FlowKinetics™ LLC
feel the pressure

FKS 1DP-PBM-E Multi-Function Meter

Pressure & Velocity

User Manual

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LIMITATIONS OF USAGE AND CAUTIONS

The FKS series of instruments are not *intrinsically safe*, and must not be used in dangerous or hazardous areas. Servicing of these instruments incorporating battery changing must only occur in a safe area. Use of the FKS series may require working in a hazardous environment. Necessary safety precautions must be followed.

FlowKinetics™ LLC's products (including the FKS series) are not authorized for use as any component in a life support system or device or as component of an aircraft's on board flight system. Life support systems or devices are defined as any system that can sustain, monitor or support life.

The pressure transducers used by the FKS system are compatible with most non-corrosive gases, however toxic gases are not suitable, nor are liquid pressure measurements.

Any attempts to service or modify or alter the product in any way, will void the warranty and will negate any right of claim against FlowKinetics™ LLC, relating to any liability in respect of the product.

WARRANTY

All of FlowKinetics™ LLC's instruments have been assembled using strictly defined and controlled procedures and tests, and are warranted against any faults in workmanship and materials for one year from the date of purchase. Liability under this warranty is limited to repair or replacement F.O.B. factory of any parts which prove to be defective within that time or repayment of the purchase price at the Seller's option provided the product has been returned, transportation prepaid, within one year from date of purchase. In no case is the Seller liable beyond replacement of product F.O.B. factory or the full purchase price. This warranty does not apply if the product or equipment is abused, altered, used at ratings above the maximum specified, used with disregard of instructions and specified operating procedures, or otherwise misused in any way. All technical advice, recommendations and services are based on technical data and information which the Seller believes to be reliable and are intended for use by persons having skill and knowledge of the application, on their own judgment. There are no implied warranties of merchantability or of fitness for a particular purpose for goods covered hereunder. In no event will the manufacturer be responsible for consequential, incidental or special damages resulting from the use of this product.

Buyer's Remedies: The buyer's exclusive and sole remedy on account of or in respect to the furnishing of non-conforming or defective material shall be to secure replacement thereof as said above. The seller shall not in any event be liable for the cost of any labor expended on any such material or for any special, direct, indirect, consequential or incidental damages to anyone or any property by reason of the fact that it shall have been non-conforming or defective.

Repairs: Authorization must be obtained before shipping items to FlowKinetics™ LLC for repairs. When requesting a repair please include a detailed description of the problem with the item, date of purchase, your P.O. or reference number and our invoice number if available.

Unpacking / Parts List

Carefully unpack your FKS 1DP-PBM-E meter. Ensure that there is no damage to the instrument. If any components are damaged, make a record and contact the shipper. The instrument is supplied with (some accessories are optional):

Item	Description	Quantity
FKS 1DP-PBM-E	Multi-function meter	1
Tubing	Flexible tubing for pressure connection	2
FKS Manual	User reference	1
WPA	Wall power adapter	Optional
Cable6	6' Serial cable	Optional
SwiftScan CD and manual	Real time software for monitoring the FKS outputs and downloading them to a PC	Optional

Overview / Features

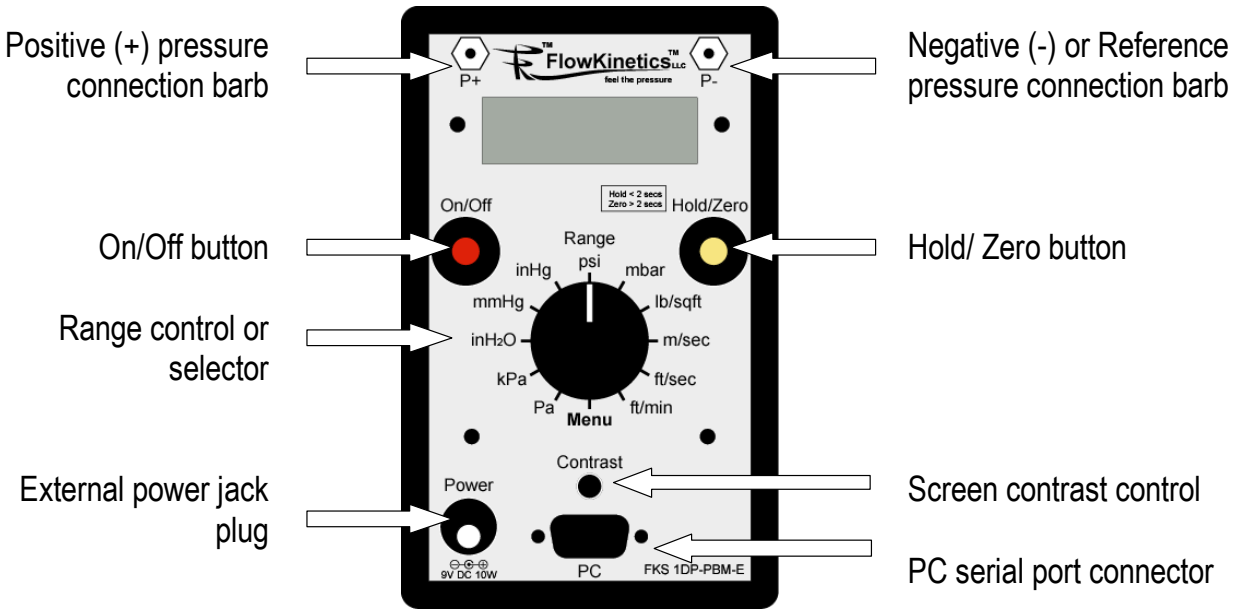
The FKS 1DP-PBM-E is a multi-function meter designed for accurate pressure and velocity measurement. The meter is exceptionally easy to use due to its prompt driven user interface and intuitive functioning.

