HVAC pressure applications with the Fluke 922

Application Note

For contractors troubleshooting pressure, a lot depends on system peculiarities. Are the installation instructions with the equipment? Is the start-up performance report with them? Is the TAB (test and balance) report available? Do you understand the control system? More often than not, it seems, you can only answer yes to the last question. You rely on your experience, knowledge, and tools to check the fundamentals. And for that much, at least, Fluke can help.

Using the Fluke 922 low pressure differential meter in a duct traverse.

Pressure measurement

Pressure is measured in several different scales. Pounds per square inch (psi), inches of water column (in. wc), inches of mercury column (in. hg), and millionths of a meter of mercury column (microns) are the most typical in HVAC work.

Bourdon gauges are the traditional choice for higher pressure readings in psi. Finer precision measurements use mercury column scales. And for the most precise measurements—and most low pressure measurements in HVAC—inches water column is the standard.

The following chart compares these common pressure scales and their precision.

Atmospheric Pressure	1 psi	1″ hg	1″ wc
14.696 psia	1 psi	0.019 psi	0.0361 psi
29.921 ″ hg	2.036″ hg	1″ hg	0.0736″ hg
406.8″ wc	27.68″ wc	13.595″ wc	1″ wc

Of the many different low pressure measuring instruments used over the years, electronic manometers/micromanometers (very low pressure gauges) now offer durability, precision, accuracy, and the significant time saving convenience of fully automatic calculations as well as minimum-maximum-average and memory functions.

How pressure sensing works

The Fluke 922 is a low pressure differential meter used in traditional manometer or micromanometer applications. It has a range of +/-16" wc, resolution of 0.001" wc, and over-pressure protection of 10 psi at each high and low pressure port. With a single tube connected to its high or low port, the meter will display positive or negative pressure relative to the ambient pressure at the meter's open port. For a pressure differential at two remote points, use tubing to connect the higher pressure sensing point to the "+" port and the lower pressure sensing point to the "-" port.

The meter uses a variety of sensing probes and fittings to access the type and location of pressure measurement points. These can be as simple as a straight metal tube for checking draft, a "Tee" for tapping into pressure sensing tubing connected to a pressure switch, a Pitot tube for sensing total pressure, a Pitot-Static tube for sensing both total and/or static pressure, or a static pressure tip.

Pressure applications

Draft pressures: Draft pressures are negative relative to ambient pressures at the burner. Measuring and controlling draft is a critical step in combustion tests and influences net thermal efficiency of the appliance. Draft is created by vertical vents or powered sidewall vent systems connected to fossil fuel equipment. Like too much air, excessive draft through a heat exchanger increases the velocity of the combustion products containing heat, thereby reducing the contact time in the heat exchanger. Follow guidelines from the manufacturer or standards authority.

Over-fire draft: Power burners typically have specifications related to over-fire draft, which relates to the velocity of combustion products through the heat exchanger. This over-fire draft typically is slightly negative (-0.01" wc to -0.02" wc) but, depending on burner type and application, may be slightly positive (0.01" wc to 0.02" wc). Follow guidelines from the manufacturer or standards authority.

Draft inducer pressure: Category I fan-assisted gas appliances utilize a combustion air inducer to create draft through the appliance and deliver the combustion products to a negative pressure vent. A pressure switch is normally connected to the inlet side of the inducer to ensure a minimum draft has been established before allowing an ignition sequence to begin or continue. For testing, a "Tee" taps into the pressure sensing tubing, to monitor the draft created by the inducer. This is an important value to benchmark at appliance installation. While the pressure switch ratings list cut-in and cut-out (or differential) pressures, without a benchmark you can't evaluate changes within the appliance or vent over time. Follow guidelines from the manufacturer.

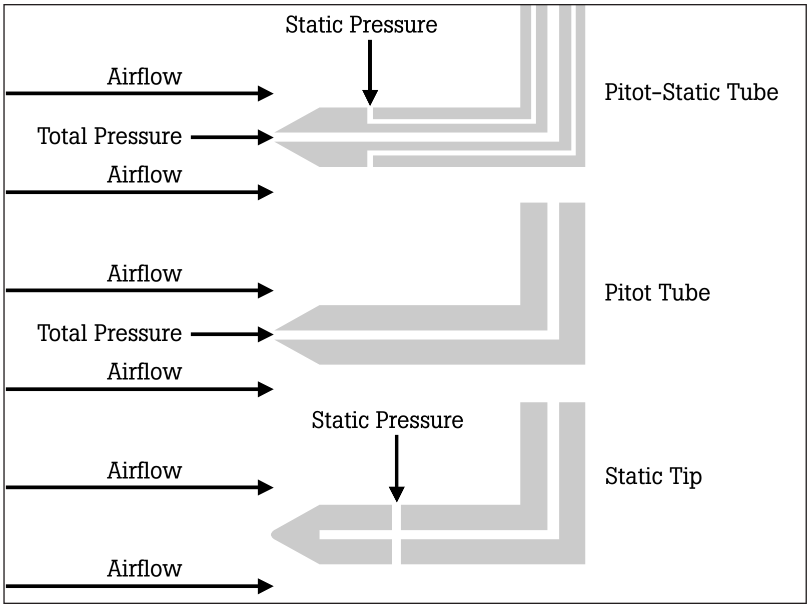
Pressure effects and measurements

Pressure is an integral part of HVAC equipment design, system design, function, application, control and diagnostics. Pressure determines

