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Measuring Air Velocities and Flow with the RAP Probe

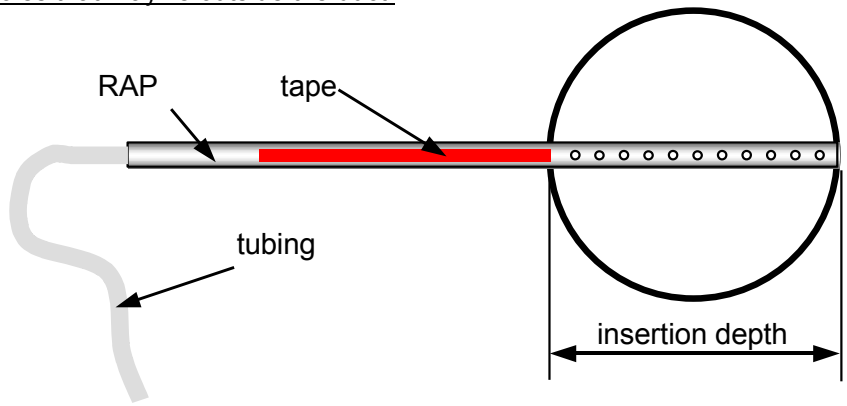
The RAP probe (Rapid Averaging Probe) is designed for fast and accurate measurements of average velocity in ductwork. The probe averages the stagnation (impact) pressure across the duct allowing for the calculation of average velocity; and consequently air flow.

Required Tools

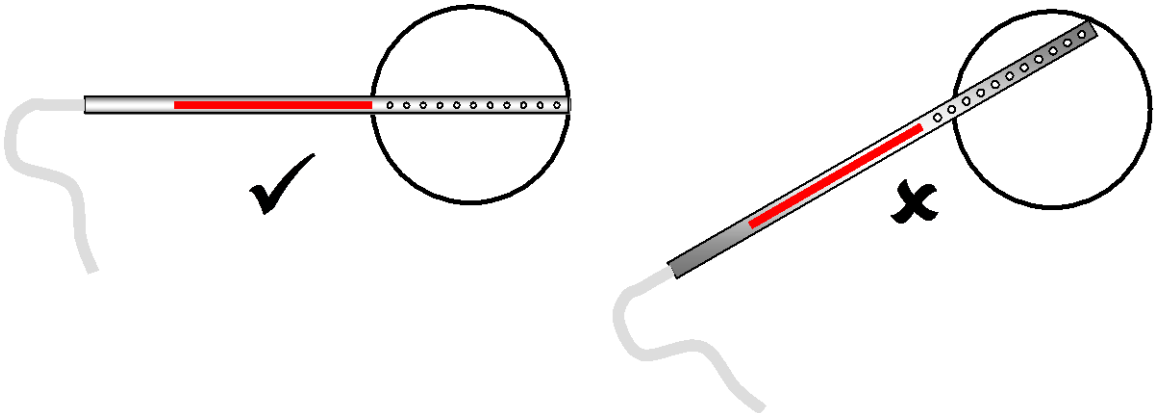
1. RAP probe
2. Length of flexible tubing
3. Adhesive tape (electrical tape or similar non-porous tape)
4. Manometer or pressure measurement instrument