Features of the PBM-E include:

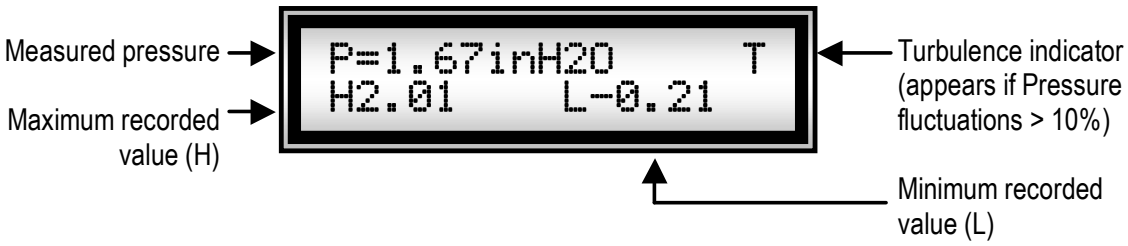
- Highly configurable operation
- Differential, static and gauge pressure
- Electronic Zero function to remove drift
- Metric and Imperial units
- Minimum & maximum reading
- Data hold (screen freeze)
- Turbulence indicator
- K factor
- Velocity (both standard and actual)
- Density correction
- Intelligent automatic damping (with user selectable averaging or smoothing)
- PC compatibility (optional software)
- Variable screen contrast
- Wall or battery power

Description of Controls & Display

Controls of the FKS 1DP-PBM-E are shown below:



Example Display Presentations for Pressure and Velocity are Shown Below:



How Do I:

The majority of this manual is written in the form of a *How Do I…* Some topics are repeated to maintain description continuity.

Q: How Do I Insert Batteries / Use Wall Power?

Batteries: The unit uses two 9V batteries. The batteries are inserted by removing the cover located on the back of the instrument. The cover slides off. The ribbon under the batteries can be used to ease battery removal. Only use new batteries (dry Alkaline leak proof) and discard the old batteries in compliance with regulations.

Wall Power: An AC adaptor power supply can be supplied with the instrument as an option. The adaptor can operate from $100V_{AC}$ to $240V_{AC}$ 50-60Hz supplies and provides 1100mA at $9V_{DC}$. The adaptor has the facility for easy interchange between US, European, English and Australian plugs. To use, simply insert the jack from the adapter into the jack plug on the face of the instrument (see Description of controls). It is not necessary to remove the batteries, as they are automatically disconnected. Do not attempt to use the supplied adapter as a battery charger.

CAUTION: Use of any power adaptor other than that supplied (optional) with the instrument will remove any rights of claim against FlowKinetics™ LLC, relating to product liability or consequential damage against a third party and will void the warranty. If an alternative adaptor is used, its output voltage range must be regulated and within:

$$9V_{DC} \le V_{ADAPTOR} \le 12V_{DC}$$

If the meter is stored, or not used for over a week, the batteries must be removed.

Q: How Do I Connect the Tubing?

Pressure: The supplied flexible tubes attach over the barbs labeled P+ and P-. A higher pressure at port P+ than port P- will result in an indicated positive pressure. To measure static or gauge pressure, tubing can be connected to the P+ barb. An indicated positive pressure shows that the static or gauge pressure is higher than atmospheric (or the pressure at P-).

Velocity: To measure velocities, the P+ port should be connected to the Total pressure port on the Pitot and the P- port connected to the Static port (see *How Do I Connect the Pitot Probe?*) of the Pitot probe.

CAUTION: The FKS series are not suitable for use with toxic or corrosive gases or for liquid pressure measurement. The series are not approved for use in any life support application.

Q: How Do I Switch the Unit On (and Off)?

