Designation: ~~D5366 – 96 (Reapproved 2011)~~ D5366 – 96 (Reapproved 2017)

Standard Test Method for Determining the Dynamic Performance of a Wind Vane[1]

This standard is issued under the fixed designation D5366; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the starting threshold, delay distance, and overshoot ratio of a wind vane from direct measurements in a wind tunnel. This test method is applicable only to wind vanes having measurable overshoot.

1.2 This test method provides for determination of the performance of a system consisting of a wind vane and its associated position-to-output transducer in wind tunnel flow. Use of values determined by this test method to describe performance in atmospheric flow of a wind direction measuring system incorporating the vane must be done with an understanding of the differences between the two systems and the two environments.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

3. Terminology

3.1 For terms that are not defined herein, refer to Terminology D1356.

3.2 *Definitions:*

3.2.1 *delay distance (D)*—the distance the air flows past a wind vane during the time it takes the vane to return to 50 % of the initial displacement.

3.2.2 *overshoot (θ_n)*—the amplitude of a deflection of a wind vane as it oscillates about θ_B after release from an initial displacement.

3.2.3 *overshoot ratio (Ω)*—the ratio of two successive overshoots, as expressed by the equation:

$$\Omega = \theta_{(n+1)}/\theta_n \quad (1)$$

where θ_n and $\theta_{(n+1)}$ are the n and $n + 1$ overshoots, respectively. In practice, since deflections after the first (to the side opposite the release point are normally small, the initial release point (that is, the $n = 0$ deflection) and the first deflection after release ($n = 1$) are used in determining the overshoot ratio.

3.2.4 *starting threshold (U_o)*—the lowest speed at which the vane can be observed or measured moving from a 10° offset in a wind tunnel.

3.3 *Symbols:*

[1] This test method is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.11 on Meteorology.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

D	(m)	delay distance
U_o	(m/s)	starting threshold
Ω	(none)	overshoot ratio
η	(none)	damping ratio
λ_d	(m)	damped natural wavelength
θ_n	(degrees)	overshoot; maximum angular excursion
θ_o	(degrees)	reference direction
θ_B	(degrees)	vane equilibrium position
$\theta_B - \theta_o$	(degrees)	dynamic vane bias

3.4 *Calculated or Estimated Values:*

3.4.1 *damping ratio (η)*—calculated from the overshoot ratio **(1, 2)**.[3]

$$\eta = \frac{ln(1/\Omega)}{(\pi^2 + [ln(1/\Omega)]^2)^{0.5}} \tag{2}$$

3.4.2 *damped natural wavelength (λ_d)*—at sea level in the U.S. Standard Atmosphere, damped natural wavelength is related to delay distance and damping ratio by the empirical expression **(1, 2)**.[3]

$$\lambda_d = \frac{D(6.0 - 2.4\eta)}{(1 - \eta^2)^{0.5}} \tag{3}$$

4. Summary of Test Method

4.1 *Reference Direction* (θ_o, degrees) is the indicated angular position of the vane when aligned along the centerline of the wind tunnel.

4.2 *Vane Equilibrium Position* (θ_B, degrees) is the final resting position of the vane after motion in response to an initial displacement. Ideally, $\theta_B = \theta_o$.

4.3 *Dynamic Vane Bias* ($\theta_B - \theta_o$, degrees) is the displacement of the vane from the wind tunnel centerline at 5 m/s. This measurement will identify wind vanes with unbalanced aerodynamic response because of damage (for example, bent tail) or poor design.

4.4 *Starting Threshold* (U_o, m/s) is determined by observing or measuring the lowest speed at which the vane, released from a 10° offset position in a wind tunnel, moves toward θ_B. Movement must be distinguishable from vibration.

4.5 *Delay Distance* (D, m) may be determined at a number of wind speeds but shall include 5 m/s and 10 m/s. It is computed from the time required for the vane to reach 50 % of the initial displacement from 10° off θ_B. This time in seconds is converted to delay distance by multiplying by the wind tunnel speed in metres per second. Tests shall include an equal number of displacements to each side of θ_B.

4.6 *Overshoot Ratio* (Ω) may be determined at the same time as the delay distance. The maximum angular excursion on the opposite side of θ_B from the initial 10° displacement fromθ_B is measured. This value is divided by the initial displacement to obtain Ω.

5. Significance and Use

5.1 This test method will provide a standard for comparison of wind vanes of different types. Specifications by regulatory agencies and industrial societies **(3-5)** have stipulated performance values. This test method provides an unambiguous method for measuring starting threshold, delay distance, and overshoot ratio.

6. Apparatus

6.1 *Wind Tunnel* **(6)**:

6.1.1 *Size*—The wind tunnel shall be large enough so that the total projected area of supports, sensor apparatus, and the vane in its displaced position is less than 5 % of the cross-sectional area of its test section.

6.1.2 *Speed Range*—The wind tunnel shall have a speed control that will allow the flow rate to be varied from 0 to at least 10 m/s. The speed control shall maintain the flow rate within ±0.2 m/s.

6.1.3 *Turbulence and Swirl*—Across the volume to be occupied by the vane, the flow profile shall vary by no more than 1 % about the mean speed and shall exhibit a turbulence of less than 1 %. (**Warning—** Swirl in the wind tunnel may influence starting threshold measurements. Variations in the measurement of θ_B a low speeds likely indicate the existence of swirl.)

6.1.4 *Calibration*—The mean flow rate shall be verified at the mandatory speeds of 5 and 10 m/s by use of transfer standards that have been calibrated by the National Institute of Standards and Technology (formerly called the National Bureau of Standards)[4] or by a fundamental physical method.

[3] The boldface numbers in parentheses refer to the list of references at the end of this standard.

[4] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.