Setup

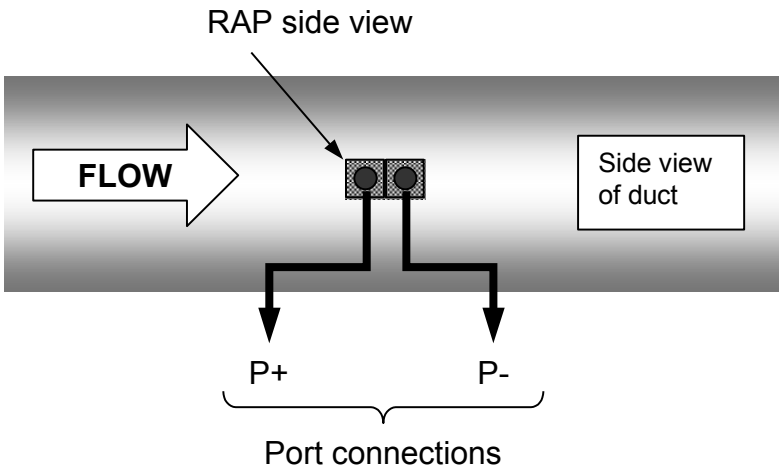
1. Measure the internal width or diameter of the duct to be surveyed (this is the insertion depth).
2. Mark the insertion depth on the RAP probe.
3. Use the adhesive tape to seal over the pressure ports that would lie outside the duct. Make sure that you tape over the ports on both the front and back of the probe. Ensure that the tape is smoothly attached and covers all holes that may lie outside the duct.

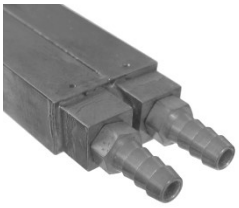


4. Always insert the RAP probe the full internal width or diameter of the duct. Try to ensure that the probe is perpendicular to the duct walls.



5. The RAP probe measures the total or impact pressure as well as a static pressure in the duct.
6. Connect the upstream facing port barb of the RAP probe to the **P+** port on your manometer and the downstream facing port barb to the **P-** port (sometimes called “reference”) on your manometer.

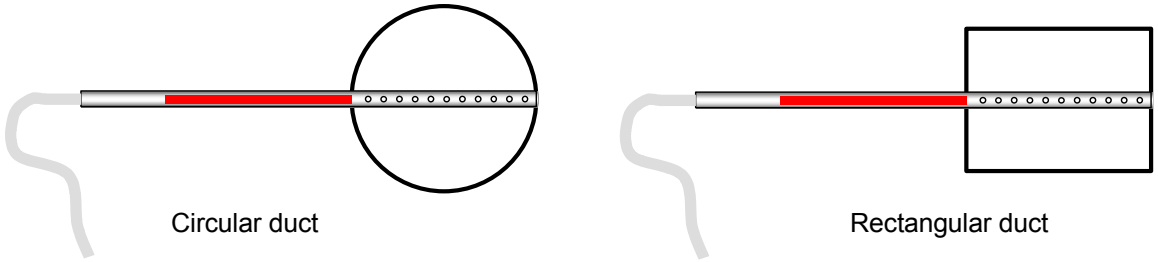




RAP barbs

Taking Velocity Measurements: Single Row

1. See setup section
2. A single velocity measurement can be taken by inserting the RAP probe at a single location. The probe should go through the center of the duct.
3. Slowly rotate the RAP probe back and forth until the greatest differential pressure or velocity is shown on your manometer. Read this value.

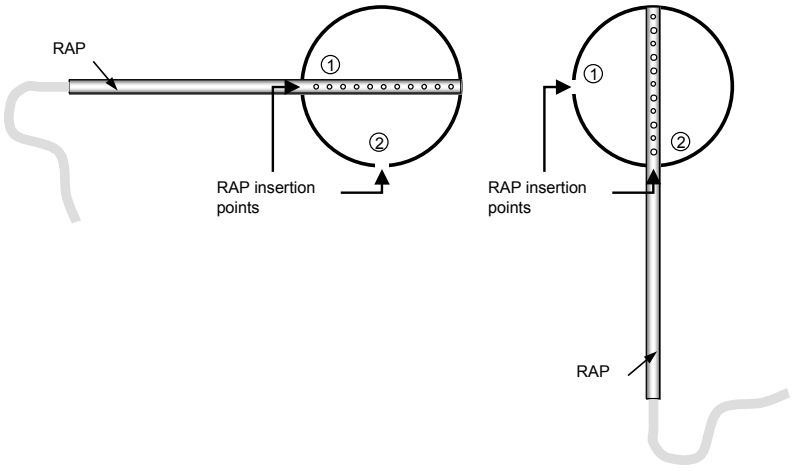


Taking Velocity Measurements: Survey

Before starting see setup section. Conducting a survey using the RAP probe is similar to performing a survey using a Pitot static probe.