To switch the meter on, press in the On/Off button. You will hear and feel a *click* indicating unit power up. To switch the unit off, press the On/Off button again. If the Range selector is set to a pressure unit, the instrument will show the meter model description and then indicate that that the instrument is performing an electronic Zero. If the Range selector is set to a velocity unit, the meter will additionally show the stored velocity and flow settings (K, Patm and T) in both metric (kPa and °C) and imperial units (inHg and °F). Cycling the meter On/Off can be used to rapidly check the velocity/flow settings.

Q: How Do I Adjust the Screen Contrast?

Screen contrast is adjusted by rotating the screen contrast knob. Only use your fingers to operate this control.

Q: How Do I Zero the Meter?

Zeroing is easily accomplished using the inbuilt electronic Zero. Disconnect any pressure source from the meter. Depress the Hold/Zero button for greater than 2 seconds. The meter will indicate that the Electronic Zero is in progress. Zeroing should be performed periodically while taking measurements to ensure accuracy.

Q: How Do I Know if the Batteries Need Replacement?

If the battery voltage drops excessively, a B will appear at the top RHS of the display. This indicates that the batteries should be replaced. The B may blink occasionally.

Q: How Do I Know If the Meter is Overloaded?

If the pressure rating for the transducer is exceeded, the meter will indicate on the display an overload condition (Overload). Pressure should be relieved immediately to avoid damage.

CAUTION: The maximum differential pressure that may be imposed on the transducer is 5psi, with a maximum line pressure of 10psi.

Q: How Do I Change the Smoothing of My Data?

The FKS 1DP-PBM-E meter contains sophisticated routines to process your measurements (very useful when they are unsteady or fluctuating). Two methods can be used to *smooth* your readings. An exponential moving average (sometimes called exponential smoothing) can be used (somewhat similar to a *normal* moving average) and of the form:

$$P2^{*} = P1f + (1-f)P2 \qquad \text{(Exp. Smoothing)}$$

where P2* is the new pressure estimate (shown on the display), P2 is the latest pressure value measured from the transducer and P1 is the last pressure estimate. In the PBM-E meter, *f* is adjusted continuously (adaptive) depending on the level of fluctuation of the measured pressure. If there is little fluctuation f will be close to zero. If fluctuation is large, *f* has a maximum value of 0.9. Thus *f* is continuously adjusted by the meter (between 0 and 0.9) to provide the most stable reading.

The second method that can be used is a simple averaging of readings (Average). The meter will read the output from the pressure transducer multiple times, and then average these values. The meter will continuously adjust the number of averages (from 5 to 75 averages). This operation may be noticeable, as the screen update rate may change as the meter changes (adapts) the number of averages to give the best and most stable estimate of the pressure or velocity.

To select the method you want set the Range selector to Menu. The menu will cycle through various functions. When Smooth/Average appears, rotate (any direction) the Range control to select it. The menu will cycle, Exp. Smoothing followed by Averaging. Rotate the Range selector (any direction or unit) when the desired method is displayed. The instrument will then return to measurement mode. The method you selected is stored in memory and will be retained after switching the unit off. For very unstable readings, the exponential smoothing may offer a more stable estimate, where the averaging will offer a quicker estimate.

Measuring Pressure

Q: How Do I Change Units?

Units are changed by rotating the Range selector knob. The knob has no stop and can rotate more than 360 degrees.

Q: How Do I Measure the Minimum (L) and Maximum (H) Reading

The Minimum and Maximum readings are continuously shown by the FKS meter on the second line of the display. The maximum reading is preceded by H and the minimum reading is preceded by L. No units are shown but correspond to the units displayed on the first line.

Q: How Do I Reset Min/Max?

To reset the Min/Max (or L-H) readings, simply change the units (to any other unit

setting) by rotating the Range knob and then set back to your desired units.

Q: How Do I Hold or Freeze the Display?

Press the Hold/Zero button for less than 2 seconds. The display will freeze, indicated by the appearance of a H at the top RHS of the display. To resume operation, press the Hold/Zero button again.

Q: How Can I Estimate if the Pressure May Be Too Unsteady for Accurate Measurement?

If the measured pressures fluctuate more than 10%, an indicator ~ will appear at the top RHS of the display. This may suggest that another measurement location may be necessary.

Measuring Velocity

The PBM-E uses differential pressure probes (Pitot or S type) to take velocity measurements.

Q: How Do I Change Units?

Units are changed by rotating the Range selector knob. The knob has no stop and can rotate more than 360 degrees.

Q: How Do I Measure the Minimum (L) and Maximum (H) Reading

The Minimum and Maximum readings are continuously shown by the FKS meter on the second line of the display. The maximum reading is preceded by H and the minimum reading is preceded by L. No units are shown but correspond to the units displayed on the first line.

Q: How Do I Reset Min/Max?

To reset the Min/Max (or L-H) readings, simply change the units (to any other unit setting) by rotating the Range knob and then set back to your desired units.

