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Designation: D 3464 – 96

An American National Standard

Standard Test Method for Average Velocity in a Duct Using a Thermal Anemometer[1]

This standard is issued under the fixed designation D 3464; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method describes the measurement of the average velocity with a thermal anemometer for the purpose of determining gas flow in a stack, duct, or flue **(1-5)**.[2] It is limited to those applications where the gas is essentially air at ambient conditions and the temperature, moisture, and contaminant loading are insignificant as sources of error compared to the basic accuracy of the typical field situation.

1.2 The range of the test method is from 1 to 30 m/s (3 to 100 ft/s).

1.3 The values stated in SI units are to be regarded as the 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1356 Terminology Relating to Sampling and Analysis of Atmospheres[3]

D 3796 Practice for Calibration of Type S Pitot Tubes[3]

2.2 *Other Standards:*

ASME PTC 19.5-72 *Application of Fluid Meters*, Sixth Ed. 1971 (Interim Supplement 19.5 on Instruments & Apparatus)[4]

3. Terminology

3.1 For definitions of terms used in this test method, refer to Terminology D 1356.

4. Summary of Test Method

4.1 This test method describes the operational and calibration procedures necessary for the measurement of point velocity and calculation of the average velocity of air or gas flows in flues, ducts, or stacks utilizing a thermal anemometer.

5. Significance and Use

5.1 The method presented is a "short method" that may be used where contamination levels are less than 5000 ppm by weight or volume, temperatures are between 0°C (32°F) and 65°C (150°F), and the humidity is not considered. The gas is considered as standard air and the velocity is read directly from the instrument.

5.2 This test method is useful for determining air velocities in HVAC ducts, fume hoods, vent stacks of nuclear power stations, and in performing model studies of pollution control devices.

6. Apparatus

6.1 *Thermal Anemometer*—A commercially available electrically operated hot sensor anemometer with direct readout. A thermal anemometer senses the cooling effect of a moving gas stream passing over an electrically heated sensor. This cooling effect or heat transfer rate is correlated to the velocity of the gas stream. The instrument is calibrated to display a direct readout in terms of velocity.

6.2 *Sensors and Probes*—There are a number of different types of sensors available for thermal anemometry including the hot-wire sensor, the hot-film sensor, and the quartz-coated sensor. Probes are available in many different shapes depending upon application.

6.3 *Temperature Compensation*—If the temperature of the gas stream changes during velocity measurements, the anemometer reading will change accordingly unless a constant-temperature or "temperature-compensated" anemometer is utilized. This type of instrument shall be specified for most applications of this measurement standard.

6.3.1 *Temperature-Compensated Anemometer*—A temperature-compensated anemometer has a temperature-sensing probe within the instrument sensor that automatically corrects errors caused by changes in temperature in the gas stream. For temperature-compensated anemometers, a change in temperature (ΔT) of 28°C (50°F) typically produces an error of 2 %.

6.3.2 *Temperature-Uncompensated Anemometer*—For a "constant-current" or uncompensated anemometer a change in temperature (ΔT) of 28°C (50°F) typically produces a 25 %

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[1] This test method is under the jurisdiction of ASTM Committee D-22 on Sampling and Analysis of Atmospheres, and is the direct responsibility of Subcommittee D22.03 on Ambient Atmospheres and Source Emissions.

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[2] The boldface numbers in parentheses refer to the references listed at the end of this method.

[3] *Annual Book of ASTM Standards*, Vol 11.03.

[4] Available from The American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017.

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error. For laboratory work where this type of anemometer might be preferred, the output data shall be corrected for temperature changes in the gas stream.

6.4 *Calibration Apparatus*:

6.4.1 *Flows above 3 m/s (10 ft/s)*—See Section 6, Practice D 3796.

6.4.2 *Flows below 3 m/s (10 ft/s)*—See PTC 19.5-72.

7. Calibration

7.1 For velocities in excess of 3 m/s (10 ft/s) calibrate the thermal anemometer with a standard pitot tube, in accordance with Practice D 3796. It is preferable to make these calibrations under laboratory conditions; however, where expediency dictates, field calibration at the sampling site is permissible.

