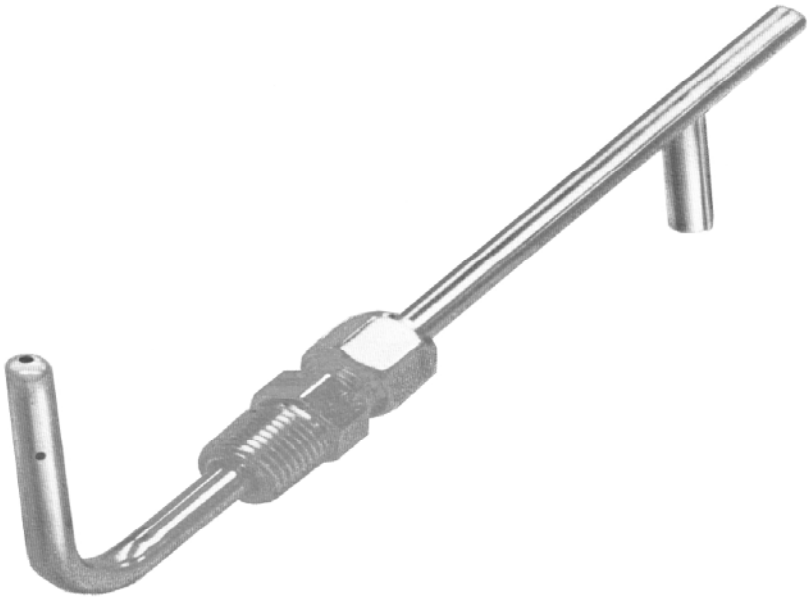
PITOT-STATIC PRESSURE PROBES



FOR MEASURING TOTAL AND STATIC PRESSURES OF A MOVING FLUID

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United Sensor stainless steel Pitot–Static probes sense total and static pressures at the same point in a moving fluid. These measurements are often sufficient for calculating flow velocity and weight flow rate if the density is known. As a fluid's density is often a function of its temperature, it may be necessary to measure temperature in addition to velocity pressure. Pitot – Static probes may standardly be equipped with a thermocouple for simultaneous temperature measurements at the same point in the fluid stream as pressure measurements.
(See Combination Pitot-Static and Temperature Probes)

The shape of the probe measuring tip determines the sensitivity of the Pitot–Static probe to flow angularity (yaw and pitch angle error) caused by flow not parallel to the head. The length of the head governs sensitivity to Mach Number errors; the longer the head, the more accurate the reading over a wide flow range. The two most popular designs for aerodynamic measurements are the modified Prandtl type with a head 14 probe diameters long and the NPL with a head 24 diameters long. There is very little difference in calibration of the two designs, and because the Prandtl type is more compact, it is more generally used. United Sensor Pitot – Static probes are of the modified Prandtl type.

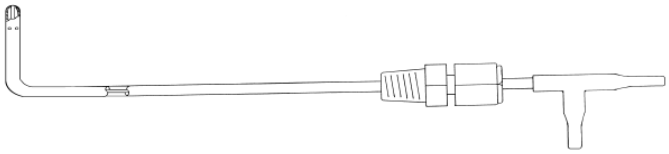
How to Order:

To order standard Pitot–Static probes, select the probe Type (e.g. Type PA, PB, etc.) best matching your application requirements. Then order from the specification chart the ordering Part Number (e.g. PAA-8-KL), which covers the exact specifications shown.

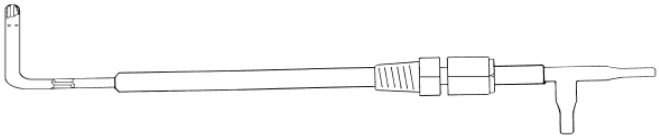
To order non-standard probes (e.g. special lengths, configurations, constructions) consult United Sensor.

SIX BASIC TYPES

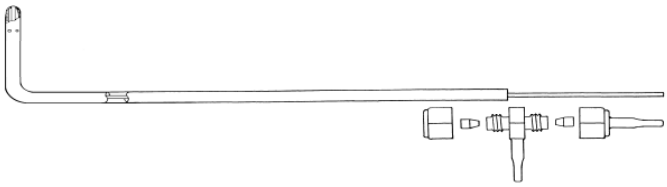
TYPE PA
Fixed Take-Offs, Attached Mounting Chuck, No Reinforcement Tubing.



