STANDARD

ANSI/AMCA Standard 230-23

Laboratory Methods of Testing Air Circulating Fans for Rating and Certification

An American National Standard
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Laboratory Methods of Testing Air Circulating Fans for Rating and Certification

1. Purpose

The purpose of this standard is to establish uniform methods for laboratory testing of air circulating fans to determine performance for rating or certification.

2. Scope

This standard shall be used as the basis for testing electrically powered air circulating fan heads and ceiling fans when air is used as the test gas. The scope is limited to air circulating fans with an input power greater than or equal to 125 W—except for ceiling fans, which do not have a lower input power limit. The diameter of the fan being tested shall be limited by the minimum dimensions as shown in the applicable test figures.

Exclusions:

- Jet fans as defined in ANSI/AMCA Standard 214
- Powered roof ventilators, induced flow fans, laboratory exhausts
- Positive pressure ventilators as defined in ANSI/AMCA Standard 240
- Compressors
- Positive displacement machines

Only tests that fulfill all mandatory requirements of this standard may be designated as tests conducted in accordance with this standard.

3. References

ANSI/AMCA Standard 208-18, Calculation of the Fan Energy Index, Air Movement and Control Association International Inc., Arlington Heights, IL USA.

ANSI/AMCA Standard 214-21, Test Procedure for Calculating Fan Energy Index (FEI) for Commercial and Industrial Fans and Blowers, Air Movement and Control Association International Inc., Arlington Heights, IL USA.

ANSI/AMCA Standard 240, Laboratory Methods of Testing Positive Pressure Ventilators for Aerodynamic Performance Rating, Air Movement and Control Association International Inc., Arlington Heights, IL USA.

ANSI/AMCA Standard 250, Laboratory Methods of Testing Jet Fans for Performance, Air Movement and Control Association International Inc., Arlington Heights, IL USA.

ANSI/ASHRAE Standard 41.1-2020, Standard Methods for Temperature Measurement, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Peachtree Corners, GA USA.

ANSI/ASHRAE Standard 41.11-2020, Standard Methods for Power Measurement, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Peachtree Corners, GA USA.

ASHRAE Handbook — Fundamentals, American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Peachtree Corners, GA USA.

Axial Flow Fans and Ducts, Krieger Publishing Co., New York, NY USA.

Guideline 2-2010 (RA 2014), Engineering Analysis of Experimental Data [Withdrawn], American Society of Heating, Refrigerating and Air-Conditioning Engineers Inc., Peachtree Corners, GA USA.

IEC 62301: 2011, Household electrical appliances — Measurement of standby power, International Electrotechnical Commission, Geneva, Switzerland.

ISO/IEC 17025, Testing and calibration laboratories, International Organization for Standardization, Geneva, Switzerland.

Psychrometric Equations for the Partial Vapor Pressure and the Density of Moist Air — Report to AMCA Standard 210/ASHRAE 51P Committee, Air Movement and Control Association International Inc., Arlington Heights, IL USA.

Special Publication 330, The International System of Units (SI), National Institute of Standards and Technology, Gaithersburg, MD, USA.

Steam Tables — Compact Edition, The American Society of Mechanical Engineers, New York, NY USA.

4. Definitions/Units of Measurement/Symbols

4.1 Definitions

4.1.1 Air circulating fan

A fan that has no provision for connection to ducting or separation of the fan inlet from its outlet using a pressure boundary, operates against zero external static pressure loss and is not a jet fan (as defined in ANSI/AMCA Standard 214). Refer to Annex B for additional details on examples and categorization of air circulating fans.

4.1.1.1 Air circulating fan head (ACFH), housed

An air circulating fan that is not a ceiling fan with an axial or centrifugal impeller and a housing.

4.1.1.2 Air circulating fan head (ACFH), unhoused

An air circulating fan without housing, having an axial impeller with a ratio of fan-blade span in centimeters (inches) to a maximum rate of rotation (in revolutions per minute) less than or equal to 1.524 mm/rpm (0.06 in./rpm) and discharging air in a horizontal direction. The impeller may or may not be guarded.

4.1.1.3 Ceiling fan

A nonportable fan that is designed to be suspended from the ceiling or overhead structure of a building, usually with a vertically oriented fan shaft. The impeller may or may not be guarded. A ceiling fan has a ratio of fan blade span in millimeters (inches) to maximum rotation rate (in revolutions per minute) greater than 1.524 mm/rpm (0.06 in./rpm) and discharges air up or down.

4.1.1.4 Cylinder

A circular housing with a width greater than 20 cm (8 in.).

4.1.1.5 Housing

A surrounding, continuous physical barrier that directs airflow into or away from the impeller, typically a box, cylinder, panel, orifice plate, ring or scroll.

4.1.1.6 Ring

A circular housing with a width less than or equal to 20 cm (8 in.).

4.1.2 Fan performance variables

4.1.2.1 Discharge area
Area of a circle having a diameter equal to the blade tip diameter.

4.1.2.2 Electrical input power
The electrical power required to drive the fan and any elements in the drive train that are considered a part of the fan. Electrical input power (W_E) is the measured electrical input power (W_O) converted to standard air density.

4.1.2.3 Fan outlet area
The gross inside area, perpendicular to the airstream, measured at the plane of the outlet opening.

4.1.2.4 Fan speed
The rotational speed of the impeller.

4.1.2.5 Fan thrust
The reaction force due to the momentum change of the mass flow through the fan.

4.1.2.6 Standby power consumption
The electrical power consumed when the fan is connected to a main power source, fan speed is 0 rpm and the unit offers one or more of the following user-oriented or protective functions:

- Facilitates the activation or deactivation of other functions (including active mode) by remote switch (including remote control), internal sensor or timer.
- Continuous tasks, including information or status displays (including clocks) or sensor-based functions.

4.1.3 Force

4.1.3.1 Load differential
The difference in measured force, using either standard weights or a load cell, when the fan is energized vs. when it is not energized.

4.1.4 Miscellaneous

4.1.4.1 Determination
A complete set of measurements for the free-air operation of an air circulating fan. A determination shall, at a minimum, include the following measurements:

- Ambient dry-bulb temperature, °C (°F)
- Ambient wet-bulb temperature, °C (°F)
- Barometric pressure, Pa (in. Hg)
- Electrical input power, W
- Fan diameter, m (ft)
- Fan speed, rpm
- Input current, A
- Input voltage, V
- Load differential, N (lbf)
- Number of phases, Φ

4.1.4.2 Shall and should
The word *shall* is to be understood as mandatory, the word *should* as advisory.

4.1.4.3 Test
A series of determinations for one or more points of fan operation, e.g., various fan speeds, voltages or frequencies.

4.1.5 Pressure

4.1.5.1 Absolute pressure
The value of pressure when the datum pressure is absolute zero. It is always positive.

4.1.5.2 Barometric pressure
The absolute pressure exerted by the atmosphere.

4.1.5.3 Pressure
Pressure is force per unit area. This corresponds to energy per unit volume of fluid.

4.1.6 Psychrometrics

4.1.6.1 Air density
The mass per unit volume of air.

4.1.6.2 Dry-bulb temperature
The air temperature as measured by a dry temperature sensor.

4.1.6.3 Standard air
Air with a density of 1.2 kg/m^3 (0.075 lbm/ft^3), a ratio of specific heats of 1.4 and a viscosity of 1.8185 × 10^{-5} Pa•s (1.222 × 10^{-5} lbm•s). Air at 20°C (68°F), 50% relative humidity and 101.325 kPa (29.92 in. Hg) barometric pressure has these properties, approximately.

4.1.6.4 Wet-bulb depression
The difference between the dry-bulb and wet-bulb temperatures at the same location.

4.1.6.5 Wet-bulb temperature
The air temperature measured by a temperature sensor covered by a water-moistened wick and exposed to air in motion. When properly measured, it is a close approximation of the temperature of adiabatic saturation.

4.1.7 Test configuration

4.1.7.1 Minimum testable configuration
A fan with sufficient components (impeller, shaft, driver, bearings, etc.) to allow for wire-to-air testing and rating calculation. Appurtenances and other devices that are sold or supplied with the product must be installed on the test fan, but not energized. If sold or supplied with the fan, an on/off switch or speed control device shall be included in the minimum testable configuration.

4.2 Units of measurement

4.2.1 System of units
The International System of Units (SI units) are the primary units employed in this standard, with inch-pound (I-P) units given as the secondary reference. SI units are based on the fundamental values of the International Bureau of Weights and Measures, and I-P units are based on the values of the National Institute of Standards and Technology, which are in turn based on the values of the International Bureau.

4.2.2 Basic units
The SI unit of length is the meter or the millimeter; the I-P unit of length is the foot or the inch. The SI unit of mass is the kilogram; the I-P unit of mass is the pound mass. The unit of time is either the minute or the second. The SI unit of temperature is either the Kelvin or the degree Celsius; the I-P unit of temperature

is either the degree Fahrenheit or the degree Rankine. The SI unit of force is the newton; the I-P unit of force is the pound force.

4.2.3 Velocity
The SI unit of velocity is the meter per second; the I-P unit of velocity is the foot per minute.

4.2.4 Thrust
The SI unit of thrust is the newton; the I-P unit is the pound force.

4.2.5 Pressure
The SI unit of pressure is the pascal. The I-P unit of pressure is either the inch water gauge or the inch mercury. Values in inch mercury shall be used only for barometric pressure measurements.

The inch water gauge shall be based on a 1-in. column of distilled water at 68 °F under standard gravity and a gas column balancing effect based on standard air. The inch mercury shall be based on a 1-in. column of mercury at 32 °F under standard gravity in a vacuum.

4.2.6 Power
The unit of input power is the watt.

4.2.7 Speed
The unit of rotational speed is the revolution per minute.

4.2.8 Gas properties
The SI unit of density is the kilogram per cubic meter; the I-P unit of density is the pound mass per cubic foot. The SI unit of viscosity is the pascal-second; the I-P unit of viscosity is the pound mass per foot-second. The SI unit of gas constant is the joule per kilogram-kelvin; the I-P unit of gas constant is the foot-pound force per pound-mass-degree Rankine.