7.2 For velocities below 3 m/s (10 ft/s) calibrate in the laboratory using a calibrated orifice or nozzle in accordance with PTC 19.5-72.

7.3 Calibrate the thermal anemometer for a minimum of three velocities covering the range of velocities which are anticipated for a particular test. Calibrate an increased number of points, typically five to seven, for the complete range of the instrument if the anticipated test velocity range is not known.

NOTE 1—**Caution:** If this test method is used for gases other than air, calibrate using the test gas.

8. Single-Point Velocity Measurement

8.1 *Velocity*—The hot-wire anemometer is effective for measuring velocities over a range from 1 m/s (3 ft/s) to 30 m/s (100 ft/s). Record measurements at specific points within the flue in accordance with a plan determined by the flue size. Place marks on the instrument probe or probe extension to aid in locating the sampling points at which the velocity is to be measured.

9. Average Velocity Measurements

9.1 *Average Velocity*—Average flue gas velocity is equal to the algebraic average of the single point velocity measurements made in accordance with 9.2-9.2.4.

9.2 To determine the average velocity in a flue it is necessary to record several velocities. This is true even if the flow does not vary with time. Velocities in any flue cannot be assumed to be uniform across any large cross-sectional area. However, in any single subarea, one may assume a constant rate of change of velocity over the area with average velocity at the centroid of this area. Determine the number of points and their locations, at which velocities are to be recorded in accordance with commonly accepted practices when gas flow patterns are essentially uniform, that is, 80 to 90 % of the measurements are greater than 10 % of the maximum flow. In all cases, divide the effective inside area of the flue into a number of equal areas, and record the gas velocity at the centroid of each of these areas.

9.2.1 In rectangular flues, divide the cross-sectional area into equal rectangular subareas as shown in Fig. 1. The number of areas to be used depends on the flow pattern and flue size. Use Table 1 to find the minimum number of areas when sampling at least eight equivalent diameters downstream and two equivalent diameters upstream from the nearest flow disturbance, such as a bend, expansion or contraction. The equivalent diameter can be determined as follows:

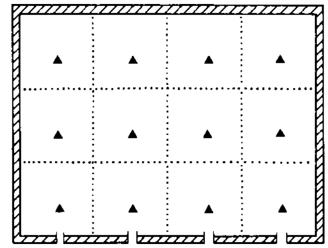

FIG. 1 Traverse Positions for Rectangular Flue

TABLE 1 Minimum Number of Measurements for Rectangular Ducts

Cross Sectional Area of Sampling Sites $m^2(ft^2)$	Number of Measurements
Less than 0.2 (2)	4
0.2 to 2.3 (2 to 25)	12
Greater than 2.3 (25)	20

$$D_e = 2LW/(L + W) \quad (1)$$

where:

D_e = equivalent diameter, m (ft),
L = duct length, m (ft), and
W = duct width, m (ft).

If a site less than eight diameters downstream and two diameters upstream from a flow disturbance, such as a bend, expansion or contraction is used increase the number of sampling points in accordance with 9.2.4.

9.2.2 In circular flues divide the area concentrically as shown in Fig. 2. The minimum number areas to be used and the distance to the test point are shown in Table 2 or calculate as follows:

$$r_n = D_s \sqrt{(2n - 1)/4N} \quad (2)$$

where:

D_s = internal diameter of flue, cm (in.),
r_n = radial distance from center of flue to nth sampling point, cm (in.),
n = nth sampling point from center of flue, and
N = number of sampling points across a diameter.

Conduct traverses across two diameter axes right angles to each other. Again, if a site less than eight diameters downstream and two diameters upstream from a flow disturbance is used, increase the number of sampling points as indicated in 9.2.4.

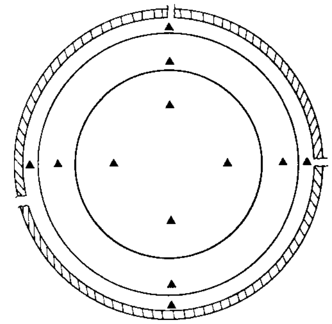

FIG. 2 Traverse Positions for Round Flue

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