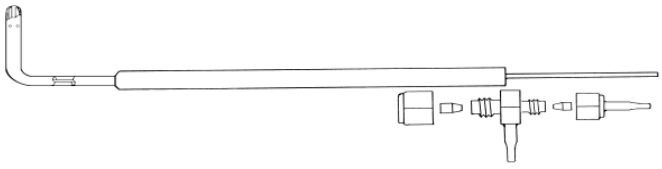
TYPE PB
Fixed Take-Offs, Attached Mounting Chuck, Reinforcement Tubing added.



TYPE PC
Removable Take-Offs, No Mounting Chuck, No Reinforcement Tubing.



TYPE PD
Removable Take-Offs, No Mounting Chuck, Reinforcement Tubing added.



TYPE PS
Senses Static Pressure Only.

TYPE PT
Senses Total Pressure Only.

Properties and Characteristics

MACH NUMBER RANGE

The lower usable limit for Pitot-Static probes depends on the sensitivity of the readout device used with the probe. A differential pressure of 1" of water, for example is about the minimum that can be measured with 1% accuracy with ordinary slant gauges, so the lower limit is approximately at a Mach Number of 0.06 or velocity of 70 ft/sec for air at standard atmospheric conditions. While there is no minimum Mach Number for the probe itself, there are viscous drag effects that should be considered when using a probe in a low velocity fluid field. (See Reynolds Number Range). The upper limit is at about Mach 0.95 for the total pressure reading and 0.70 for the static as shown in Figure 1. The static reading is accurate to 0.5% to a Mach Number of 0.50 and to 1.5% up to Mach 0.70. At this point the calibration becomes erratic due to the formation of local shock waves on and around the tip of the probe and the reading can vary as much as 10% with slight changes in flow conditions or proximity to solid boundaries. Above Mach 1.0 both the total and static readings vary considerably from true stream values but they can be corrected theoretically.

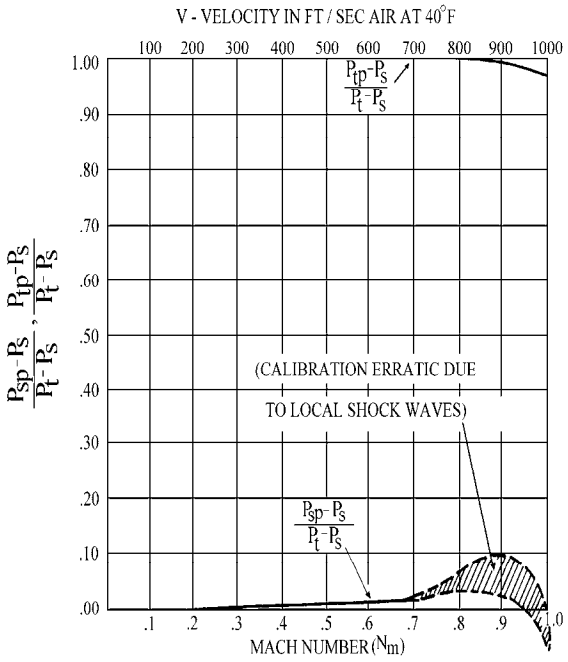


Figure 1. Mach Number Range

Pt Total pressure (impact / stagnation pressure)
Ps Static pressure (ambient / stream pressure)
Ptp Indicated total pressure
Psp Indicated static pressure

YAW AND PITCH ANGLE RANGE

If the fluid stream is not parallel to the probe head, errors occur in both total and static readings. These are the most important errors in this type of instrument because they cannot be corrected without taking independent readings with another type of probe.

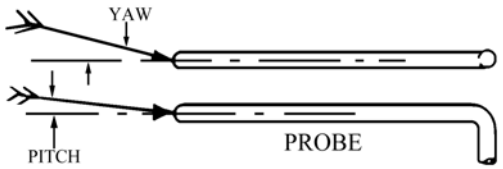


Figure 2 shows the errors in total and static pressure, velocity, and weight flow at various yaw and pitch angles.