Q: How Do I Hold or Freeze the Display?

Press the Hold/Zero button for less than 2seconds. The display will freeze, indicated by the appearance of an H at the top RHS of the display. To resume operation, press the Hold/Zero button again.

Q: How Can I Estimate if the Air Velocity May Be Too Unsteady for Accurate Measurement?

If the measured pressures fluctuate more than 10%, an indicator T will appear at the top RHS of the display. This may suggest that another measurement location may be necessary.

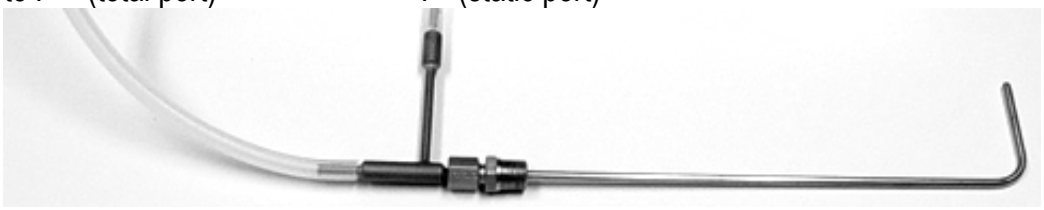
Q: What Probes can I use with the FKS 1DP-PBM-E?

Any Pitot static probe or S type probe can be used. Most Pitot probes have unity calibration coefficients (K factor). S type probes (used for *dirty* air streams) have coefficients around 0.80 to 0.92. To set K, see below.

Q: How Do I Connect the Pitot Probe?

See the sketch below. P+ is the top left barb; P- is the top right barb. For connection of other types of probes, the stagnation (total) pressure port should be connected to the P+ barb; the static or reference pressure should be connected to the P- barb.

to P+ (total port) P- (static port)



Q: How Do I Change K?

To set K, or a probe's calibration constant (default value = 1), set the Range selector to Menu. The menu will cycle through various functions. When Set K factor appears, rotate (any direction) the Range control to select it. The menu will prompt, Set K Rotate followed by K factor. Rotate the Range selector (any direction or unit). Press & Rotate will be briefly displayed. The screen will display 0.00. The first digit will begin to blink. To increment this digit press the Hold/Zero button. You can also keep the button pressed to advance rapidly. If the displayed digit increments beyond 9, it will wrap around and continue from 0. When the desired value for this digit is set, rotate the Range selector (any direction or unit). The second digit will begin to blink. Use the Hold/Zero button to set the desired value; similarly for the third digit. The instrument will then return to measurement mode. Any calculated velocities will then use the K factor you set. The K factor is stored in memory and will be retained after switching the unit off. The measured velocity multiplies K, see Appendix A. See the Pitot probes instructions for the value of K (usually = 1 for most Pitot probes).

Q: How Do I Measure Standard Velocity?

Standard velocity corresponds to a density based on a pressure, Patm, of 101.325kPa (29.92 inHg @ 32ºF) and a temperature, T, of 21.1ºC (70ºF). The FKS 1DP-PBM-E allows you to manually set Patm and T. These values can be set in two ways:

1. Set the Range selector to Menu. The menu will cycle through various functions. When `Set Patm & Temp` appears, rotate (any direction) the Range control to select it. The menu will prompt, `Set Units Rotate` followed by `kPa` alternating with `inHg @ 32F`. When the desired unit appears, rotate the Range selector (any direction or unit) to set in either metric or imperial units. Depending on your selection, the screen will display `000.00` (metric) or `00.00` (imperial). The first digit will begin to blink. To increment this digit press the Hold/Zero button. You can also keep the button pressed to advance rapidly. If the displayed digit increments beyond 9, it will wrap around and continue from 0. When the desired value for this digit is set, rotate the Range selector (any direction or unit). The second digit will begin to blink. Use the Hold/Zero button to set the desired value; similarly for the third digit, etc. After setting the atmospheric or absolute pressure, the unit will prompt for the Temperature to be set. After setting, the instrument will then return to measurement mode. Any calculated velocities will then use the values you set for Patm and T. Patm and T are stored in memory and will be retained after switching the unit off.
2. Set the Range selector to Menu. The menu will cycle through various functions. When `Reset K, Patm, T` appears, rotate (any direction) the Range control to select it. The menu will indicate that K, Patm and T have been reset to default (i.e. standard conditions). Note that K is also reset to 1 (default).

Q: How Do I Measure Actual Velocity?

The atmospheric pressure (Patm, this is the absolute pressure in the flow to be measured) and temperature (T) of your airflow measurements should be set manually. To measure actual velocity, the temperature and absolute (barometric) pressure of the air to be measured must be known.