4.2.9 Dimensionless groups
Various dimensionless quantities appear in the standard. Any consistent system of units may be employed to evaluate these quantities unless a numerical factor is included, in which case units must be as specified.

4.2.10 Physical constants
The SI value of standard gravitational acceleration shall be taken as 9.80665 m/s^2, which corresponds to mean sea level at 45° latitude; the I-P value of standard gravitational acceleration is 32.1740 ft/s^2, which corresponds to mean sea level at 45° latitude. The SI density of distilled water at saturation pressure shall be taken as 998.278 kg/m^3 at 20°C; the I-P value is 62.3205 lbm/ft^3 at 68°F. The density of mercury at saturation pressure shall be taken as 13595.1 kg/m^3 at 0°C; the I-P value is 848.714 lbm/ft^3 at 32°F. The specific weights in kg/m^3 (lbm/ft^3) of these fluids in vacuum under standard gravity are numerically equal to their densities at corresponding temperatures.

4.3 Symbols and subscripts

Table 1 — Symbols and Subscripts

Symbol	Description	SI Unit	I-P Unit
A	Fan outlet or discharge area	m^2	ft^2
D	Fan diameter	m	ft
CFEI	Ceiling fan energy index	Dimensionless	
E	Input voltage	V	V
Eff_{circ}	Efficacy of a circulating fan	(m^3/s)/W	cfm/W
Eff_t	Thrust efficiency ratio	N/kW	lbf/kW
F_t	Thrust at standard air density	N	lbf
ΔF	Load differential	N	lbf

I	Input current	A	A
L_1	Lever arm length	mm	in.
L_2	Lever arm length	mm	in.
N	Fan speed	rpm	rpm
p_b	Corrected barometric pressure	Pa	in. Hg
p_e	Saturated vapor pressure	Pa	in. Hg
p_p	Partial vapor pressure	Pa	in. Hg
Q_0	Airflow rate	m^3/s	cfm
Pt	Fan total pressure	Pa	in. wg
R	Gas constant	J/(kg•K)	ft•lb/(lbm•°R)
t_{d0}	Ambient dry-bulb temperature	°C	°F
t_{w0}	Ambient wet-bulb temperature	°C	°F
V	Air velocity	m/s	fpm
W_E	Electrical input power	W	W
W_O	Measured electrical input power	W	W
W_{SB}	Standby power consumption	W	W
η_o	Overall efficiency	Dimensionless	
Φ	Number of phases	Dimensionless	
ρ_0	Ambient air density	kg/m^3	lbm/ft^3
ρ_{std}	Standard air density	kg/m^3	lbm/ft^3

5. Instruments and Methods of Measurement

5.1 Accuracy

The instrument specifications and measurement methods that follow include accuracy requirements and specific examples of equipment capable of meeting those requirements. Equipment other than that utilized in the cited examples may be used provided the accuracy requirements are met or exceeded.

5.1.1 Instrument accuracy

The specifications regarding accuracy correspond to two standard deviations based on an assumed normal distribution. This is frequently how instrument suppliers identify accuracy, but that should be verified. The calibration procedures, which are specified below, shall be employed to minimize errors. In any calibration process, the large systematic error of the instrument is exchanged for the smaller combination of the systematic error of the standard instrument and the random error of the comparison. Instruments shall be set up, calibrated and read by qualified personnel trained to minimize errors.

5.1.2 Measurement uncertainty

Every test measurement contains some error, and the true value cannot be known because the magnitude of the error cannot be determined exactly. However, it is possible to perform an uncertainties analysis to identify a range of values within which the true value probably lies. A probability of 95% has been chosen as acceptable for this standard.

The standard deviation of random errors can be determined by statistical analysis of repeated measurements. No statistical means are available to evaluate systematic errors, so these must be estimated. The estimated upper limit of a systematic error is called the systematic uncertainty and, if properly estimated, it will contain the true value 99% of the time. The two standard deviation limit of a random error has been selected as the random uncertainty. Two standard deviations yield 95% probability for random errors.

5.1.3 Uncertainty of a result

The results of a fan test are the various fan performance variables listed in Section 4.1.2. Each result is based on one or more measurements. The uncertainty in any result can be determined from the uncertainties in the measurement. It is best to determine the systematic uncertainty of the result, then the random uncertainty of the result before combining them into the total uncertainty of the result. This may provide clues on how to reduce the total uncertainty. When systematic uncertainty is combined in quadrature with random uncertainty, the total uncertainty will give 95% coverage. In most test situations, it is wise to perform a pre-test uncertainties analysis to identify potential problems. A pre-test uncertainties analysis is not required for each test covered by this standard because it is recognized that most laboratory tests for rating are conducted in facilities where similar tests are repeatedly run. Nevertheless, a pre-test analysis is recommended, as is a post-test analysis. The simplest form of analysis is a verification that all accuracy and calibration specifications have been met. The most elaborate analysis considers all the elemental sources of error, including those due to calibration, data acquisition, data reduction, calculation assumptions, environmental effects and operational steadiness.

5.2 Measurements to determine thrust and airflow rate

5.2.1 Airflow rate

Airflow rate shall be calculated from the thrust, standard air density and fan outlet or discharge area using Eq. 8.9 SI or Eq. 8.10 I-P (see Section 8.5).

5.2.2 Thrust

The thrust at standard air density shall be calculated from the measured load differential, ambient air density and physical dimensions of the test setup. Load differential shall be determined using either standard weights or a load cell.

5.2.2.1 Standard weights

Standard weights shall be accurate within ±0.5%. Weights shall be added to the test apparatus to balance the apparatus (see Figure 10.2A) prior to energizing the fan. After the fan is energized, additional weights are added to balance the fixture. Load differential is the difference between these two weights. The test apparatus should remain balanced for at least 120 s.

5.2.2.2 Load cell

Load cell measurements shall be accurate within ±0.5% of the measured value. Load cell measurements shall be recorded at intervals lasting at most 1 s through a 120-s test period, and the mean of the measured values shall be reported.

5.2.3 Dimensional measurements

5.2.3.1 Lever arm lengths

Lever arm lengths, L_1 and L_2, shall be measured to within ±0.5% of the actual value (see test figures 10.1B, 10.2A, 10.2B1 and 10.2B2).

5.2.3.2 Fan diameter

Fan diameter, *D*, is the outermost impeller blade tip diameter. It shall be measured to within ±0.5% of the actual value (see test figures 10.1A, 10.1B, 10.2A, 10.2B1, 10.2B2, 10.3A, 10.3B).

5.3 Power

Measured electrical input power and standby power consumption shall be determined from the measurement of active (real) power in all phases simultaneously by an electric meter.

5.3.1 Meters

Electrical meters shall have certified accuracies of ±1% of observed reading.

5.3.2 Calibration

Each voltmeter, ammeter and wattmeter shall be calibrated over the range of values to be encountered during testing against a meter with a calibration that is traceable to the National Institute of Standards and Technology (NIST) or other national physical measurements recognized as equivalent by NIST.

All electrical equipment used to measure fan performance shall be calibrated with uncertainties by an ISO/IEC 17025 accredited laboratory for calibration.

5.3.3 Averaging
The power a fan requires is never strictly steady; therefore, to obtain a true reading, either the instrument must be damped or the readings must be averaged in a suitable manner. The power measurement shall be recorded at intervals lasting at most 1 s through a 120-s test period, and the mean of the measured values shall be reported. Multipoint or continuous record averaging can be accomplished with instruments and analyzers designed for this purpose.

5.4 Fan speed
The fan speed measurement shall be recorded at intervals lasting at most 1 s through a 120-s test period, and the mean of the measured values shall be reported. The fan speed shall be measured at regular intervals throughout the test period for each point of operation to ensure the determination of average rotational speed during each such period with an uncertainty not exceeding ±0.5% of the value being measured or ±0.1 rpm, whichever is greater. No device used shall significantly affect the test fan's rotational speed or performance.

5.5 Air density
Air density shall be calculated from wet-bulb temperature, dry-bulb temperature and barometric pressure measurements. Other parameters may be measured and used if the maximum error in the calculated density does not exceed 0.5%.

5.5.1 Thermometers
Both wet- and dry-bulb temperatures shall be measured with thermometers or other instruments with demonstrated accuracies ±1 °C (±2 °F) and resolution of 0.5 °C (1 °F) or finer.

5.5.1.1 Calibration
Thermometers shall be calibrated with uncertainties over the temperature range to be encountered during testing against a thermometer with a calibration by an ISO/IEC 17025 accredited calibration laboratory that is traceable to NIST or other national physical measures recognized as equivalent by NIST.

5.5.1.2 Wet-bulb
The wet-bulb thermometer shall have an air velocity over the water-moistened wick-covered bulb of 3.5 to 10 m/s (700 to 2000 fpm). The dry-bulb thermometer shall be mounted upstream of the wet-bulb thermometer so its reading will not be depressed.

5.5.2 Barometers
The ambient barometric pressure shall be measured with a barometer or other instrument with a demonstrated accuracy ±200 Pa. (±0.05 in. Hg) and readable to 50 Pa (0.01 in. Hg) or finer.

5.5.2.1 Calibration
Barometers shall be calibrated and calibration traceable to NIST or other national physical measures NIST recognizes as equivalent. Barometers shall be maintained in good condition.

All equipment used to measure psychometric data shall be calibrated with uncertainties by an ISO/IEC 17025 accredited calibration laboratory.

6. Equipment and Setups

6.1 Allowable test setups
Seven setups are diagrammed in test figures 10.1A, 10.1B, 10.2A, 10.2B1, 10.2B2, 10.3A, and 10.3B.

The following shall be used as a guide to the selection of a proper setup.

- Test figures 10.1A and 10.1B shall be used only for ceiling fans.
- Test figures 10.2A, 10.2B1, 10.2B2, 10.3A and 10.3B shall be used only for air circulating fan heads.