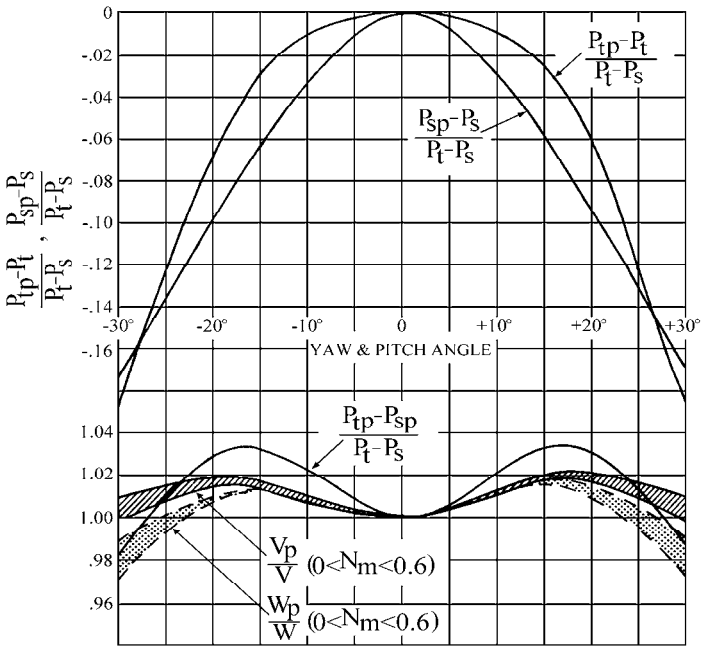


Figure 2. Yaw and Pitch Angle Error

VP Indicated velocity calculated from Ptp and Psp using standard equations.
W Weight flow rate – lbs. sec x ft²
Wp Indicated weight flow rate from Ptp and Psp

Note that yaw and pitch angle affect the readings exactly the same. The errors in total and static pressure increase quite rapidly for angles of attack higher than 5°, but they tend to compensate each other so the probe yields velocity and weight flow readings accurate to 2% up to angles of attack of 30°. This is the chief advantage of the Prandtl design over other types.

BOUNDARY EFFECTS

The static pressure indication is sensitive to distance from solid boundaries. Figure 3

shows how this error increases the indicated velocity pressure at a Mach Number 0.25. The probe and boundary form a Venturi passage, which accelerates the flow and decreases the static pressure on one side. The curve shows that static readings should not be taken closer than 5 tube diameters from a boundary for 1% accuracy and 10 tube diameters is safer.

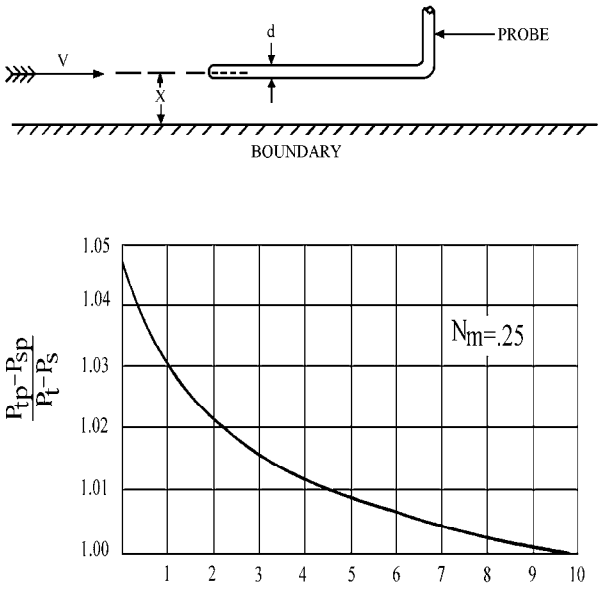


Figure 3. Boundary Effects

REYNOLDS NUMBER RANGE

Pitot-Static probes are not directly affected by Reynolds Number except at very low velocities. Therefore, in liquids where compressibility effects are absent, their calibration is substantially constant at all velocities.

The minimum Reynolds Number for the total pressure measurement is about 30 where the characteristic length is the diameter of the impact hole. Below this value the indicated impact pressure becomes higher than the stream impact pressure due to viscosity effects. This error is only noticeable in air under standard atmospheric conditions for velocities under 12 ft/sec with impact holes 0.010" diameter or less.

TURBULENCE ERRORS

Pitot-Static tubes appear to be insensitive to isotropic turbulence, which is the most common type. Under some conditions of high intensity, large scale turbulence, could make the angle of attack at a probe vary over a wide range. This probe would presumably have an error corresponding to the average yaw or pitch angle produced by the turbulence.

TIME CONSTANT

The speed of reading depends on the length and diameter of the pressure passages inside the probe, the size of the pressure tubes to the manometer, and the displacement volume of the manometer. The time constant is very short for any of the standard tubes down to 1/8" diameter; however, it increases rapidly for smaller diameters. For this reason 1/16" OD is the smallest recommended size for ordinary use – this will take 15 to 60 seconds to reach equilibrium pressure with ordinary manometer hook-ups. These tubes have been made as small as 1/32" OD, but their time constant is as long as 15 minutes and they clog up very easily with fine dirt in the flow stream. If very small tubes are required, it is preferable to use separate total and static tubes rather than the combined total-static type. Where reinforcing stems are specified on small sizes, the inner tubes are enlarged at the same point to ensure minimum time constant.