Round Duct

1. At the measurement location (see Guidelines below) drill two perpendicular holes large enough to allow the RAP to pass through.
2. Insert the RAP into one hole. Make sure that the total pressure holes on the RAP probe face into the air stream.
3. Rotate the RAP slowly until you read the largest differential pressure or velocity. Read the value.
4. Position the RAP probe in the second hole and read the indicated value. Sketch shows RAP probe positioning for two-point traverse of a round duct.



Rectangular Duct

To take measurements in a rectangular duct it is common to divide the duct up into equal areas. A measurement point is then located at the centroid of each equal area. When using a standard Pitot probe, the Pitot would be positioned at each measurement point. For a survey with a 7 × 7 grid, a total of 49 readings is necessary. To use the RAP probe, a similar spacing of measurement points is used (either centroids of equal areas or Log-Tchebycheff, see below) to a standard Pitot survey. However, for the example mentioned above, only 7 insertions would be required, one for each row, as each insertion measures the velocity across the entire duct width.

1. Decide on how many points (N) you would like to use (4,5,6 or 7).
2. At the measurement location (see Guidelines below) drill N points in one side of the duct, use the point spacing from Table 1 OR Table 2.
3. Insert the RAP probe into the top hole.
4. Rotate the RAP slowly until you read the largest differential pressure or velocity. Take the reading.
5. Move the RAP probe to the next hole down and take the reading. Repeat until all velocities have been measured.

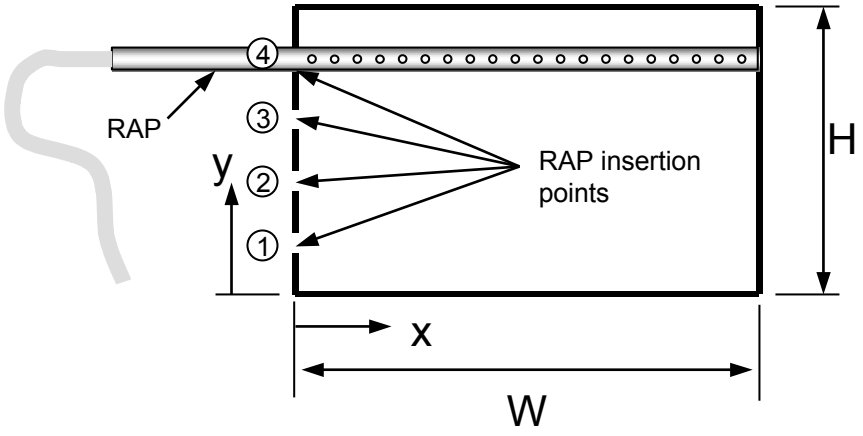


Table 1. Rectangular Ducts – Centroids of Equal Areas							
Points	**RAP insertion point along wall, x/W or y/H**						
4	0.125	0.375	0.625	0.875			
5	0.100	0.300	0.500	0.700	0.900		
6	0.083	0.250	0.417	0.583	0.750	0.917	
7	0.071	0.214	0.357	0.500	0.643	0.786	0.929

Table 2. Rectangular Ducts – Log-Tchebycheff							
Points	**RAP insertion point along 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

Processing Your Measurements to Find Average Velocity and Flow Rate

To find the velocity from each pressure reading you can use the following equation to find the velocity:

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

Where K is the RAP calibration factor. **K = 0.77 for a RAP shorter than 36 inches overall. K = 0.8 if the RAP is longer than 36 inches overall.**

$P_{differential}$ is the differential pressure measured by your manometer

ρ = air density in the duct

For standard conditions (70ºF and 29.92inHg), velocity (ft/min) may be calculated from the differential pressure (inH_2O) using

$$V = K \times 4004.4\sqrt{P_{differential(inH2O)}}$$

where $P_{differential(inH2O)}$ is the pressure, in inches of water, measured using your manometer.