- cleanliness of airside devices (pressure drop across filters, evaporators, etc.)
- boiler steam temperature
- the saturation temperature of a fluid (boiling temperature of a liquid, the condensing temperature of a vapor)
- the direction of fluid flow (fluids flow from higher to lower pressures)
- fluid volume flow rate (pressure drop across an orifice)
- whether or not a control or safety switch will make or break (high/low pressure switches, draft proving switches)
- the availability of a fluid to perform work (oxygen/nitrogen tank pressures, gas supply pressures, duct static pressures)

Pressure also

- senses zone device positions, modulates VFD drives, bypass dampers and valves
- affects solubility of air in water
- contributes to flue gas velocity (stack draft)



Options for sensing probes and fittings when accessing pressure measurement points.

Combustion air blower pressure differential: Category IV direct vent gas appliances typically use a combustion air blower to ensure airflow through the vent system and appliance before ignition. In most cases, a pressure differential switch monitors pressure differential across an orifice. Greater pressure differential indicates more airflow, lower differential indicates less airflow. In this case, two tees are needed to tap into both the high and low pressure sensing tubes connected to the pressure differential switch. This is an important value to benchmark during appliance installation. Pressure differential depends on the length of connected vent and the application. If this value is benchmarked when installed, degradation to differential created by heat exchanger, condensate or vent problems is more likely to be detected before a failure occurs. If not benchmarked, there's no way to evaluate degradation. Follow guidelines from the manufacturer.

Fan effects on combustion pressures: When checking stack draft, over-fire draft or combustion air inducer/blower pressure differential, an abrupt change in pressure when the blower starts may indicate a compromise between the flue passages and the air passages. Fan pressure can easily be 15 times or more greater than flue passage pressure (-0.03" wc draft vs 0.5" ESP), so abruptly changing draft pressures commonly indicate heat exchanger leaks. Gradual changes in draft pressures most likely mean combustion air supply problems or vent problems, especially when accompanied by rising CO and CO_2, and falling O_2 levels in the combustion products. This can be caused by insufficient make-up air or return leaks, especially in spaces that are considered confined (less than 50 cu ft per 1,000 Btu input) or tight construction. Use the Fluke 922 to compare equipment room pressure to outside pressure before and during equipment operation. Simply adding a small supply register in the equipment room can often compensate for this engineering design deficiency.

VAV (Variable Air Volume) control: Pressure sensors are often used to control VFD (variable frequency drive motor) RPM. For instance, a supply duct pressure sensor can modulate the RPM of a VFD, based on pressure changes caused by a combination of open and closed zone dampers. Exhaust VFD blowers may modulate RPM based on pressure differential between the occupied space and outdoors. In each of these cases, the VFD varies RPM to maintain a relatively consistent pressure or pressure differential. The Fluke 922 can be used to monitor or check the calibration of these sensors.

CAVB (Constant Air Volume with Bypass) damper control: Equipment with a constant RPM blower may need to simulate VAV in the supply duct, when zoning is used. The control is similar to a true VAV system. A pressure sensor monitors supply and modulates a bypass damper. The damper relieves pressure from the supply to the return, maintaining a consistent supply static pressure. The Fluke 922 can monitor or check the calibration of these sensors.

Pressure differential defrost control: Some enthalpy wheels use a differential pressure sensor to determine if a defrost cycle is needed during cold weather. A pressure differential increase (indicating a frost build up) will cycle the outdoor air intake blower off , so it can use the indoor air to defrost the wheel. The Fluke 922 can be used to monitor pressure differential, check the calibration of the sensor, or test defrost operation. Some air-to-air heat pumps use a pressure switch to monitor pressure drop across the outdoor coil to determine if frost build-up warrants a defrost cycle. In that circumstance, the Fluke 922 can be used to monitor defrost pressure differential, since restricted airflow may indicate a frosted coil.