Set the Range selector to Menu. The menu will cycle through various functions. When `Set Patm & Temp` appears, rotate (any direction) the Range control to select it. The menu will prompt, `Set Units Rotate` followed by `kPa` alternating with `inHg @ 32F`. When the display shows the units

you want, rotate the Range selector (any direction or unit) to set in either metric or imperial units. Depending on your selection, the screen will display 000.00 (metric) or 00.00 (imperial). The first digit will begin to blink. To increment this digit press the Hold/Zero button. You can also keep the button pressed to advance rapidly. If the displayed digit increments beyond 9, it will wrap around and continue from 0. When the desired value for this digit is set, rotate the Range selector (any direction or unit). The second digit will begin to blink. Use the Hold/Zero button to set the desired value; similarly for the third digit, etc.
After setting the atmospheric pressure, the unit will prompt for the Temperature to be set. After setting, the instrument will then return to measurement mode. Any calculated velocities will then use the values you set for Patm and T. Patm and T are stored in memory and will be retained after switching the unit off

Q: How Do I Check the Stored Values for K, Patm and T?
The values of these parameters can be checked in two ways:

1. Before switching the unit on, set the Range selector to a velocity unit. On power up, the meter will show the stored velocity and flow settings (K, Patm and T) in both metric (kPa and °C) and imperial units (inHg and °F). The unit can be cycled On/Off as needed.
2. Set the Range selector to Menu. The menu will cycle through various functions. When View K, Patm & T appears, rotate (any direction) the Range control to select it. The unit will then display the stored K factor, followed by Patm and T in metric units (kPa and °C) followed by imperial units (inHg @ 32F and °F). After displaying each unit set for approx. 2 seconds, the instrument will return to measurement mode.

Q: How Do I Set K, Patm and T to Default (Standard Conditions)?
Set the Range selector to Menu. The menu will cycle through various functions. When Reset K, Patm, T appears, rotate (any direction) the Range control to select it. The menu will indicate that K, Patm and T have been reset to default (i.e. standard conditions). Note that K is also reset to 1 (default).

Measuring Flow Rate

Flow rate is measured by calculating an average velocity for the conduit of interest, and then, multiplying this velocity by the cross sectional area of the duct at the measurement location. The velocity value may estimated using a single reading, or a survey across the duct at a station (see Appendix A).

The Menu System

The menu system uses prompt driven operation for ease of use. All option selections are performed by rotating the Range selector (in any direction and to any unit). This provides positive tactile and audible feedback that your selection has been made. All numbers are set by pressing the Hold/Zero button to increment the digit and by rotating the Range selector to accept the displayed number and advance to the next digit. Options available through using the menu system are:

- Set Patm & T
  - Used to set actual velocity
- Set K factor
  - Used to set the calibration constant (K) for non-unity probes (e.g. S type probes)
- View K, Patm & T
  - Used to view the currently stored values for these parameters
- Reset K, Patm, T
  - Used to reset to default and standard conditions (K=1, Patm=29.92inHg and T=70ºF)
- Smooth/Average
  - Used to select between exponential smoothing or averaging for measurements

Maintenance

Operational Maintenance

- Ensure that the FKS meter is kept clean dry and does not come into contact with any corrosive elements.
- Do not use any solvents for cleaning purposes. To clean surfaces, wipe with a clean dry cloth.
- When not in use, the pressure barbs should be covered with the supplied Silicone tubing links to avoid dust and moisture contamination.
- When the low battery warning appears on the display (▯), the batteries should be replaced.
- The FKS series should be returned to FlowKinetics™ LLC, for calibration annually.

Battery Maintenance

The batteries of the FKS series are changed as follows:

- Check to ensure that the instrument is turned off.
- Remove the battery compartment cover plate, this located on the back of the instrument. The plate slides off.
- Carefully remove the old batteries. The ribbon under the batteries may be used to aid removal.
- Replace all the batteries with fresh batteries (2 x 9V dry alkaline leak proof). Be careful to ensure the correct battery polarity. Do not mix new and old batteries.
- Replace the compartment cover plate.

Specifications

Enclosure

The enclosure is manufactured from ABS plastic:

length:	5.7 in (145 mm)
width:	3.5 in (90 mm)
height:	1.7 in (44 mm)
mass:	0.67lb (0.305kg) excluding batteries

Working Temperatures

Meter:	32°F to 122°F	(0°C to 50°C)
Storage:	14°F to 140°F	(-10°C to 60°C)

Power Supply

2 x 9V Alkaline batteries, field replaceable, or $100V_{AC}$ - $240V_{AC}$ wall adaptor, 10W, (optional).