6.2 Load cell orientation

In all cases, the test apparatus shall provide the means of isolating the load cell from torque loading.

In test figures 10.1A, 10.1B, 10.3A and 10.3B the axis of the load cell shall be perpendicular to the discharge or outlet area.

In all other setups, lever L1 shall be parallel to the axis of the load cell and lever L2 shall be perpendicular to the fan outlet or discharge area.

6.3 Minimum testable configuration

The fan shall be tested wire-to-air.

Any appurtenances sold or supplied with the fan shall be included in the minimum testable configuration. This includes, but is not limited to, optional features such as safety guards and turning vanes.

If sold or supplied with the fan, an on/off or speed control device shall be included in the minimum testable configuration. The power consumption of the on/off or speed control device shall be included in the active and standby mode power measurements. If multiple controllers are offered, test using the minimally functional controller.

Optional product features not related to generating air movement shall not be energized for testing purposes. Optional product features not related to generating air movement include, but are not limited to, lighting, heaters and germicidal devices as well as external sensors and communication devices not required for fan operation. If the optional product feature cannot be turned off, it shall be set to the lowest energy-consuming mode during testing.

7. Observations and Conduct of Test

7.1 General test requirements

7.1.1 Equilibrium

Equilibrium conditions shall be established before each measurement. To test for equilibrium, trial observations shall be made until steady readings are obtained, as specified in Section 7.3.

7.1.2 Extraneous airflow

Air velocity in the test room that is not generated by the test circulating fan shall not exceed 0.25 m/s (50 fpm) prior to, during and after the test. Velocity measurements shall be taken immediately before and after the test to ensure this condition is met.

Extraneous airflow shall be measured at the location shown in the applicable test figures (Figures 10.1A, 10.1B, 10.2A, 10.2B1, 10.2B2, 10.3A, and 10.3B).

7.1.3 Run-in requirements

All fans shall be run-in for no less than 15 min prior to the commencement of data collection.

7.2 Data to be recorded

7.2.1 Test unit

The description of the test unit and its nameplate data shall be recorded.

7.2.2 Test setup

The description of the test setup, including specific dimensions, shall be recorded and included in the final report. Reference shall be made to the test figures in this standard. Alternatively, a drawing or annotated photograph of the setup may be attached to the data.

7.2.3 Instruments

The instruments and apparatus used in the test shall be listed. Manufacturer, model numbers, serial numbers, scale ranges and calibration information shall be recorded.

7.2.4 Test data

7.2.4.1 Active mode

Test data for each determination shall be recorded. Readings shall be made simultaneously whenever possible. For all tests, ambient dry-bulb temperature (t_{d0}), ambient wet-bulb temperature (t_{w0}), ambient barometric pressure (p_b), fan diameter (D), fan outlet or discharge area (A), load differential (ΔF), fan speed (N), measured electrical input power (W_O), input voltage (E), number of phases (Φ), frequency, date and input current (I) shall be recorded.

All air circulating fans shall be tested at their highest fan speed.

Ceiling fans shall also be tested at 40% of maximum fan speed (or to the nearest speed that is not less than 40% speed).

Performance data at additional fan speeds may be captured and reported (for example, additional measurements at 20%, 60% and 80% of maximum fan speed for variable speed fans).

7.2.4.2 Standby mode

Standby power consumption, as defined in Section 4.1.2.6 of this standard, shall be measured according to sections 4 and 5.3.1 through 5.3.2 of IEC 62301 with the following modifications:

- Allow a minimum of 3 min. after the fan stops rotating before beginning the standby power test.
- Simultaneously in all phases, measure active (real) electrical power consumption continuously for 100 s and record the average value of the standby power consumption in watts (W).

Determine standby power consumption according to Section 5.3.2 of IEC 62301 or using the following average reading method. Note that a shorter measurement period may be possible using the sample method in Section 5.3.2 of IEC 62301.

(1) Connect the product to the electrical power supply and electrical power measuring instrument.

(2) Select the mode to be measured (which may require a sequence of operations and could require waiting for the product to automatically enter the desired mode) and then monitor the power reading.

(3) Calculate the average electrical power using either the average power method or the accumulated energy method. For the average power method, where the electrical power measuring instrument can record true average electrical power over an operator selected period, the average electrical power is taken directly from the electrical power measuring instrument. For the accumulated energy method, determine the average electrical power by dividing the measured energy by the time for the monitoring period. Use units of watt-hours and hours for both methods to determine average electrical power in watts.

7.2.5 Personnel

The names of test personnel shall be listed with the data for which they are responsible.

7.3 Test procedures

Ambient conditions shall be measured prior to startup and throughout the test as specified. Load differential measured electrical input power and fan speed measurements shall be averaged for a minimum of 120 s. All readings shall be recorded when both speed and measured electrical input power have stabilized, and at least 15 min. after startup. Measured electrical input power stability is established when the averaged results from two successive readings differ by no more than 1% or 1 W, whichever is greater. Fan speed stability is established when the averaged results from two successive readings differ by no more than 1% or 1 rpm, whichever is greater.

8. Calculations

8.1 Calibration correction

Calibration corrections, when required, shall be applied to individual readings before averaging or other calculations. Calibration corrections need not be made if the correction is smaller than one half the maximum allowable error as specified in Section 5.

8.2 Ambient air density

The density of ambient air (ρ_0) shall be determined from various measurements taken at the time of testing in the general test area; the measurements shall include dry-bulb temperature (t_{d0}), wet-bulb temperature (t_{w0}) and barometric pressure (p_b) using the following formulae:

$$p_e = 3.25t_{w0}^2 + 18.6t_{w0} + 692$$ SI Eq. 8.1

$$p_e = (2.96 \times 10^{-4})t_{w0}^2 - (1.59 \times 10^{-2})t_{w0} + 0.41$$ I-P Eq. 8.2

$$p_p = p_e - p_b\left(\frac{t_{d0} - t_{w0}}{1500}\right)$$ SI Eq. 8.3

$$p_p = p_e - p_b\left(\frac{t_{d0} - t_{w0}}{2700}\right)$$ I-P Eq. 8.4

$$\rho_0 = \left(\frac{p_b - 0.378p_p}{R(t_{d0} - 273.15)}\right)$$ SI Eq. 8.5

$$\rho_0 = 70.73\left(\frac{p_b - 0.378p_p}{R(t_{d0} - 459.67)}\right)$$ I-P Eq. 8.6

Equation 8.1 is approximately correct for saturated vapor pressure (p_e) for a range of t_{w0} between 4 °C and 32 °C (40 °F and 90 °F). More precise values of p_e can be obtained from the ASHRAE Handbook of Fundamentals. The gas constant (R) may be taken as 287 J/(kg•K) (53.35 ft lb/(lbm•°R) for air.

8.3 Thrust

Thrust shall be calculated according to the following:

For test figures 10.1A, 10.3A, and 10.3B:

$$F_t = \Delta F \left(\frac{\rho_{std}}{\rho_0}\right) \quad \text{Eq. 8.7}$$

For test figures 10.1B, 10.2A, 10.2B1 and 10.2B2:

$$F_t = \Delta F \left(\frac{L_2}{L_1}\right)\left(\frac{\rho_{std}}{\rho_0}\right) \quad \text{Eq. 8.8}$$

Where:

F_t = Thrust, N (lbf)
L_1 = Lever arm length, mm (in.)
L_2 = Lever arm length, mm (in.)
ΔF = Load differential, N (lbf)
ρ_0 = Ambient air density, kg/m^3 (lbm/ft^3)
ρ_{std} = Standard air density, 1.2 kg/m^3 (0.075 lbm/ft^3)

8.4 Area

Airflow rate and efficiency calculations for unhoused air circulating fan heads and ceiling fans shall use the discharge area as defined in Section 4.1.2.1. Airflow rate and efficiency calculations for housed air circulating fan heads shall use the lesser of the values for fan outlet area as defined in Section 4.1.2.3 and discharge area as defined in Section 4.1.2.1.

8.5 Airflow rate

The velocity distribution downstream of a circulating fan is determined by a variety of factors, including the aerodynamic design of the fan. It is beyond the scope of this standard to measure, predict or describe details of this velocity distribution. The airflow rate associated with the calculated thrust shall be calculated as:

$$Q_0 = \sqrt{\frac{AF_t}{\rho_{std}}} \quad \text{SI} \quad \text{Eq. 8.9}$$

$$Q_0 = 340.3\sqrt{\frac{AF_t}{\rho_{std}}} \quad \text{I-P} \quad \text{Eq. 8.10}$$

Where:

Q_0 = Airflow rate, m^3/s (cfm)
F_t = Thrust, N (lbf)
A = Fan outlet or discharge area, m^2 (ft^2)
ρ_{std} = Standard air density, 1.2 kg/m^3 (0.075 lbm/ft^3)

8.6 Power

The electrical input power, W_E, shall be calculated from the measured electrical input power, W_O, using the following equation:

$$W_E = W_O \left(\frac{\rho_{std}}{\rho_0}\right) \qquad \text{Eq. 8.11}$$

8.7 Fan total pressure

The fan total pressure at a given airflow shall be calculated according to the following equations:

$$P_t = \frac{\rho_0}{2}\left(\frac{Q_0}{A}\right)^2 \qquad \text{SI} \qquad \text{Eq. 8.12}$$

$$P_t = \rho_0 \left(\frac{Q_0}{1097.8 \times A}\right)^2 \qquad \text{I-P} \qquad \text{Eq. 8.13}$$

Where:

A = Fan outlet or discharge area, m^2 (ft^2)
P_t = Fan total pressure, Pa (in. wg)
Q_0 = Airflow rate, m^3/h (cfm)
ρ_0 = Air density, kg/m^3 (lbm/ft^3)

