LOW SPEED PROPELLER ANEMOMETERS

Introduction

Low speed propeller anemometers were the first types of commercially available wind gauges for use in athletics. Cantabrian was a well-known brand in the early days but is no longer made. Other makes of propeller wind gauges specifically for athletics purposes are commercially available.

The purpose of this paper is to note the shortcomings in this type of instrument.

Description

The low speed anemometer is characterised by having a low friction and the starting torque due to the wind is large compared with the resisting friction torque. Also the instrument must be able to follow rapid fluctuations in wind speed.

The athletics propeller wind gauge has a propeller rotating in a vertical plane midway in a cylindrical tube. Rule 163.11 now requires that the length of the tube on either side of the measuring device be a t least twice the diameter of the tube. There is a correlation between the number of revolutions of the propeller and the wind velocity.

A typical well-made anemometer will have a near straight-line relationship between true wind speed and indicated wind speed except at very low speeds less than 0.3 m/s when there is a frictional effect. Calibration tests establish the actual relationship.

Effect of Variations in Air Density

Ower and Pankhurst[1] have shown, from their examination of the characteristics of numerous propeller anemometers, that the error in the measured velocity will be less than 1 percent if

$$|\sqrt{(\rho_0/\rho_1)} - 1| < V/61$$

The limits of the variation of the density ratio ρ_0/ρ_1 calculated using the above formula are as shown in the table hereunder.

V m/s	Limits of ρ_0/ρ_1
0.5	0.98-1.02
1.0	0.97-1.03
1.5	0.95-1.05
2.0	0.93-1.07
3.0	0.90-1.10

ρ_0 is the air density for which the anemometer was calibrated and ρ_1 is the air density when a velocity measurement is taken.

Air density varies with temperature, pressure and humidity.

If the anemometer is calibrated at 20^0C the ρ_0/ρ_1 ratios would be approximately 1.07 and 0.97 respectively for temperatures of 40^0C and 10^0C respectively. Therefore if a velocity of 2 m/s were taken as the velocity of most interest for us, from the above table the error in the measured velocity would be less than 1 percent for a range of temperatures. Similarly the effect of varying atmospheric pressure and relative humidity at or near sea level on density is even smaller. Of course all these effects could be cumulative.

The situation where air density becomes significant is at elevation. The densities in kg/m^3 for a standard atmosphere are given in the table below.

Altitude m	Density ρ Kg/m^3	ρ_0/ρ_1
0	1.225	1.00
500	1.1673	1.049
1000	1.1116	1.102
1500	1.0581	1.158
2000	1.0065	1.217
2500	0.9569	1.280
3000	0.9091	1.347

Thus it can be seen that if a wind gauge is calibrated at sea level then there starts to be significant error when the wind gauge is used at over 1000m altitude. This means that a wind gauge used at altitude should be calibrated for the altitude to eliminate this error.

Effect of Gusting Wind

Ower and Pankhurst [1] have shown that the speed indicated by an anemometer in a pulsating wind overestimates the true average wind speed by about 8 percent. In natural winds the situation is much more complex as there is no dominant natural frequency.

Effect of Crosswind

By far the greatest problem is the effect of a crosswind. A Finnish study [2] has shown that as the angle of the crosswind to the axis of the tube increases propeller anemometers overestimates the velocity by up to 30 percent.

Other Possible Error Sources

There should be no obstacle near the wind gauge that could cause disturbance to the wind flow. This means that a wind gauge operator seated near the gauge or a scoreboard could be an obstacle.

The wind component we are interested in is parallel to the runway or the sprint track as the case may be. If the tube of the wind gauge is not parallel to the runway then there will be a velocity underestimation error depending on the cosine of the angle deviation as shown in the table below.

Deviation Angle	Percentage Error
1^0	0.02
2^0	0.06
3^0	0.14
4^0	0.24
5^0	0.38

Thus it will be seen that the error is small compared with other possible errors.

Accuracy

The 95% confidence accuracy of commercially available sensitive propeller anemometers is stated (3) to be ± 0.2 to ± 0.5 m/s.

Conclusion

Whilst propeller anemometers have been the most used wind gauges for athletics their susceptibility to errors of various kinds, but particularly in a crosswind, should preclude their use in high level IAAF competitions.

Further the effect of altitude on air density and consequently on the measured air velocity means that wind gauges used at altitude should be calibrated for the altitude at which the gauge is used.

Recommendations

1. Only ultrasonic wind gauges shall be used at IAAF competitions under Rule 12.1(a), (b), (c) and (d) and it is desirable that such wind gauges also be used at all other International Meetings.
2. At locations with an altitude of 1000 m or greater, any propeller anemometers shall be calibrated for that altitude.

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1. Ower E and Pankhurst R C, The measurement of air flow, 4th edition, Oxford, New York, Pergamon Press [1966].
2. Helle L, Calibration Results of Wind Gauges, VTT Manufacturing Technology communication 25 January 1997.
3. AS 2923 - 1987, Ambient Air Guide for Measurement of Horizontal Wind for Air Quality Applications.