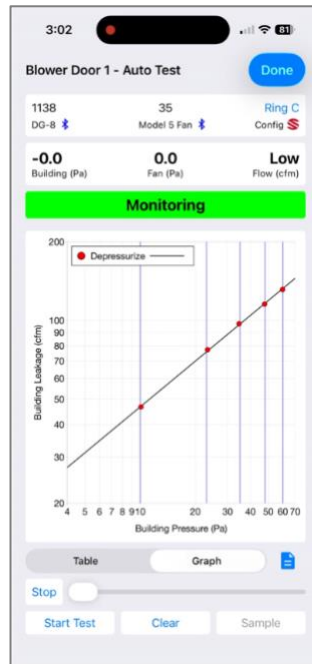
Samples each flow of multi-point test



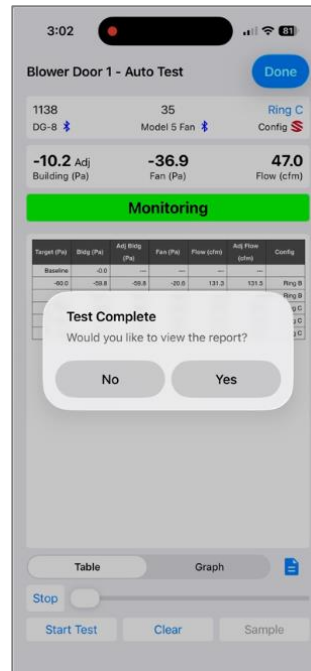
Fan prompts user when a ring change is needed



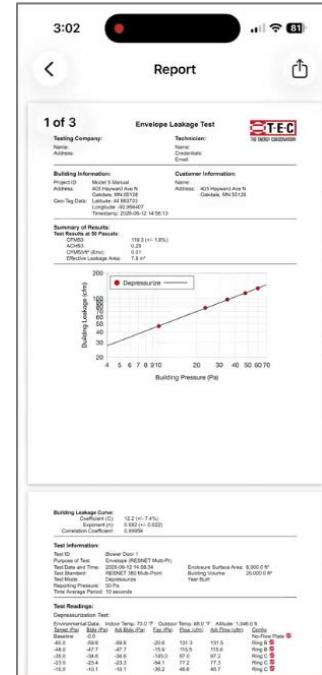
Results shown in table



Results shown in Graph



Test complete. Prompts to open PDF report



View PDF with Results, including geo tag location, detected rings, measured pressures & flows

Appendix B: Step-by-Step Process for Running an Automated Test with a DG-1000

Follow these steps to set up and conduct a manual or cruise-controlled Blower Door test using the M5 fan and DG-1000 gauge.

1. Turn on the DG-1000 and the M5 Blower Door fan. Hold each power button for 3 seconds until the device powers on.
2. Confirm Bluetooth is enabled on the DG-1000. From the main screen, go to Settings and set Bluetooth to ON.
3. Connect the M5 to Channel B of the DG-1000. Select M5 in the lower-left of the Channel B screen. The M5 will be paired via Bluetooth. Confirm that Channel B flow units are set to your preferred output (typically CFM50).
4. Connect the Green building pressure tubing to Channel A of the DG-1000 (Reference tap). The other end of the tubing runs outside through the nylon panel this measures building pressure relative to outdoors.
5. Take a Baseline reading. Install the M5 No-Flow Plate on the fan inlet. Select Baseline on Channel A of the DG-1000 and allow 10 or more seconds for the reading to stabilize.
6. Remove the No-Flow Plate and select the appropriate Flow Ring. When uncertain, start with Ring A or Open Fan and switch to a smaller ring if flow falls below the ring's minimum range. Press the Play button on the DG-1000 to engage cruise control to your target pressure (typically 50 Pa).
7. Once the target pressure is stable, select the 10-second average on Channel A to record averaged pressure and CFM50 results.
8. To freeze the screen for recording or photographing results, press the Hold Hand button in the upper right of the DG-1000 display. The screen freezes and the fan will stop. Press Hold Hand again to resume.