8.8 Overall efficiency

The overall efficiency, η_o, shall be calculated from the calculated thrust, F_t, and electrical input power, W_E, using the following equations:

$$\eta_o = \frac{\frac{1}{2} \cdot \sqrt{\frac{F_t^3}{A\rho_{std}}}}{W_E} \qquad \text{SI} \qquad \text{Eq. 8.14}$$

$$\eta_o = \frac{3.845 \cdot \sqrt{\frac{F_t^3}{A\rho_{std}}}}{W_E} \qquad \text{I-P} \qquad \text{Eq. 8.15}$$

Where:

F_t = Thrust, N (lbf)
A = Fan outlet or discharge area, m^2 (ft^2)
W_E = Electrical input power, W
ρ_{std} = Standard air density, 1.2 kg/m^3 (0.075 lbm/ft^3)

8.9 Circulating fan efficacy

The efficacy of a circulating fan shall be expressed in cubic meters per second per watt [(m^3/s)/W] or cubic feet per minute per watt (cfm/W).

$$Eff_{circ} = \frac{Q_0}{W_E} \qquad \text{Eq. 8.16}$$

Where:

Q_0 = Fan airflow rate m^3/s (cfm)
W_E = Electrical input power, W

8.10 Ceiling fan energy index (CFEI)

CFEI shall be calculated at 100% of maximum speed and 40% of maximum speed (or the nearest speed that is not less than 40% speed) according to ANSI/AMCA Standard 208-18, with the following modifications:

- Using an airflow constant (Q_0) of 12.507 m^3/s (26,500 cfm).
- Using a pressure constant (P_0) of 0.6719 Pa (0.0027 in. wg).
- Using a fan efficiency constant (η_0) of 42%.

Note: 42 U.S. Code 6295(ff)(6)(C)(i)(I) defines CFEI as the FEI for large-diameter ceiling fans (blade tip diameter greater than 216 cm (84.5 in.) with the modifications to FEI shown in Section 8.10.

8.11 Thrust efficiency ratio

The thrust efficiency ratio, Eff_t, shall be calculated from the thrust at standard air density, F_t, and electrical input power, W_E (W), and expressed in newtons per kilowatt (N/kW) or pound force per kilowatt (lbf/kW).

$$Eff_t = \frac{F_t}{W_E/1000} \qquad \text{Eq. 8.17}$$

Where:

F_t = Thrust at standard air density, N (lbf)
W_E = Electrical input power, W

9. Report and Results of Test

A fan's laboratory test report shall include object, results, test data and descriptions of the test fan, including appurtenances, test setup, test instruments and personnel as outlined in Section 7. At a minimum, the report shall include the following items:

General test information:
Appurtenances (if applicable)
Laboratory name
Laboratory address
Date of testing
Test number
Personnel performing testing
Air circulating fan type
Test setup description, including test figure number

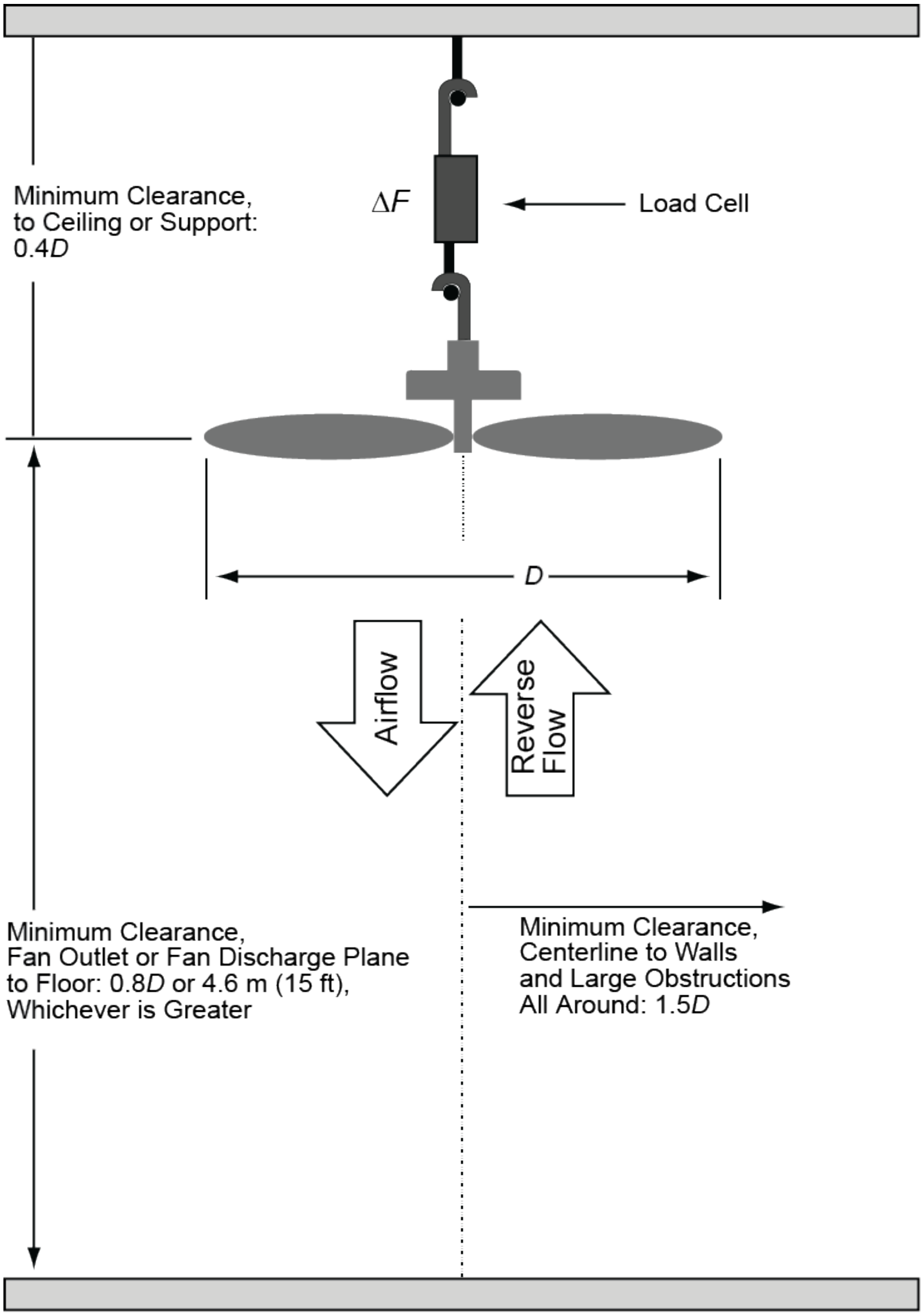
Room dimensions
Minimum clearances to walls, floor and ceiling or support (per applicable test figure)
Lever arm length 1 (if applicable)
Lever arm length 2 (if applicable)
Fan diameter (blade span rounded to the nearest mm or in.)
Fan model number
Fan serial number (if applicable)
Motor model number
Motor serial number
Motor nameplate data
Variable speed drive (VSD) model number (if applicable)
VSD serial number (if applicable)
Transmission type (gear drive, belt drive or direct drive)
Number of available fan speeds
Reverse flow capability
Fan speed controls separate from lighting controls (if applicable)

Data at test conditions:
Ambient dry-bulb temperature
Ambient wet-bulb temperature
Ambient barometric pressure
Extraneous airflow before test
Extraneous airflow after test
Measured electrical input power
Standby power consumption
Input voltage
Input current
Input electrical frequency
Number of phases
Fan speed
Direction of operation (forward or reverse flow)
Load differential

Calculated values:
Fan outlet or discharge area
Ambient air density
Percent of maximum fan speed
Thrust at standard air density
Airflow rate
Fan total pressure
Overall efficiency at ambient conditions
Efficacy at ambient conditions (if applicable)
Electrical input power
Ceiling fan energy index (if applicable)
Tip speed (rounded to the nearest m/s or fps)
Blade span ratio (mm/rpm or in./rpm)

Calibration information (per instrument):
Manufacturer
Model number
Serial number
Scale range
ISO/IEC 17025 calibration laboratory
Date of last calibration
Date of next required or scheduled calibration

