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Standard Test Methods for Measuring Surface Atmospheric Pressure[1]

This standard is issued under the fixed designation D3631; 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 These test methods cover the measurement of atmospheric pressure with two types of barometers: the Fortin-type mercurial barometer and the aneroid barometer.

1.2 In the absence of abnormal perturbations, atmospheric pressure measured by these test methods at a point is valid everywhere within a horizontal distance of 100 m and a vertical distance of 0.5 m of the point.

1.3 Atmospheric pressure decreases with increasing height and varies with horizontal distance by 1 Pa/100 m or less except in the event of catastrophic phenomena (for example, tornadoes). Therefore, extension of a known barometric pressure to another site beyond the spatial limits stated in 1.2 can be accomplished by correction for height difference if the following criteria are met:

1.3.1 The new site is within 2000 m laterally and 500 m vertically.

1.3.2 The change of pressure during the previous 10 min has been less than 20 Pa.

The pressure, P_2 at Site 2 is a function of the known pressure P_1 at Site 1, the algebraic difference in height above sea level, $h_1 - h_2$, and the average absolute temperature in the space between. The functional relationship between P_1 and P_2 is shown in 10.2. The difference between P_1 and P_2 for each 1 m of difference between h_1 and h_2 is given in Table 1 and 10.4 for selected values of P_1 and average temperature.

1.4 Atmospheric pressure varies with time. These test methods provide instantaneous values only.

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

1.6 *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.* Specific safety precautionary statements are given in Section 7.

1.7 *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

D3249 Practice for General Ambient Air Analyzer Procedures

IEEE/ASTM SI 10 Standard for Use of the International System of Units (SI): The Modern Metric System

3. Terminology

3.1 Pressure for meteorological use has been expressed in a number of unit systems including inches of mercury, millimetres of mercury, millibars, and others less popular. These test methods will use only the International System of Units (SI), as described in IEEE/ASTM SI 10.

3.1.1 Much of the apparatus in use and being sold reads in other than SI units, so for the convenience of the user the following conversion factors and error equivalents are given.

3.1.1.1 The standard for pressure (force per unit area) is the pascal (Pa).

3.1.1.2 One standard atmosphere at standard gravity (9.80665 m/s^2) is a pressure equivalent to:

29.9213 in. Hg at 273.15 K
760.000 mm Hg at 273.15 K
1013.25 millibars
14.6959 lbf/in.^{2}
101325 Pa or 101.325 kPa

[1] These test methods are under the jurisdiction of ASTM Committee D22 on Air Quality and are 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.

TABLE 1 Selected Values

Average Temperature, $\frac{T_1+T_2}{2}$	Pressure P_1, Pa				
	110 000	100 000	90 000	80 000	70 000
	Correction to P_1, Pa/m, positive if $h_1 > h$, negative if $h_1 < h_2$				
230	16	15	13	12	10
240	16	14	13	11	10
250	15	14	12	11	10
260	14	13	12	11	9
270	14	13	11	10	9
280	13	12	11	10	9
290	13	12	11	9	8
300	13	11	10	9	8
310	12	11	10	9	8

3.1.1.3 1 Pa is equivalent to:
0.000295300 in. Hg at 273.15 K
0.00750062 mm Hg at 273.15 K
0.01000000 millibars
0.000145037 lbf/in.^{2}
0.000009869 standard atmospheres

3.2 *standard gravity*—as adopted by the International Committee on Weights and Measures, an acceleration of 9.80665 m/s^2 (see 10.1.3).

3.3 The definitions of all other terms used in these test methods can be found in Terminology D1356 and Practice D3249.

4. Summary of Test Methods

4.1 The instantaneous atmospheric pressure is measured with two types of barometers.

4.2 Test Method A utilizes a Fortin mercurial barometer. The mercury barometer has the advantage of being fundamental in concept and direct in response. The disadvantages of the mercury barometer are the more laborious reading procedure than the aneroid barometer, and the need for temperature correction.

4.3 Test Method B utilizes an aneroid barometer. The aneroid barometer has the advantages of simplicity of reading, absence of mercury, no need for temperature compensation by the observer, and easy detection of trend of change. The main disadvantages of the aneroid barometer are that it is not fundamental in concept as the mercury barometer, and it requires calibration periodically against a mercury barometer.

5. Significance and Use

5.1 Atmospheric pressure is one of the basic variables used by meteorologists to describe the state of the atmosphere.

5.2 The measurement of atmospheric pressure is needed when differences from "standard" pressure conditions must be accounted for in some scientific and engineering applications involving pressure dependent variables.

5.3 These test methods provide a means of measuring atmospheric pressure with the accuracy and precision comparable to the accuracy and precision of measurements made by governmental meteorological agencies.

6. Apparatus

6.1 *Fortin Barometer,* which is a mercurial barometer consisting of a glass tube containing mercury with an adjustable cistern and an index pointer projecting downward from the roof of the cistern. The mercury level may be raised or lowered by turning an adjustment screw beneath the cistern.

6.1.1 To provide acceptable measurements, the specifications of 6.1.2 – 6.1.11 must be met.

6.1.2 Maximum error at 100 000 Pa ± 30 Pa.

6.1.2.1 Maximum error at any other pressure for a barometer whose range: (*a*) does not extend below 80 000 Pa ± 50 Pa (*b*) extends below 80 000 Pa ± 80 Pa.

6.1.2.2 For a marine application the error at a point must not exceed ±50 Pa.

6.1.3 Difference between errors over an interval of 10 000 Pa or less ±30 Pa.

6.1.4 Accuracy must not deteriorate by more than ±50 Pa over a period of a year.

6.1.5 It must be transportable without loss of accuracy.

6.1.6 A mercurial barometer must be able to operate at ambient temperatures ranging from 253 to 333 K (−20 to 60°C) and must not be exposed to temperatures below 253 K (−38°C). It must be able to operate over ambient relative humidities ranging from 0 to 100 %.

6.1.7 A thermometer with a resolution of 0.11 K and a precision and accuracy of 0.05 K must be attached to the barrel of the barometer.

6.1.8 The actual temperature for which the scale of a mercury barometer is designed to give true readings (at standard gravity) must be engraved on the barometer.

6.1.9 If the evacuated volume above the mercury column can be pumped, the head vacuum must be measured with a gauge such as a McLeod gauge or a thermocouple gauge and reduced to 10 Pa or less.

6.1.10 The meniscus of a mercurial barometer must not be flat.

6.1.11 The axis of the tube must be vertical (that is, aligned with the local gravity vector).

6.2 *Precision aneroid barometer,* consisting of an evacuated elastic capsule coupled through mechanical, electrical, or optical linkage to an indicator.

6.2.1 To provide acceptable measurements, an aneroid barometer must meet the specifications of 6.2.2 – 6.2.7.

6.2.2 Resolution of 50 Pa or less.

6.2.3 Precision of ±50 Pa.

6.2.4 Accuracy of ±50 Pa root mean square error with a maximum observed error not to exceed 150 Pa throughout the calibration against a basic standard.

6.2.5 Temperature compensation must be included to prevent a change in reading of more than 50 Pa for a change of temperature of 30 K.

6.2.6 The accuracy must not deteriorate by more than ±100 Pa over a period of a year.

6.2.7 The hysteresis must be sufficiently small to ensure that the difference in reading before a 5000-Pa pressure change and after return to the original value does not exceed 50 Pa.