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TRANSDUCER SHADOW CORRECTION FOR APPLIED TECHNOLOGIES' SONIC K-PROBE

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In the K-probe, as in many sonic probes available today, the transducers at the ends of its acoustic paths cast a "shadow" on the paths, causing the measured wind velocity component along the path to be underestimated. The degree of attenuation is a function of the angle between the wind direction and the acoustic path which increases with decreasing angle, reaching a minimum at 0°. At angles close to 90°, there is virtually no attenuation.

The exact functional form for the attenuation varies with probe design. For the K-probe, the form is approximated by two straight line fits based on wind tunnel tests conducted by C.B. Baker (personal communication, 1989):

$$\begin{aligned} V_d\left(0.84 + 0.16\,\theta/70\right) \quad &; \quad 0° \le \theta \le 70° \\ \left(V_d\right)_m = V_d \quad &; \quad 70° \le \theta \le 90° \end{aligned} \tag{1}$$

where $(V_d)_m$ and V_d are the measured and true wind components along the path, and θ is the angle between the instantaneous wind direction and the path. The form would be symmetrical in either direction as shown in Figure 1. The two horizontal wind components are corrected for this attenuation immediately following the calculation of wind velocity from the reciprocals of the transit times by the sonic anemometer's microprocessor.

$$V_d = \left(d/2\right)\left(1/t_1 - 1/t_2\right) \tag{2}$$

where d is the path length and t_1 and t_2 are the travel times for sound pulses moving downwind and upwind, respectively. No correction is applied to the vertical velocity because wind elevation angles seldom exceed ±20° in the first 30 m or so above the ground.

A fixed 18.3-μs delay is subtracted from t_1 and t_2 to compensate for delays introduced in the transducers. This procedure, while important for the temperature calculation, (see WPL Application Note No. 3), has only a negligible effect on the velocity calculation.

In many wind tunnel studies, the response to flow distortion in a sonic anemometer probe is presented in the form of total wind speed measured by the probe divided by the wind tunnel speed. For comparison with such data, the uncorrected speed measured by the K-probe at 0° elevation as a function of azimuth angle is shown alongside the individual axes response in Figure 1. The curve rises to a maximum of 0.94 at ±45° and dips to a minimum of 0.84 at 0° and ±90°. Uncorrected wind speeds can therefore be expected to be 10% lower, on the average, than the true wind speeds.

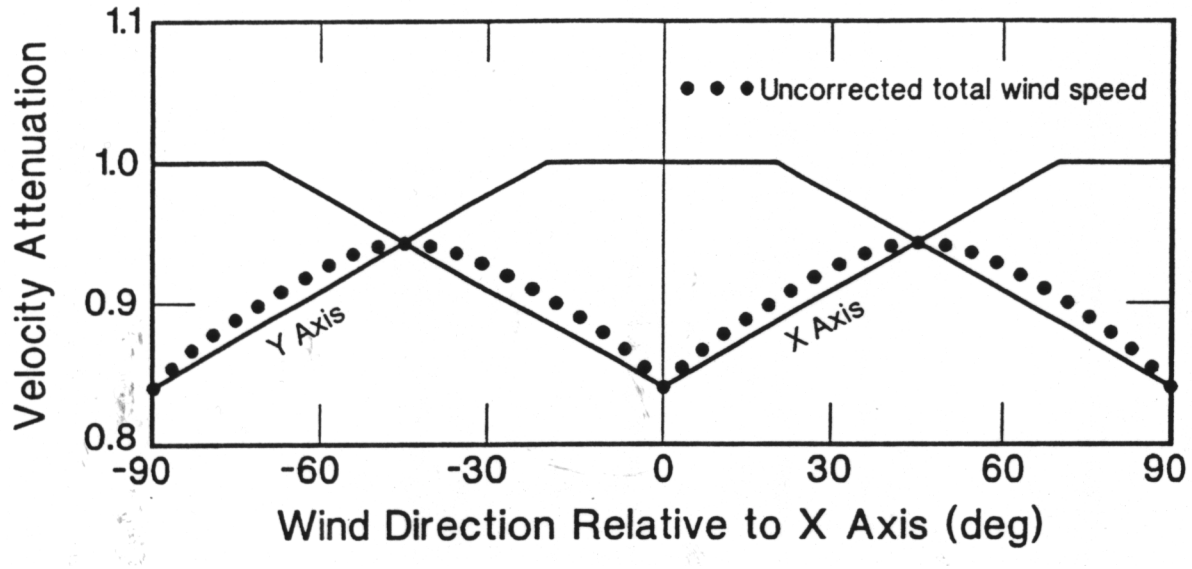

Figure 1. Velocity attenuation in the ATI K-probe from transducer shadowing is shown as a function of azimuth angle relative to the X axis (parallel to the support boom). Also shown is attenuation in the total wind speed from the combined attenuations along the X and Y axes.

NOTE UPDATE

Later instrument designs have also taken into account the shadow correction of the vertical velocity (w) component, even though it is considered minimal.