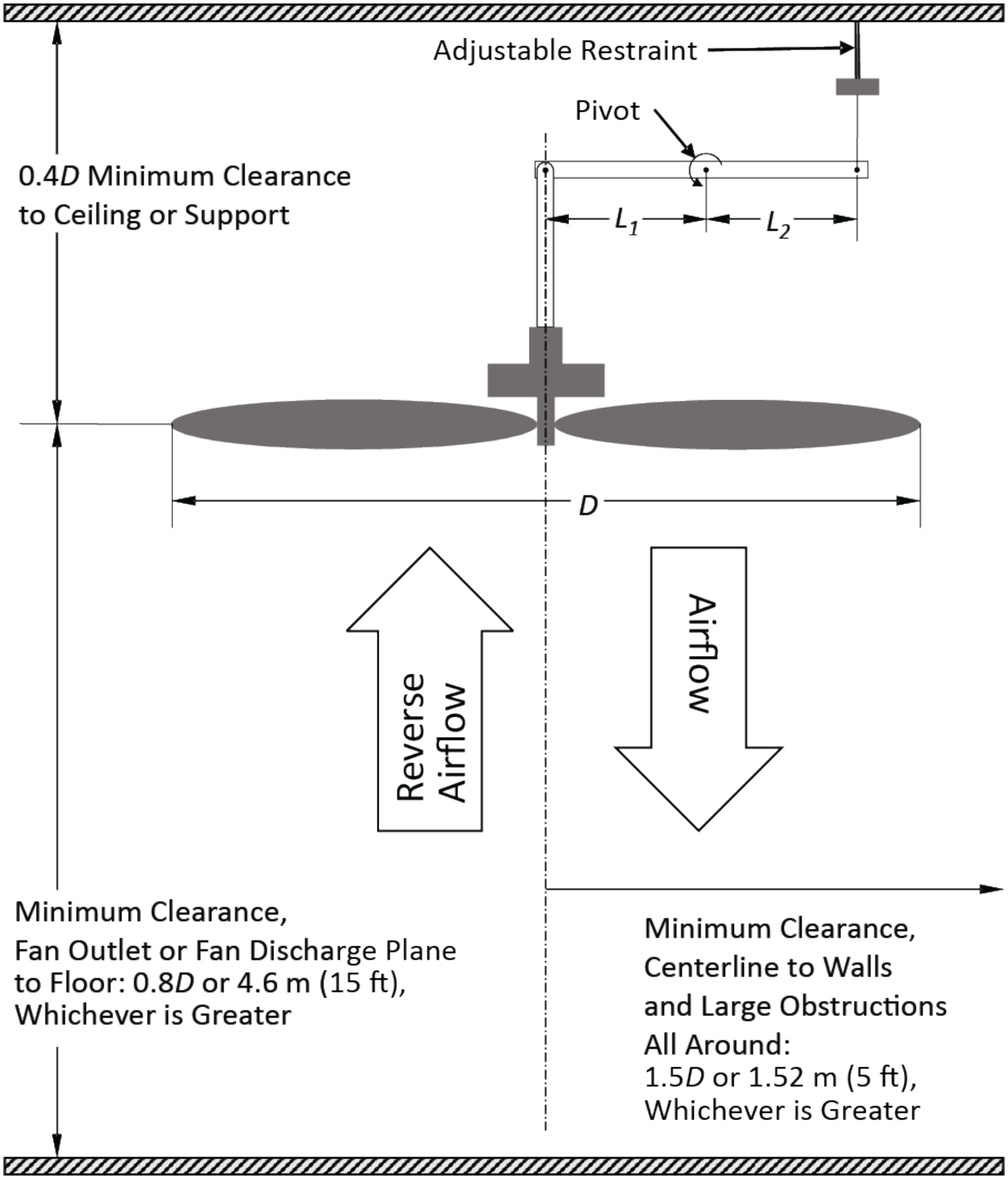
10. Figures



Notes:

1. The vertical centerline through the test setup shall be kept vertical within ±1° during testing.
2. Location of extraneous airflow measurement shall be directly under the center of the fan at an elevation of 1.7 m (67 in.) above floor.

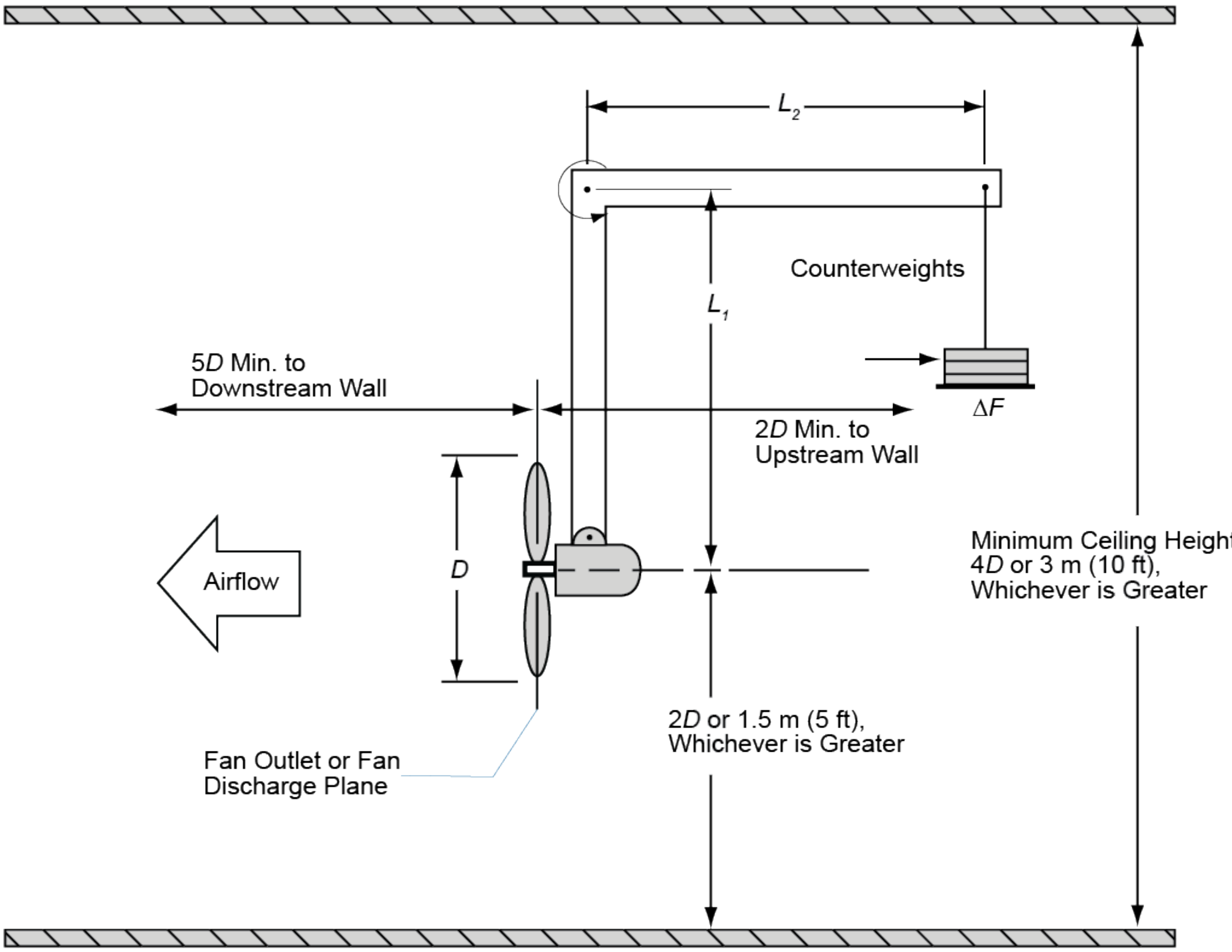
Test Figure 10.1A — Vertical Airflow Setup with Load Cell Direct (Ceiling Fans)



Notes:

1. The vertical centerline through the test setup shall be kept vertical within ±1° during testing.
2. Location of extraneous airflow measurement shall be directly under the center of the fan at an elevation of 1.7 m (67 in.) above floor.

Test Figure 10.1B — Vertical Airflow Setup with Load Cell Pivot Above Test Subject (Ceiling Fans)

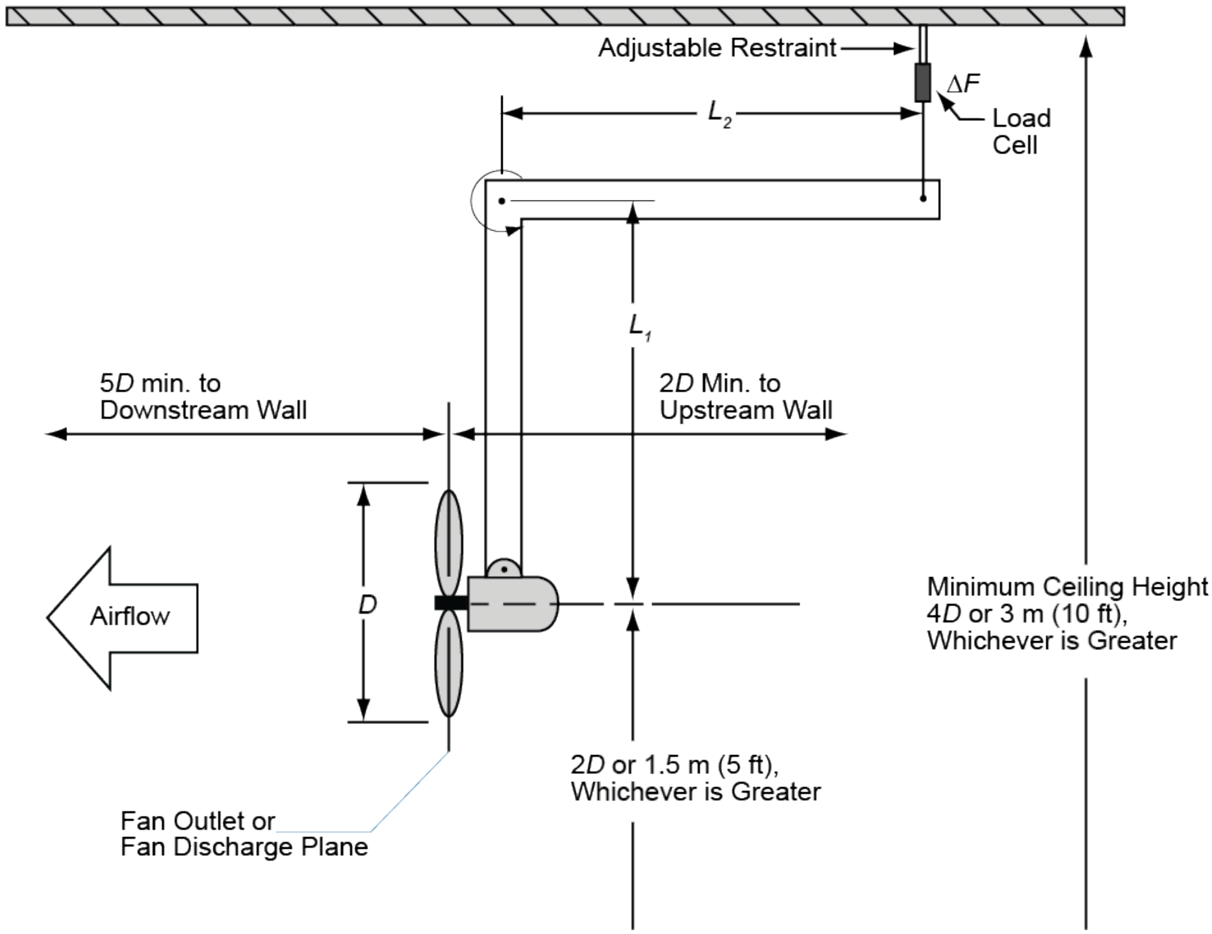


Side Elevation

Notes:

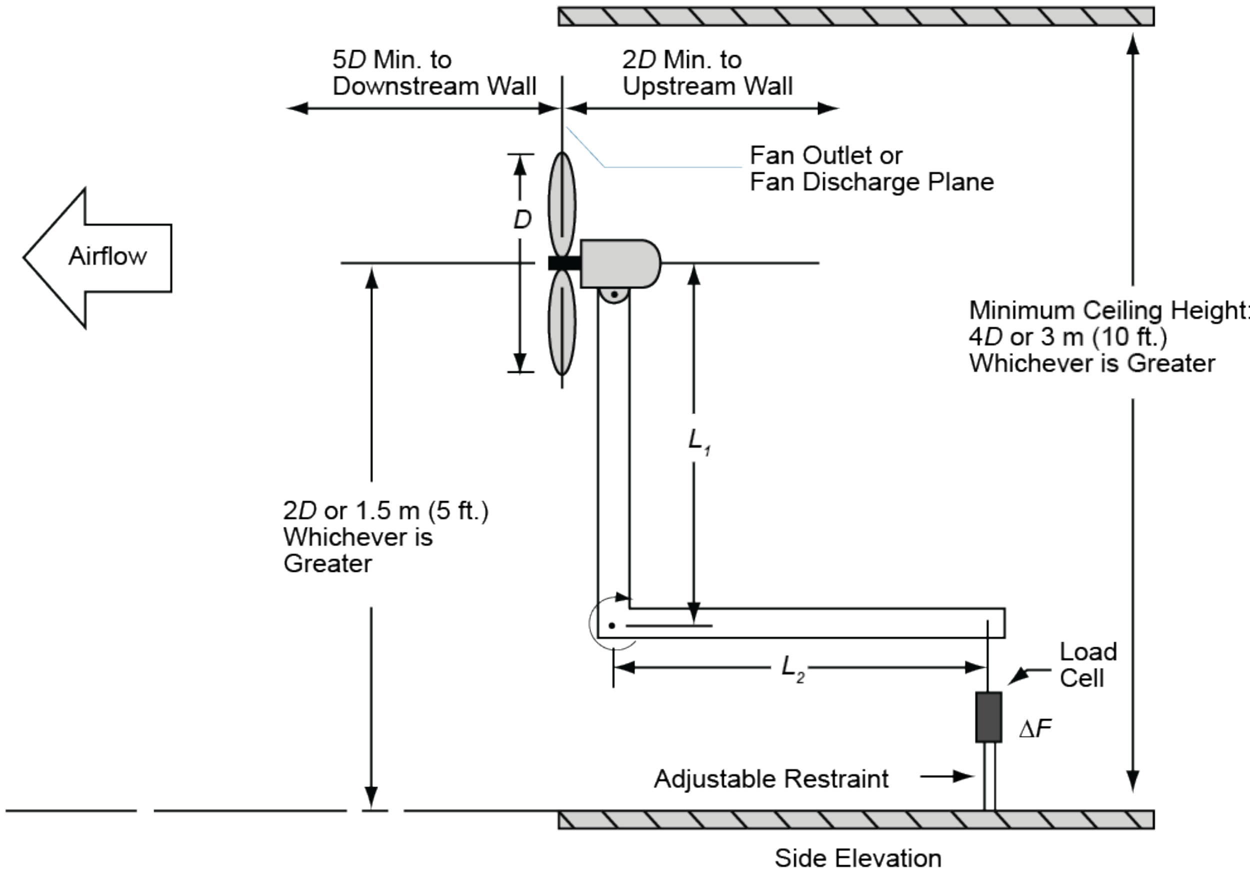
1. The horizontal centerline through the test setup shall be kept horizontal within ±1° during testing.
2. 2*D* minimum space needed to walls and large obstructions on sides of test unit.
3. The location of extraneous airflow measurement shall be at the center of the fan at a distance of 1.5 m (5 ft) downstream of the fan impeller.

Test Figure 10.2A — Horizontal Airflow Setup with Counterweights Pivot Above Test Subject (Air Circulating Fan Heads)



Notes:
1. The horizontal centerline through the test setup shall be kept horizontal within ±1° during testing.
2. 2*D* minimum space needed to walls and large obstructions on sides of test unit.
3. The location of extraneous airflow measurement shall be at the center of the fan at a distance of 1.5 m (5 ft) downstream of the fan impeller.

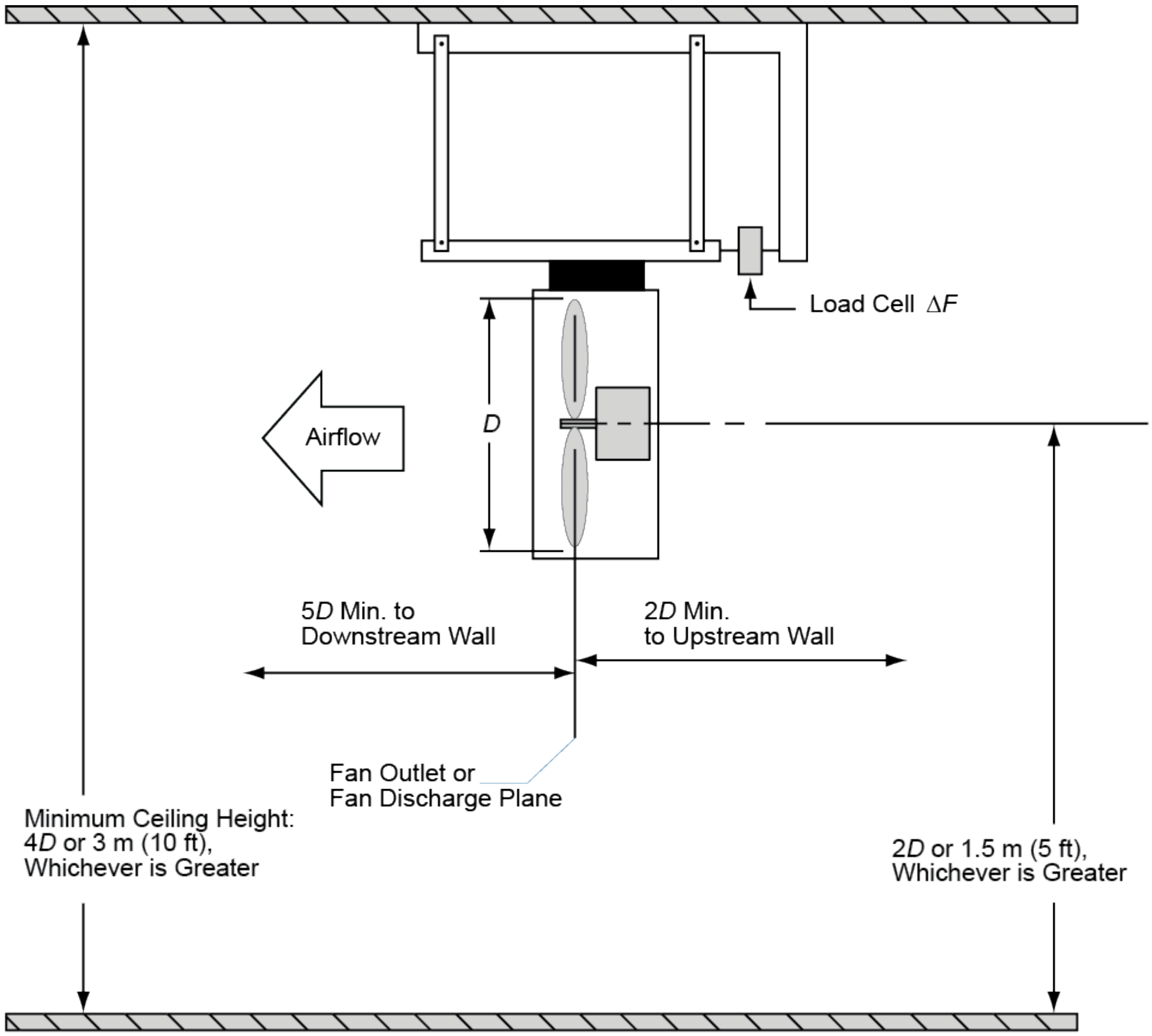
Test Figure 10.2B1 — Horizontal Airflow Setup with Load Cell Pivot Above Test Subject (Air Circulating Fan Heads)



Notes:

1. The horizontal centerline through the test setup shall be kept horizontal within ±1° during testing.
2. 2*D* minimum space needed to walls and large obstructions on sides of test unit.
3. The location of extraneous airflow measurement shall be at the center of the fan at a distance of 1.5 m (5 ft) downstream of the fan impeller.