Airside devices: Pressure drop across airside devices is published by manufacturers and is necessary for design considerations, including selecting equipment for satisfactory blower performance and for duct design considerations. Once installed, these same performance tables are useful in estimating airflow and determining end of life for filters. Evaporators, for instance, will have pressure drops with associated cfm's for a clean dry coil and for a clean wet coil. High performance filters will have pressure drops with associated cfm's for a clean filter, and pressure drops with associated cfm's for that same filter when it has reached the end of its life.

The Fluke 922 can be used with a choice of pressure sensing devices to check pressure drop across an airside device. If the approach to and from the device is straight, a Pitot tube can be placed on each side of the device and the difference in total pressure readings will result in pressure drop. The tube connected to the upstream side Pitot tube is connected to the 922 "+" port, the tube connected to the downstream side Pitot tube is connected to the "-" port, the pressure reading displayed will be the device pressure drop. If the approach is not straight to the device, then use the static sensing side of the two Pitot-Static tubes, or use two static pickups connected to the meter in the same manner.

Confirming pressure drop across the air filter bank.

TSP and ESP: Total Static Pressure (TSP) and External Static Pressure (ESP) are used in conjunction with the manufacturer's blower performance tables to ensure that the blower performance is sufficient to overcome airside device pressure drops and the pressure drop associated with duct friction and fittings losses. Manufacturer's blower performance tables will specify whether the tables are based on TSP or ESP. Once installed, the TSP or ESP is measured to select the appropriate fan RPM that will deliver the desired cfm. It's important to remember that manufacturer's blower curves are developed by AMCA test procedures that do not exhibit any system effect. Due to equipment installation space and configuration limitations, blower performance is rarely the same as system performance ("as-built" rarely performs exactly "as-designed"). Initial blower set up is by TSP or ESP. Duct traverses that measure actual airflow are required for final blower set up.

TSP is normally provided for commercial and industrial unitary equipment. TSP includes internal and external dynamic pressure losses the equipment fan must overcome. A static pickup is used on the inlet side of the fan to measure static pressure and the connecting tube is connected to the "–" port on the Fluke 922. A static pickup is placed on the discharge side of the blower and the connecting tube is connected to the "+" port on the Fluke 922. The displayed pressure is the TSP.

ESP is normally provided for residential unitary equipment. ESP is provided for equipment that does not have optional components that can be added within the cabinet or when drilling holes to take TSP may violate equipment agency certifications. The blower tables are based on dynamic pressure losses external to the equipment, measured at the return opening and at the supply opening of the unitary equipment. Check the blower table instructions to determine whether or not the filter should be in place when measuring ESP. Place a static pickup in the return duct at the equipment return opening. Connect this tube to the "–" port of the Fluke 922. Place a static pickup in the supply duct at the equipment discharge opening before any external devices such as an external evaporator, if so equipped. Connect this tube to the "+" port on the Fluke 922. The displayed reading will be the ESP.

FSP (P_{sf}) is Fan Static Pressure and is used to independently rate a fan's ability to overcome all system dynamic pressure losses. A Pitot tube is used on the inlet side of the fan to measure total pressure and the connecting tube is connected to the "–" port on the Fluke 922. A static pickup is placed on the discharge side of the blower and the connecting tube is connected to the "+" port on the Fluke 922. The displayed pressure is the FSP.

Conclusion

Pressure is an often-misunderstood aspect of HVAC diagnostics. Everyone has refrigerant pressure gauges, but to understand why "the pressures are wrong," you need to think about fluid flow and heat transfer too, instead of just adding gas to force the pressures up. And, while everyone probably has a pressure gauge, it's not always the right kind for accurately reading low pressure systems. Now, with electronic meters like the Fluke 922, you not only get an accurate read, you can check the actual pressure differential instead of replacing pressure differential switches by default.

Using the Min/Max/Avg feature

The MIN-MAX feature on the Fluke 922, in addition to capturing minimum and maximum readings, will record and average readings when a fluctuating pressure, velocity, or airflow is encountered.

Once you've captured pressure, velocity, and/or airflow readings and stored them in memory, they can be recalled per selected mode for review and deleted individually, or as a group.

Applications for Min/Max/Avg include checking:

- static pressure variations as zone dampers open and close
- CAVB bypass sizing and damper operation

The average function is most useful when air turbulence causes minor fluctuations in readings. The average feature smoothes out the slight variations, making pressure evaluations more accurate.

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Fluke Corporation
PO Box 9090, Everett, WA USA 98206

Fluke Europe B.V.
PO Box 1186, 5602 BD
Eindhoven, The Netherlands

For more information call:
In the U.S.A. (800) 443-5853 or
Fax (425) 446-5116
In Europe/M-East/Africa +31 (0) 40 2675 200 or
Fax +31 (0) 40 2675 222
In Canada (800)-36-FLUKE or
Fax (905) 890-6866
From other countries +1 (425) 446-5500 or
Fax +1 (425) 446-5116
Web access: http://www.fluke.com

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