INSTALLATION INFORMATION

Probes are installed in the fluid stream with the impact hole facing upstream, the head parallel to the flow direction and the stem perpendicular. Types PA and PB (Fig. 4) are well suited to mounting on thin – walled ducts where the probe is to be inserted from the outside. Types PC and PD (Fig. 5) are designed with removable pressure take-offs. This allows for installation from within the duct where it is not practical to make an insertion hole diameter equal to the length of the probe tip. Figure 6 shows a correlation between probe diameter and minimum wall insertion dimensions for a probe with fixed take-offs.

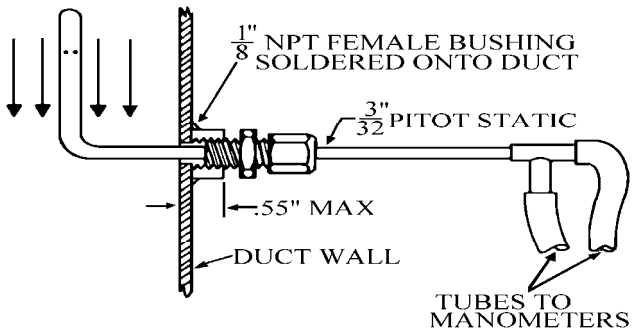


Figure 4. Thin Wall Installation

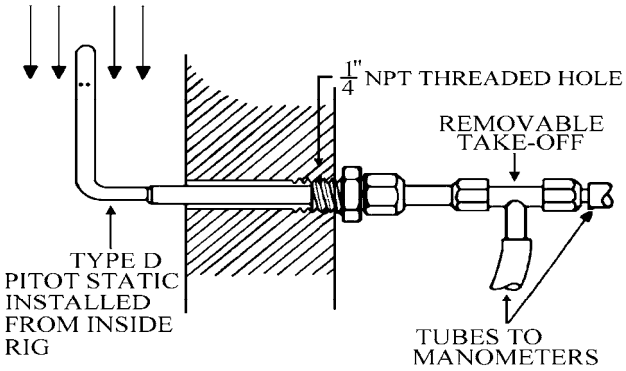


Figure 5. Thick Wall Installation

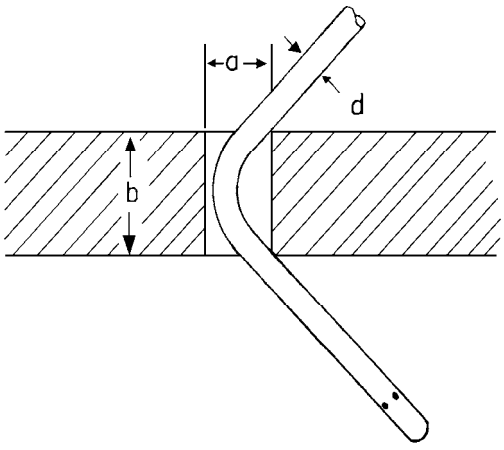


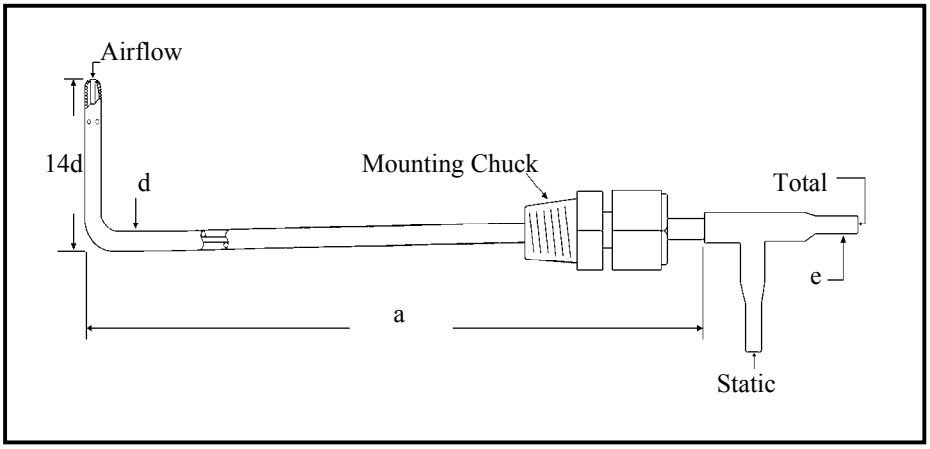
Figure 6. Limiting Lengths and Diameters

- The dimensions a, b, and d should satisfy the following:
  d □5.8 x a – 2.9 x b
- The smaller d is than the result of 5.8 x a – 2.9 x b, the easier the insertion thru a.