Battery life:	40hrs approx. (batteries not included)

Pressure Transducer

Measurements:	Differential, Static and Gauge Pressure
Connectors:	Barb, 0.5 in (12.7 mm) high. Accepts 1/8 in ID Silicone or Tygon® tubing
Media:	Clean, dry, non-corrosive gases.
Ranges:	See Table 2.
Repeatability:	±0.2% of Full Scale typical (after 1 million full span pressure cycles)
Span temperature coeff.:	±0.2% of Full Scale typical, (maximum shift over 0°C-70°C relative to 25°C reading)
Linearity and Hysteresis:	±0.1% of Full Scale typical
Accuracy at 25°C:	Within ±0.22% of Full Scale using the root sum square method. Transducers calibrated using a dead weight tester based on methodology of BS EN ISO-IEC 17025 and ANSI-CSL Z540-1-1994

Velocity

Probes:	Pitot, Pitot static, S type, RAP etc
K factor:	Variable, set by user, range: 0 to 9.99
Density Correction:	Set by user ($P_{atmospheric}$ and Temperature)

Damping

Automatic and adaptive:	Exponential smoothing or averaging (5 to 75 averages) available

Display

Description:	2 line variable contrast alphanumeric LCD
Viewing area:	0.453 in (11.5 mm) by 1.845 in (46.86 mm)
Pressure units:	Pa, kPa, inH_20, mmHg, inHg, psi, mbar and lb/ft^2.
Velocity units:	m/sec, ft/sec and ft/min.

Output

RS232 serial port interface, 9-pin connector. USB adapter available.

Table 1 Display Resolutions

Unit	Resolution for Transducer Ranges of ±1 inH_2O or lower	Resolution for Transducer Ranges of ±4 inH_2O or higher
Pa	0.1 Pa	1 Pa
kPa	0.0001 kPa	0.001 kPa
inH_2O	0.001 inH_2O	0.01 inH_2O
mmHg	0.001 mmHg	0.01 mmHg
inHg	0.0001 inHg	0.001 inHg
psi	0.0001 psi	0.001 psi
mbar	0.001 mbar	0.01 mbar
lb/ft^2	0.001 lb/ft^2	0.01 lb/ft^2
m/sec	0.01 m/sec	0.1 m/sec
ft/sec	0.01 ft/sec	0.1 ft/sec
ft/min	0.1 ft/min	1 ft/min
m^3/sec	0.0001 m^3/sec	0.001 m^3/sec
ft^3/sec	0.0001 ft^3/sec	0.001 ft^3/sec
ft^3/min	0.001 ft^3/min	0.01 ft^3/min

Table 2 Maximum and Minimum Transducer Velocity Ranges (assuming standard conditions, Patm = 29.92inHg and T = 70ºF) Using Pitot Probe

Pressure Transducer Range	Velocity (m/s)	Velocity (ft/min)
±0.25 inH_2O (±62 Pa)	0.2→ 10.2	40 → 2,004
±1 inH_2O (±248 Pa)	0.8 → 20.4	150 → 4,006
±4 inH_2O (±995 Pa)	1.0 → 40.6	200 → 7,994
±12 inH_2O (±2986 Pa)	1.7 → 70.0	335 → 13,760
-4 to +20 inH_2O (-995 to 4977 Pa)	1.7 → 90.0	335 → 17,656

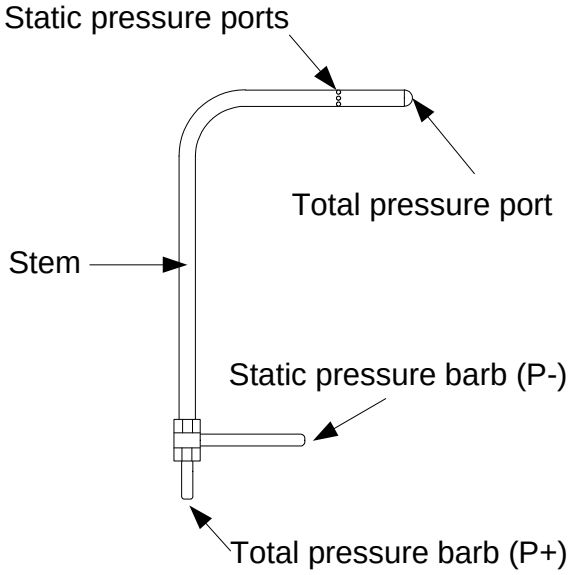
Appendix A Performing a Pitot Probe Duct Traverse

Overview

In this Appendix, use of a Pitot Static probe, in conjunction with the FKS series instrument will be explained. The Pitot Static probe allows the direct measurement of dynamic pressure allowing calculation of the air velocity in ducts, pipes, wind tunnels, etc.

Measurement of Velocity

A Pitot Static probe is shown below



The Pitot Static probe measures the total pressure (or impact pressure) at the nose of the Pitot probe and the static pressure of the air stream at side ports. The difference of these pressures, i.e. the differential (also called dynamic or velocity) pressure ($P_{differential}$) varies with the square of the air velocity. Thus the air velocity may be expressed as:

$$V_{air} = K\sqrt{\frac{2P_{differential}}{\rho}}$$

where ρ is the air density and K is a correction factor (the K factor) dependent on the design of the Pitot Static probe. **NOTE:** This equation is typically valid for incompressible (constant density) flow.