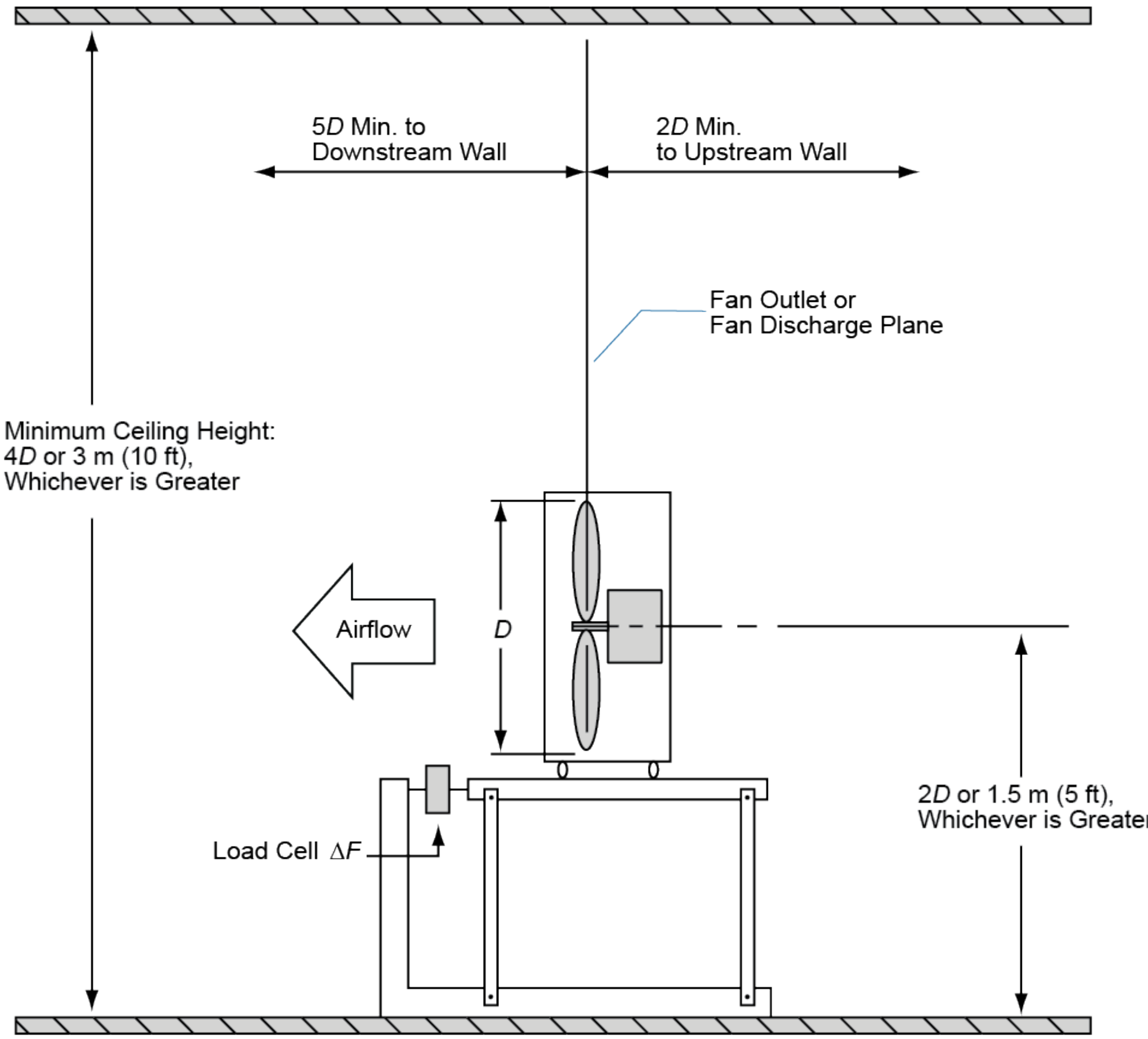
Test Figure 10.2B2 — Horizontal Airflow Setup with Load Cell Pivot Below Test Subject (Air Circulating Fan Heads)



Notes:

1. 2*D* minimum space needed to walls and large obstructions on sides of test unit.
2. The location of extraneous airflow measurement shall be at the center of the fan at a distance of 1.5 m (5 ft) downstream of the fan impeller.

Test Figure 10.3A — Horizontal Airflow Setup with Load Cell Parallel Bars Above Test Subject (Air Circulating Fan Heads)



Notes:

1. 2*D* minimum space needed to walls and large obstructions on sides of test unit.
2. The location of extraneous airflow measurement shall be at the center of the fan at a distance 1.5 m (5 ft) downstream of the fan impeller.

Test Figure 10.3B — Horizontal Airflow Setup with Load Cell Parallel Bars Below Test Subject (Air Circulating Fan Heads)

Annex A
Circulating Fans and Their Relationship to Airflow and Velocity (Informative)

The measurement of thrust and electrical power consumption serves as simple means to characterize and compare performance of air circulating fans. Fan thrust provides a measure of the change in momentum of the air in the axial direction.

In this standard, airflow is not measured directly. Rather it is calculated from the measured thrust. Attempts to calculate total airflow from measured axial air velocities downstream from the fan are usually inconsistent due to large scale turbulence within a room and the resulting time varying velocities. Swirl components are not considered useful products of a circulating fan and do not affect the thrust measurement. However, swirl components will contribute to the fan's power consumption.

A more accurate determination of the flow through the fan for academic reasons can be accomplished by measuring and integrating a velocity profile in the fan's primary jet. (See Figure A.1) Care must be taken with this type of measurement since the primary jet downstream of a circulating fan will entrain additional air from the surroundings. Consequently, the velocity profile should be obtained in a plane normal to the fan axis located about one or two chord lengths (blade width from leading edge to trailing edge) downstream to minimize the influence of air entrainment. In addition, the measurement must be able to accurately distinguish the axial component of the resultant velocity vector since radial and swirl components are also present. Specialized thermal or laser anemometers are the most accurate instruments capable of these measurements, but five- and seven-hole pressure probes can be used with reasonable accuracy.

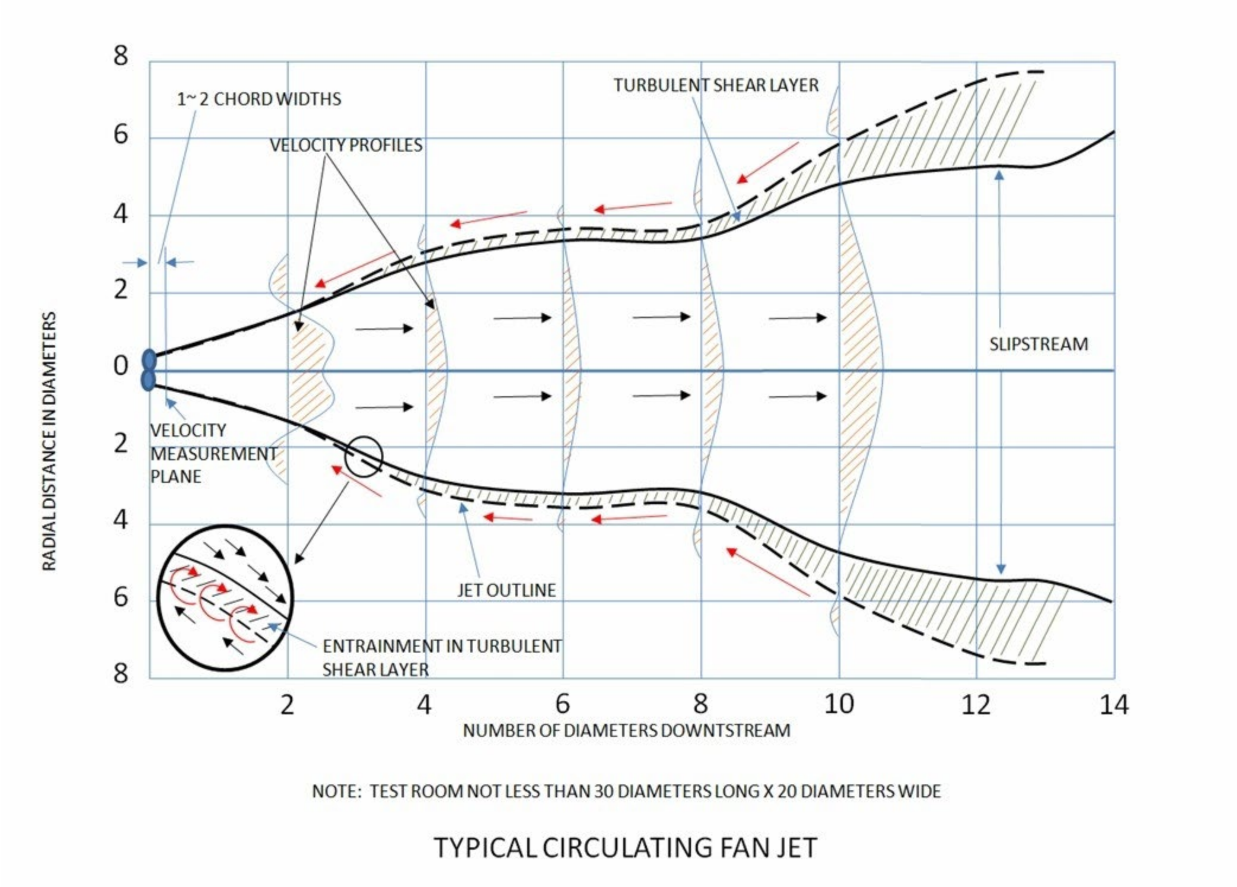


Figure A.1 — Typical Circulating Fan Jet
Adapted from “Axial Flow Fans and Ducts.”

Annex B
Air Circulating Fan Subcategories (Informative)

B.1 Purpose

This annex defines subcategories of air circulating fans. These categories may be used by regulators and utility rebate programs to establish specific minimum efficacy or efficiency requirements for specific fan types. The sub-categories may also be used by regulators and retailers to assist in identifying different types of air circulating fans for regulatory coverage. This annex does not attempt to categorize every possible configuration of air circulating fan but provides a reasonable means of grouping similar types of fans and applies to the majority of the fans that have been tested to this standard.

B.2 Air circulating fan primary categories

Section 4.1.1 defines the characteristics of the three primary categories of air circulating fans: unhoused air circulating fan heads, housed air circulating fan heads and ceiling fans.

B.3 Air circulating fan subcategories

The primary categories of air circulating fans may be divided into subcategories based on various characteristics of the fans within the scope of this standard. The subcategories, if applicable, are defined in this section and summarized in Figure B.1. A partial list of common marketing names for each fan category or subcategory is also provided at the end of each definition in sections B.3.1 to B.3.3.