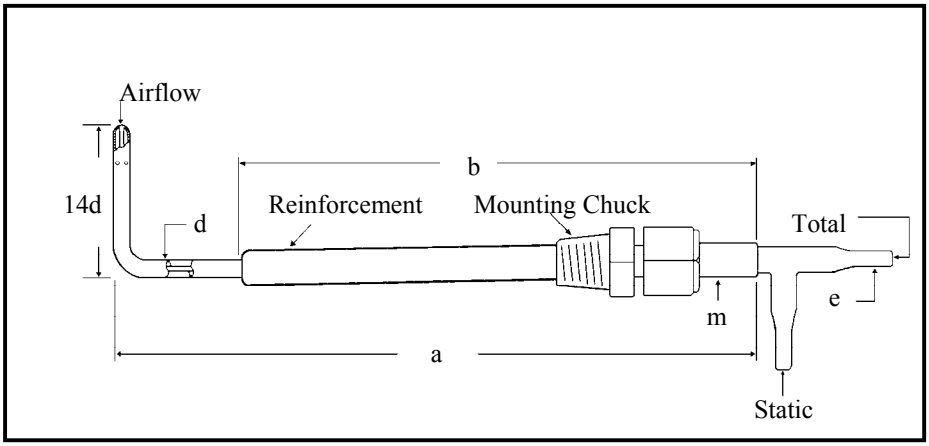
CHOOSE FROM A BROAD SELECTION OF STANDARD PITOT – STATIC MODELS

Ordering Part Number	Sensing Stem Diameter d	Probe Length a	Reinforcement		Pressure Take-Off Diameter e	Tip Joining Compound		Mounting Chuck	
			Diameter m	Length b		Metal Filler	Maximum Operating Temp.	Material	Thread
PAA-“a”-KL	1/16"	Standard Lengths are 8" 12" 18" 24"			5/32" Swaged down to 1/8"	Nicrobraz	1500°F	Stainless Steel	1/8" NPT
PAB-“a”-KL	3/32"								
PAC-“a”-KL	1/8"								
PAD-“a”-KL	3/16"								
PAE-“a”-M	1/4"				1/4"				1/4" NPT
PAE-“a”-M-W						Weld	2000°F		
PBA-“a”-F-“b”-KL	1/16"		1/8"	6" to 22"	5/32" Swaged down to 1/8"	Nicrobraz	1500°		1/8" NPT
PBB-“a”-F-“b”-KL	3/32"								
PBC-“a”-G-“b”-KL	1/8"		1/4"						1/4" NPT
PBD-“a”-G-“b”-KL	3/16"								
PBE-“a”-H-“b”-M	1/4"		3/8"		1/4"				3/8" NPT
PBE-“a”-H-“b”-M-W						Weld	2000°F		

Type PA:



Type PB:



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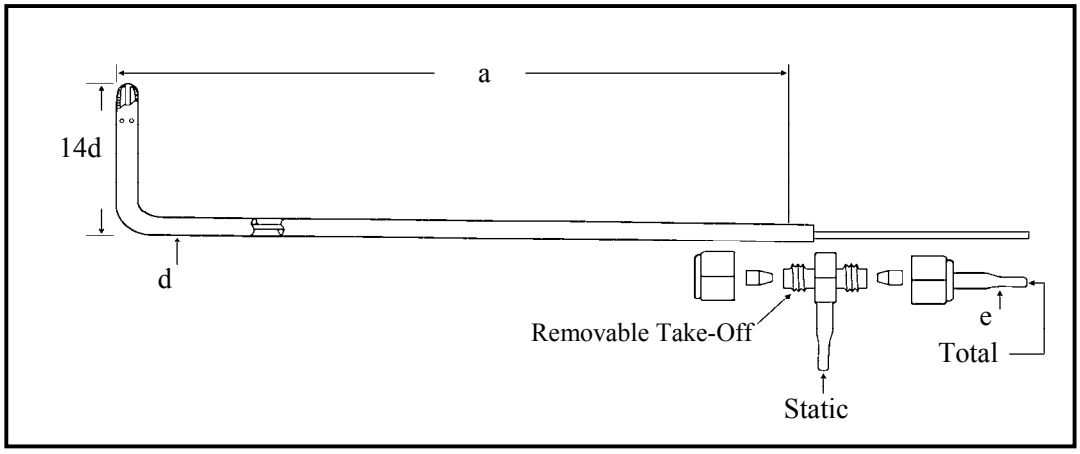
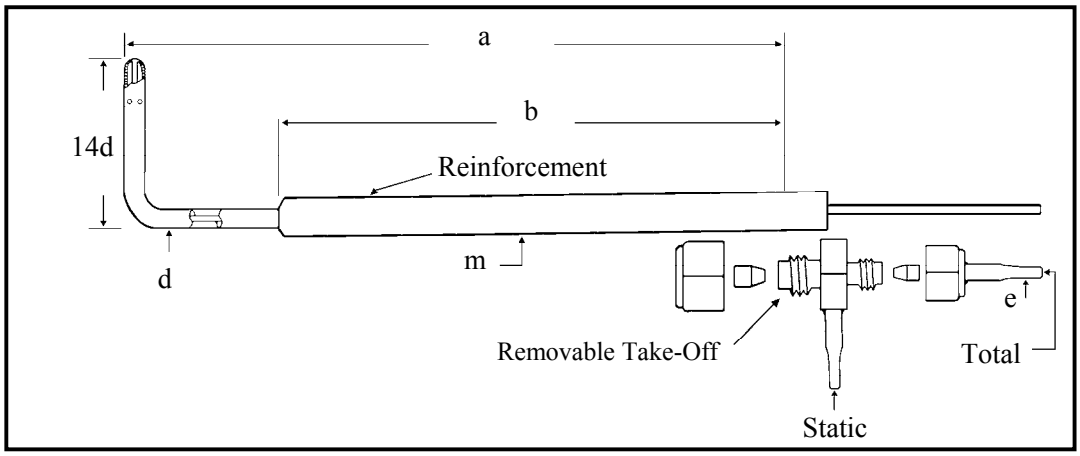
Ordering Part Number	Sensing Stem Diameter d	Probe Length a	Reinforcement		Pressure Take-Off Diameter e	Tip Joining Compound		Removable Take-Off Material	Ferrule Type
			Diameter m	Length b		Metal Filler	Maximum Operating Temp.		
PCA-“a”-KL	1/16"	Standard Lengths are 8" 12" 18" 24"			5/32" Swaged down to 1/8"	Nicrobraz	1500°F	Stainless Steel	Teflon
PCB-“a”-KL	3/32"								
PCC-“a”-KL	1/8"								
PCD-“a”-KL	3/16"								
PCE-“a”-M	1/4"				1/4"				
PCE-“a”-M-W						Weld	2000°F		
PDA-“a”-F-“b”-KL	1/16"		1/8"	6" to 22"	5/32" Swaged down to 1/8"	Nicrobraz	1500°		
PDB-“a”-F-“b”-KL	3/32"								
PDC-“a”-G-“b”-KL	1/8"		1/4"						
PDD-“a”-G-“b”-KL	3/16"								
PDE-“a”-H-“b”-M	1/4"		3/8"		1/4"				
PDE-“a”-H-“b”-M-W						Weld	2000°F		

Type PC:



Type PD:



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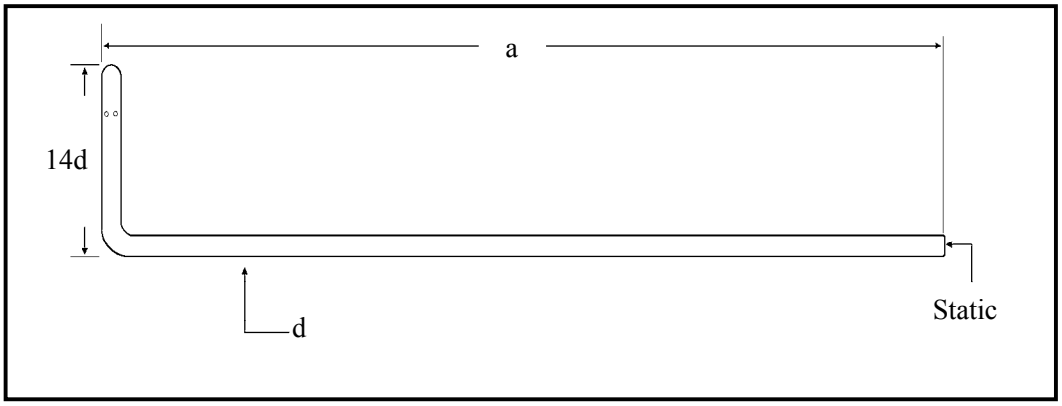
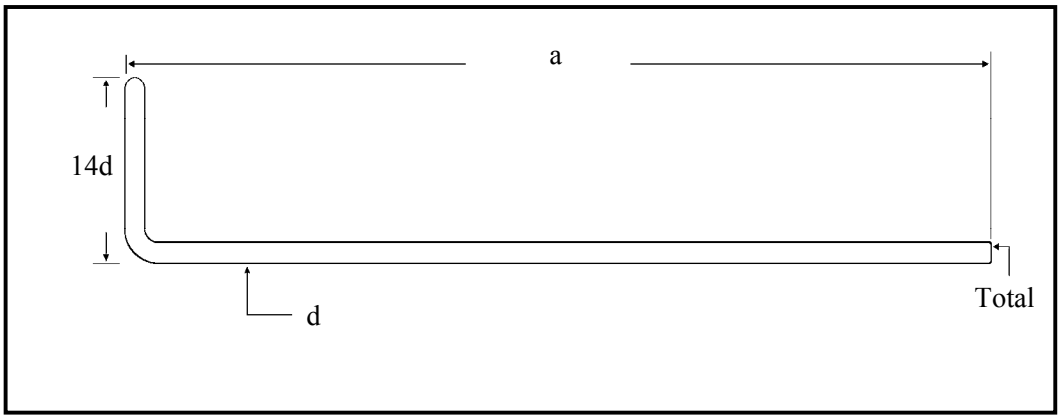
CHOOSE FROM A BROAD SELECTION OF STANDARD PITOT – STATIC MODELS

Ordering Part Number	Sensing Stem Diameter d	Probe Length a	Reinforcement		Pressure Take-Off Diameter e	Tip Joining Compound		Mounting Chuck	
			Diameter m	Length b		Metal Filler	Maximum Operating Temp.	Material	Thread
PSA-“a”	1/16"	Standard Lengths are 8" 12" 18" 24"	Optional		Same as the Probe Diameter	Nicrobraz	1500°F	Optional	
PSB-“a”	3/32"								
PSC-“a”	1/8"								
PSD-“a”	3/16"								
PSE-“a”	1/4"								
PTA-“a”	1/16"								
PTB-“a”	3/32"								
PTC-“a”	1/8"								
PTD-“a”	3/16"								
PTE-“a”	1/4"								

Type PS:



Type PT:



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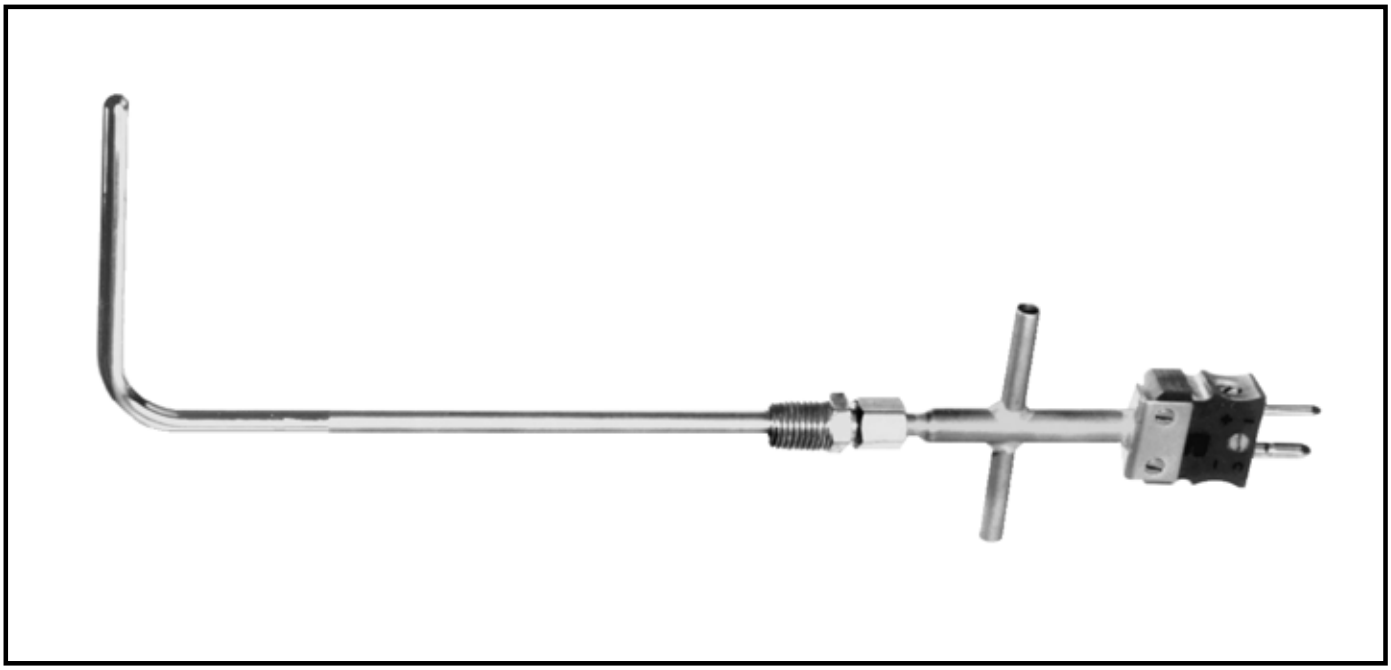
Combination Pitot-Static and Temperature Probes