For most Pitot probes, the K factor is 1. For S type (dirty air) probes, K is usually 0.8 to 0.92; refer to the manufacturer's data.

The velocity indicated by the FKS series instrument is corrected by multiplication by K (for a non-unity Pitot Static probe). The instrument automatically performs this correction after storage of the factor K.

Taking Measurements with the FKS Series

CAUTION: The FKS series are not suitable for use with toxic or corrosive gases or for liquid pressure measurement.

Measurement starts with attachment of Silicone or Tygon® tubing to the Pitot Static probe and the pressure transducer barbs. The P+ connection barb of the transducer is connected to the Total pressure port of the Pitot probe, and the Static pressure port of the Pitot probe is connected to the transducers P- barb connection.

The Pitot probe can then be carefully inserted into the airflow. It may be necessary to drill holes into the ducting for insertion.

Pitot Static Probe Duct Surveys

If average duct velocities, or volumetric flow rates are required, it is necessary to perform a Pitot traverse of the duct. This involves taking measurements at various positions across the duct. Before a traverse is conducted, it is necessary to select a suitable location to perform the survey. If possible, avoid traverses close to fans, dampers pipe bends, expansions etc. Try to survey at least 8 duct diameters downstream of the aforementioned elements and 2 duct diameters upstream of these elements. The survey is performed with the aid of Fig. A1. Either the **Centroids of Equal Areas *or* Log-Tchebycheff** point distribution may be used. A survey proceeds as follows:

1. Decide on the number of survey points and then mark these on the Pitot probe using a marker or adjustable spring clips (present on some Pitot Static probes).
2. At the selected survey location, drill two perpendicular holes in the duct (for a round duct) or the desired number of holes for a rectangular duct, ensuring sufficient hole clearance to safely insert the Pitot Static probe.
3. Carefully insert the Pitot Static probe into the duct and position at the first traverse location. Ensure that the Pitot Static probe is aligned with the axis of the duct using the alignment guide on the probe as a reference.
4. Wait for the readout on the display to stabilize. The FKS meter has sophisticated routines for taking measurements in unsteady flows. Either adaptive averaging or exponential averaging/smoothing can be used (averaging only in the Pitot routine). If the readings are still

oscillating significantly, then another measuring point should be considered, as the results may not be representative.

5. When stabilized, record the desired reading(s) (either using the inbuilt traverse routine, or log the reading to memory).
6. Move the Pitot Static probe to the next traversing point and repeat 5 and 7 until the traverse is complete.
7. Repeat for the other traverse locations.

Once the traverse has been completed, the volumetric flow rate through the duct can be calculated as follows. Find the average velocity and then multiplied it by the cross sectional area of the duct to find Q:

Volumetric flow rate (Q):

$$Q = A_{duct} \frac{1}{n} \sum_{i=1}^{n} V_i$$

where: A_{duct} is the duct cross sectional area.
n is the number of points (total number of points surveyed).
V_i is the indicated velocity at each measurement point.

Using a **Centroids of Equal Areas** or **Log-Tchebycheff** point distribution allows the velocity measurements to simply be summed and averaged.
NOTE: Assuming fully developed turbulent flow with low air swirl (rotation), i.e. after a long section of duct, the average duct velocity may be estimated using a single Pitot reading at the center of the duct. The average velocity is then approximately 0.9 of this reading with an accuracy of ±5%.

Guidelines suggest that for a velocity distribution to be acceptable, 75% or more of the velocity pressure measurements must be greater than 10% of the maximum measured velocity pressure of the survey (For specifics regarding validation of surveys, etc, the following references are suggested: (1) ASHRAE. 1988. *Practices for measurement, testing, adjusting and balancing of building heating, ventilation, air-conditioning and refrigeration systems*. Standard 111-1988, Atlanta, GA and (2) AABC. 1989. *National standards, 5th ed., volume measurements*. Washington, D.C.**).**