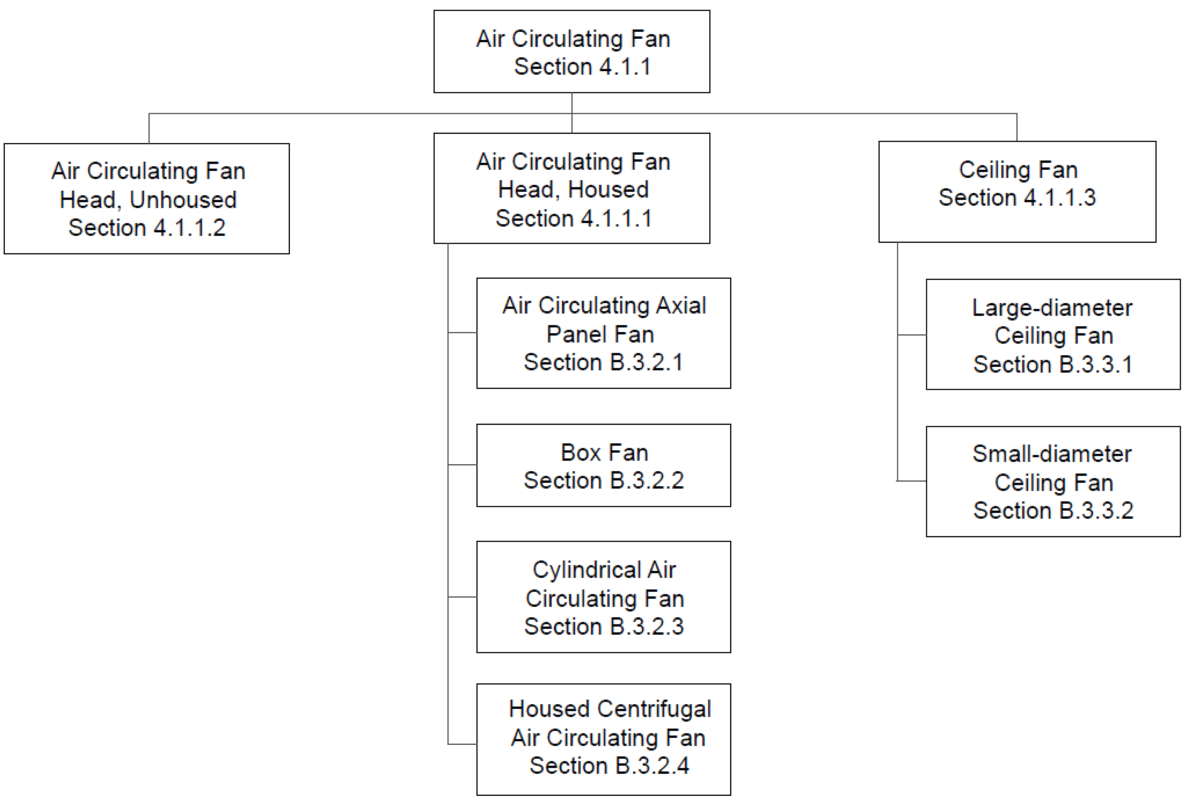


Figure B.1 — Air Circulating Fan Categories and Subcategories

B.3.1 Unhoused air circulating fan head

Refer to Section 4.1.1.2 for the definition of an unhoused air circulating fan head (see examples in Figure B.2). Also commonly known as a horizontal airflow fan (HAF), cage fan, directional fan, spot cooler, truck cooler, loading dock fan, rack mount fan, suspension blower, stir fan, table fan, floor fan or transformer cooling fan.

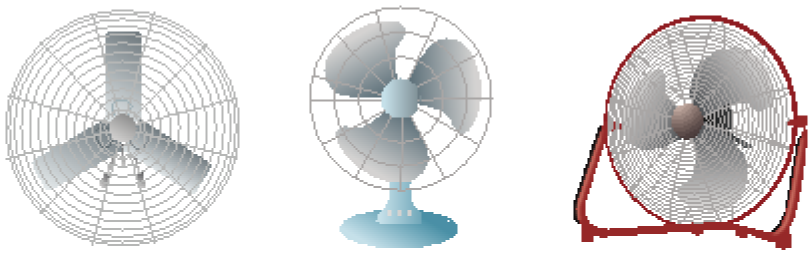


Figure B.2 – Examples of common unhoused air circulating fan heads

B.3.2 Housed air circulating fan head

Refer to Section 4.1.1.1 for the definition of a housed air circulating fan head.

B.3.2.1 Air circulating axial panel fan

An axial air circulating fan without a cylindrical housing or box housing that is mounted on a panel, orifice plate or ring. Also commonly known as a panel fan, cow cooler or livestock cooler (see Figure B.3).

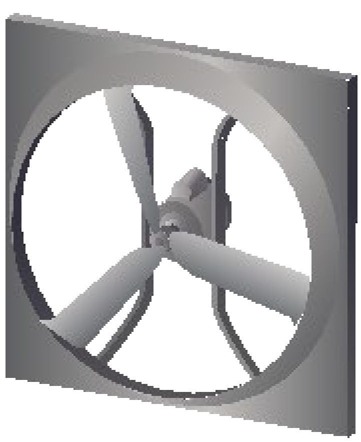


Figure B.3 — Example air circulating axial panel fan

B.3.2.2 Box fan

An axial air circulating fan without a cylindrical housing that is mounted on a panel, orifice plate or ring and is mounted in a box housing. See Figure B.4.

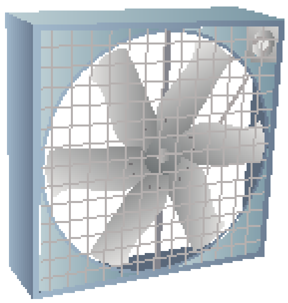


Figure B.4 — Example box fan

B.3.2.3 Cylindrical air circulating fan

An axial air circulating fan in a cylindrical housing that is not a positive pressure ventilator (PPV). See Figure B.5. Also commonly known as a personnel cooler, barrel fan, drum fan, high velocity fan, portable cooler, thermal mixing fan, destratification fan or down-blast fan.

Figure B.5 — Example of a common cylindrical air circulating fan

B.3.2.4 Housed centrifugal air circulating fan
A fan with a centrifugal or radial impeller in which airflow exits into a housing that is generally scroll shaped to direct the air through a single, narrow fan outlet. Also commonly known as a utility blower, loading dock fan, carpet dryer or floor fan. See example in Figure B.6.

Figure B.6 — Example housed centrifugal air circulating fan

B.3.3 Ceiling fan
Refer to Section 4.1.1.3 for the definition of a ceiling fan.

B.3.3.1 Large-diameter ceiling fan
A ceiling fan with a blade tip diameter that is greater than or equal to 84.5 in. (216 cm). Also commonly known as a high volume, low speed (HVLS) ceiling fan, high-volume, low-velocity (HVLV) fan or a destratification fan. See example in Figure B.7.

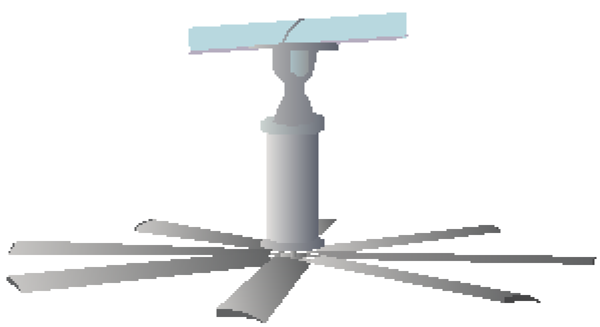


Figure B.7 — Example large-diameter ceiling fan

B.3.3.2 Small-diameter ceiling fan

A ceiling fan with a blade tip diameter that is less than 84.5 in. (216 cm). See example in Figure B.8.

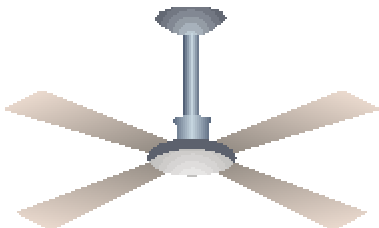


Figure B.8 — Example small diameter ceiling fan

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TECHNICAL ERRATA SHEET FOR
ANSI/AMCA STANDARD 230-23
Incorrect operator in ambient-air-density calculation
and
Incorrect SI unit
June 2, 2023

The information contained in this errata sheet is not part of ANSI/AMCA Standard 230-23, *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification*, and has not been processed in accordance with ANSI's requirements for an American National Standard (ANS). As such this errata sheet may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.

The corrections listed in this errata sheet apply to all copies of ANSI/AMCA Standard 230-23, *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification*.

1. Section 8.2

The SI and I-P equations (Eq. 8.5 and Eq. 8.6) used to calculate ambient air density, ρ_0, have in their denominator the incorrect operator used to convert Celsius and Fahrenheit temperature to Kelvin and Rankine temperature, respectively. The subtraction symbol should be an addition symbol. The two equations should read as follows:

$$\rho_0 = \left(\frac{p_b - 0.378p_p}{R(t_{d0} + 273.15)}\right) \quad \text{SI} \quad \text{Eq. 8.5}$$

$$\rho_0 = 70.73\left(\frac{p_b - 0.378p_p}{R(t_{d0} + 459.67)}\right) \quad \text{I-P} \quad \text{Eq. 8.6}$$

2. Section 8.7

Eq. 8.12, the SI equation used to calculate fan total pressure, is correct; however, the SI unit for airflow rate should be m^3/s, not m^3/h.

The unit's description following Eq. 8.12 and Eq. 8.13 should be corrected as follows:

8.7 Fan total pressure

The fan total pressure at a given airflow shall be calculated according to the following equations:

$$P_t = \frac{\rho_0}{2}\left(\frac{Q_0}{A}\right)^2 \qquad \text{SI} \qquad \text{Eq. 8.12}$$

$$P_t = \rho_0\left(\frac{Q_0}{1097.8 \times A}\right)^2 \qquad \text{I-P} \qquad \text{Eq. 8.13}$$

Where:

A = Fan outlet or discharge area, m^2 (ft^2)
P_t = Fan total pressure, Pa (in. wg)
Q_0 = Airflow rate, ~~m^3/h~~ m^3/s (cfm)
ρ_0 = Air density, kg/m^3 (lbm/ft^3)

The information contained in this errata sheet is not part of ANSI/AMCA Standard 230-23, *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification*, and has not been processed in accordance with ANSI's requirements for an American National Standard (ANS). As such this errata sheet may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.

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