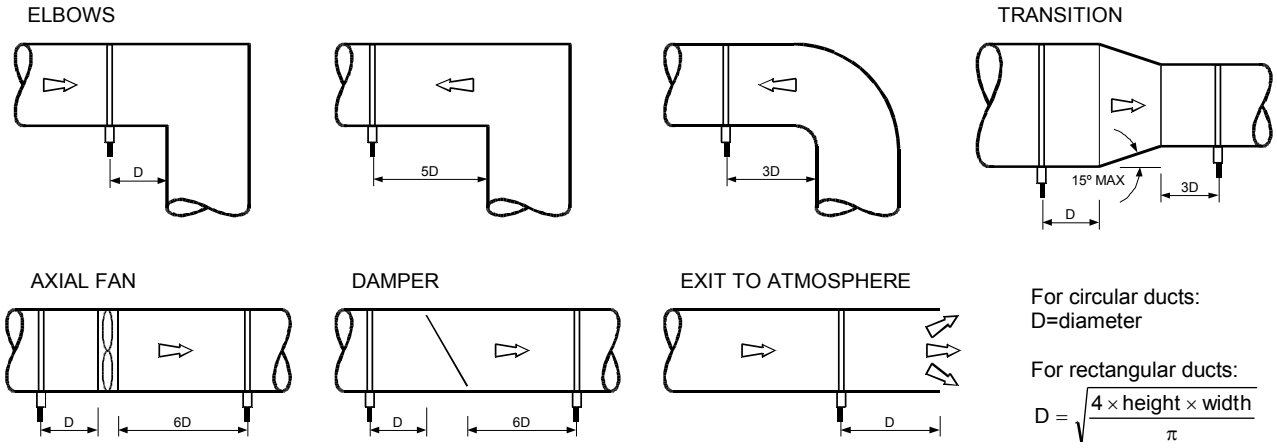
If you are using one of FlowKinetics manometers you can enter K as the flow probe coefficient and the manometer will display the corrected velocity automatically.

After determining the velocities at each reading, the average duct velocity is found by averaging the readings, i.e.Vave = (V1+V2)/2 for a round duct, or $Vave_{(N=4)}$ = (V1+V2+V3+V4)/4, $Vave_{(N=5)}$ = (V1+V2+V3+V4+V5)/5, etc, for a rectangular duct. If you had a single row reading then the average velocity is given by the single reading taken.

The volumetric flow rate (Q) is then calculated by multiplying the average velocity by the cross sectional area of the duct (A), i.e. Q = Vave × A. Remember to be consistent with units.

Guidelines for Measurement Location

The minimum installation requirements for the RAP probe for velocities of 2000 ft/min or less are shown below. Increase requirements by one diameter (D) for each additional 1000 ft/min. Always place the probe as far away as possible from duct disturbances.



Specifications

- Accuracy: ±3% of actual flow rate, even in moderately unsteady flows (when positioned in compliance with suggested recommendations)
- Speed Range: 300 fpm – 15,000 fpm (1.5 m/sec – 76 m/sec)
- Maximum temperature: 572ºF (300ºC)
- Construction: Brass
- Insertion Depth: 9” to 36” (23 cm – 91 cm)

Maintenance

- Tape attached to the probe should not be left for more then 1-2 days otherwise sticky residue may remain when removing the tape, affecting sealing.
- When wiping the probe, ensure that the cloth does not leave residue in the ports.
- The probe can be “back purged” by passing compressed air through the handle. Do not use pressures above 35psi.

Limitations of Usage and Cautions

FlowKinetics™ LLC's products including, but not limited to, instruments, sensors, probes and accessories 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 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.

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 FlowKineticsTM LLC, relating to any liability in respect of the product.