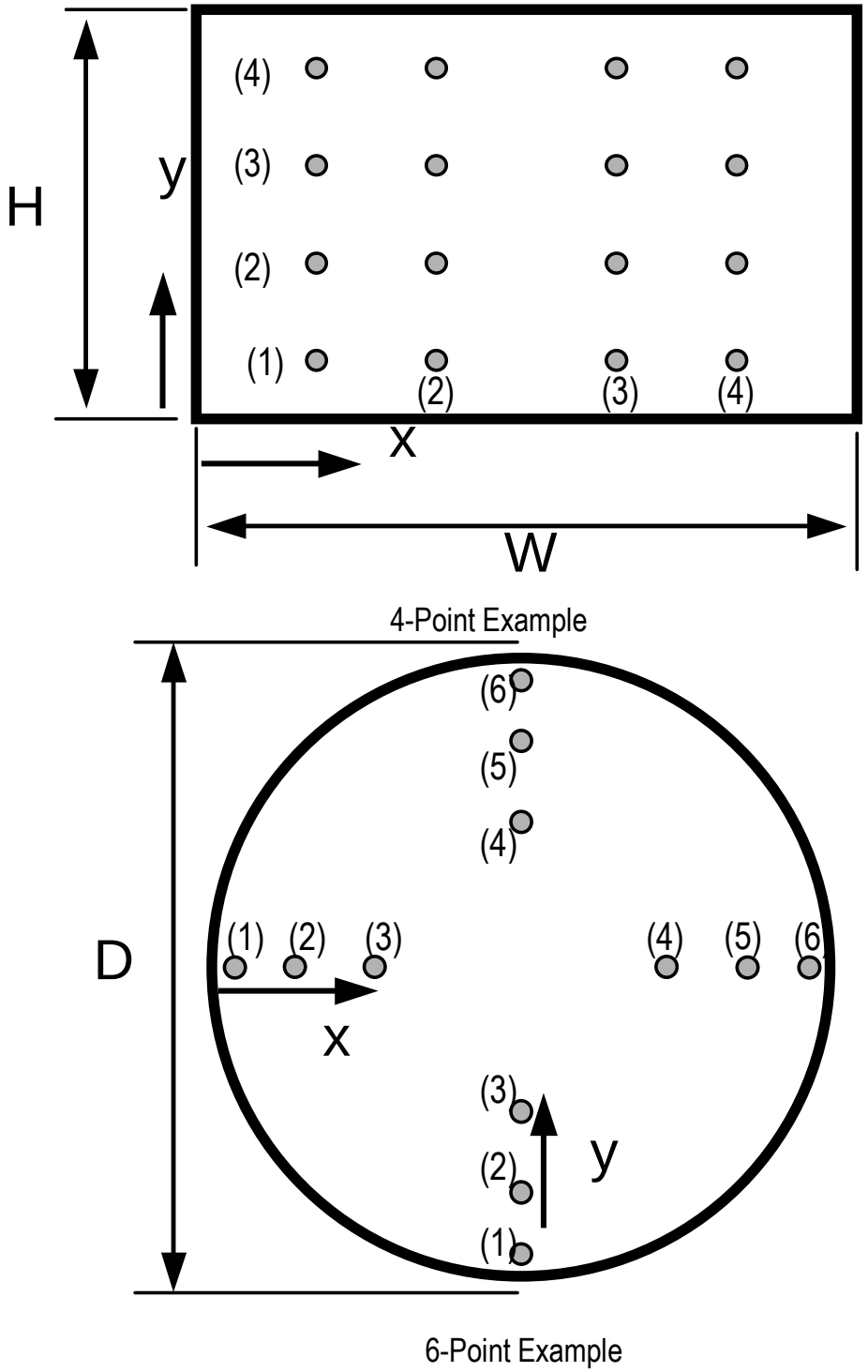


Fig. A1 Traverse points for rectangular and circular ducts. Either Centroids of Equal Areas OR Log-Tchebycheff point distributions can be used.

Rectangular Ducts – Centroids of Equal Areas							
Points	**Distance from wall, x/W or y/H**						
4	0.125	0.375	0.625	0.875			
5	0.100	0.300	0.500	0.700	0.900		
6	0.083	0.250	0.417	0.583	0.750	0.917	
7	0.071	0.214	0.357	0.500	0.643	0.786	0.929

Circular ducts – Centroids of Equal Areas												
Points	**Distance from wall, x/D or y/D**											
6	0.043	0.147	0.296	0.704	0.853	0.957						
8	0.032	0.105	0.194	0.323	0.677	0.806	0.895	0.968				
10	0.026	0.082	0.146	0.226	0.342	0.658	0.774	0.854	0.918	0.974		
12	0.021	0.067	0.118	0.177	0.250	0.356	0.644	0.750	0.823	0.882	0.933	0.979

Rectangular Ducts – Log-Tchebycheff							
Points	**Distance from wall, x/W or y/H**						
5	0.074	0.288	0.500	0.712	0.926		
6	0.061	0.235	0.437	0.563	0.765	0.939	
7	0.053	0.203	0.366	0.500	0.634	0.797	0.947

Circular ducts – Log-Tchebycheff										
Points	**Distance from wall, x/D or y/D**									
6	0.032	0.138	0.312	0.688	0.862	0.968				
8	0.024	0.100	0.194	0.334	0.666	0.806	0.900	0.976		
10	0.019	0.076	0.155	0.205	0.357	0.643	0.795	0.845	0.924	0.981