Description

This versatile stainless steel Pitot-Static Probe is equipped with a built-in thermocouple for measuring total temperature as well as total and static pressures at the same point in a fluid stream. Such a dual capability permits immediate calculation of flow velocity, weight flow rate, density, viscosity, available energy and other related properties of the moving fluid.

Capabilities

United Sensor Pressure / Temperature probes may be customized to meet industrial and research applications ranging from in-plant fluidic testing to subsonic flow measurements to engine performance analysis. Standard outside diameters are 1/8", 3/16" and 1/4" with other sizes available upon request.

Variations

A wide selection of variations permits custom designing to meet exact specifications. These include special constructions for high operating temperatures and pressures; longer or shorter probe lengths; larger diameter tubing; thermocouple jacks; lead wires. Consult United Sensor for custom applications.

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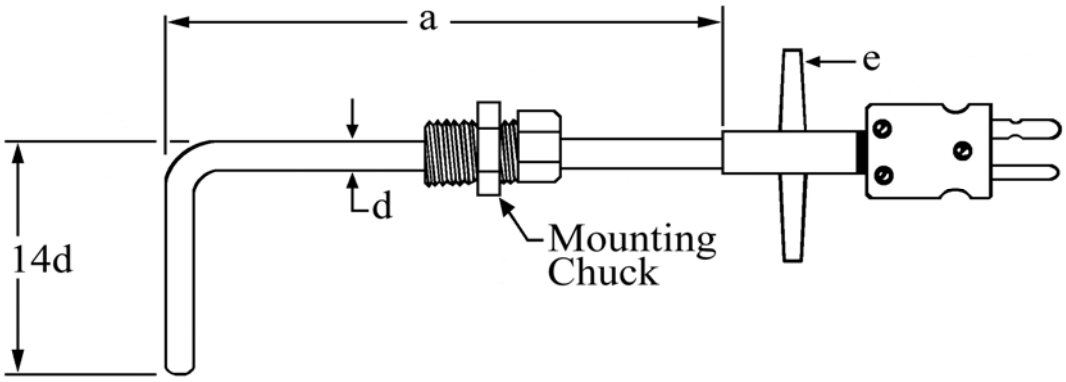
Select from these model specifications

Part Number Diameter	Diameter (see “d”)	Length (see “a”)	Mounting Chuck Thread	Take-Off (see “e”)
Type PAC-T				
PAC-T-8-*-KL	1/8"	8"	1/8" NPT	1/8"
PAC-T-12-*-KL	1/8"	12"	1/8" NPT	1/8"
PAC-T-18-*-KL	1/8"	18"	1/8" NPT	1/8"
PAC-T-24-*-KL	1/8"	24"	1/8" NPT	1/8"
Type PAD-T				
PAD-T-8-*-KL	3/16"	8"	1/8" NPT	1/8"
PAD-T-12-*-KL	3/16"	12"	1/8" NPT	1/8"
PAD-T-18-*-KL	3/16"	18"	1/8" NPT	1/8"
PAD-T-24-*-KL	3/16"	24"	1/8" NPT	1/8"
Type PAE-T				
PAE-T-8-*-KL	1/4"	8"	1/4" NPT	1/8"
PAE-T-12-*-KL	1/4"	12"	1/4" NPT	1/8"
PAE-T-18-*-KL	1/4"	18"	1/4" NPT	1/8"
PAE-T-24-*-KL	1/4"	24"	1/4" NPT	1/8"

*** Thermocouple wire type, please specify calibration: K, J, T, E.**



Straight and Custom Pitot Temperature Probes are also available.

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