

AMCA Publication 802-02 (R2008)

Industrial Process/Power Generation Fans: Establishing Performance Using Laboratory Models



**AIR MOVEMENT AND CONTROL
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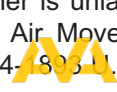


**Air Movement and Control Association International, Inc.
30 West University Drive
Arlington Heights, IL 60004-1893**

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Authority

This edition of AMCA Publication 802-02 was adopted by the membership of the Air Movement and Control Association International on October 19, 2001. It was reaffirmed on May 4, 2008.

Foreword

AMCA (Air Movement and Control Association International, Inc.) is a trade association representing manufacturers of fans used in industrial, power generation, and commercial applications; other air control devices such as louvers, dampers, and shutters; and airflow measurement stations.

This publication was written by engineers of member companies of AMCA International. AMCA member companies constitute the majority of fan manufacturers supplying the industrial process and electric power generation industry throughout the world.

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c/o Federation of Environmental Trade Associations
2 Waltham Court, Milley Lane, Hare Hatch
Reading, Berkshire

RG10 9TH United Kingdom

RELATED AMCA STANDARDS

For Aerodynamic Performance:

ANSI/AMCA Standard 210	<i>Laboratory Method of Testing Fans for Aerodynamic Performance Rating</i>
AMCA Standard 803	<i>Industrial Process/Power Generation Fans: Site Performance Test Standard</i>

For Sound:

AMCA Standard 300	<i>Reverberant Room Method for Sound Testing of Fans</i>
AMCA Standard 301	<i>Methods for Calculating Fan Sound Ratings from Laboratory Test Data</i>
AMCA Standard 320	<i>Laboratory Methods of Sound Testing of Fans Using Sound Intensity</i>

RELATED AMCA PUBLICATIONS

For Balance and Vibration:

ANSI/AMCA Standard 204	<i>Balance Quality and Vibration Levels for Fans</i>
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Industrial Process / Power Generation Series:

AMCA Publication 801	<i>Industrial Process/Power Generation Fans: Specification Guidelines</i>
AMCA Publication 802	<i>Industrial Process/Power Generation Fans: Establishing Performance Using Laboratory Models</i>
AMCA Standard 803	<i>Industrial Process/Power Generation Fans: Site Performance Test Standard</i>

Fan Application Manual:

AMCA Publication 200	<i>Air Systems</i>
AMCA Publication 201	<i>Fans and Systems</i>
AMCA Publication 202	<i>Troubleshooting</i>
AMCA Publication 203	<i>Field Performance Measurement of Fan Systems</i>

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Industrial Process / Power Generation Fans: Establishing Performance Using Laboratory Models

1. Purpose

The purpose of this publication is to outline present methods used by fan manufacturers in determining the performance of full size industrial process and power generation fans used in the world. These methods include:

- a) Predicting full size fan ratings using base performance data already obtained from a standard model.
- b) Building and testing a model of a proposed fan or already existing full size fan to verify the performance of the full size fan.

This publication provides a detailed insight into the variables that influence a fan rating and establishes the rules to be used and their limitations in converting performance from one geometrically similar fan to another. It also defines dimensional tolerances that must exist for two fans to be considered geometrically similar. It does not cover the detailed procedures used by a manufacturer in selecting a particular fan or modifying a standard fan to achieve a specific rating. The information is, of course, confidential to each manufacturer and is based upon many years of experience and individual company research.

This publication, together with other documents contained in AMCA's 800 series, forms the basis for fan-related concepts and practices.

2. Scope

This publication applies to centrifugal and axial fans. State-of-the-art criteria is provided for establishing geometric and dynamic similarity between the model and the full size fan, including appurtenances and drives.

This document does not deal with structural details, mechanical properties, or components if they do not affect fan performance.

3. Definitions and Symbols

The following list covers definitions and symbols used in the testing and rating of fans. These are standard definitions as adopted by the fan industry. Certain definitions are similar to those used in general engineering practice and have been adapted for specific use in this publication.

3.1 Rating criteria

3.1.1 Fan. A device which utilizes a power driven rotating impeller for moving air or gas. A fan may have various appurtenances, provided by the fan manufacturer as part of the fan equipment, which are accessories that affect performance. It is necessary to establish what accessories are to be considered as part of the fan.

In many instances, a customer lists the system requirements and requests that the fan manufacturer supply additional accessories such as silencers or dampers. The pressure losses for accessories must be accounted for if the system is to operate properly. If the fan manufacturer supplies these items and they are directly connected to the fan, then appropriate accessory losses are added to the system requirements and a fan is selected for the sum of the overall pressure losses.

3.1.2 Fan inlet. The plane perpendicular to the airstream where it first meets the inlet cone or the inlet box furnished by the fan manufacturer. In this publication, the fan inlet is indicated by "Plane 1" (see Figure 1).

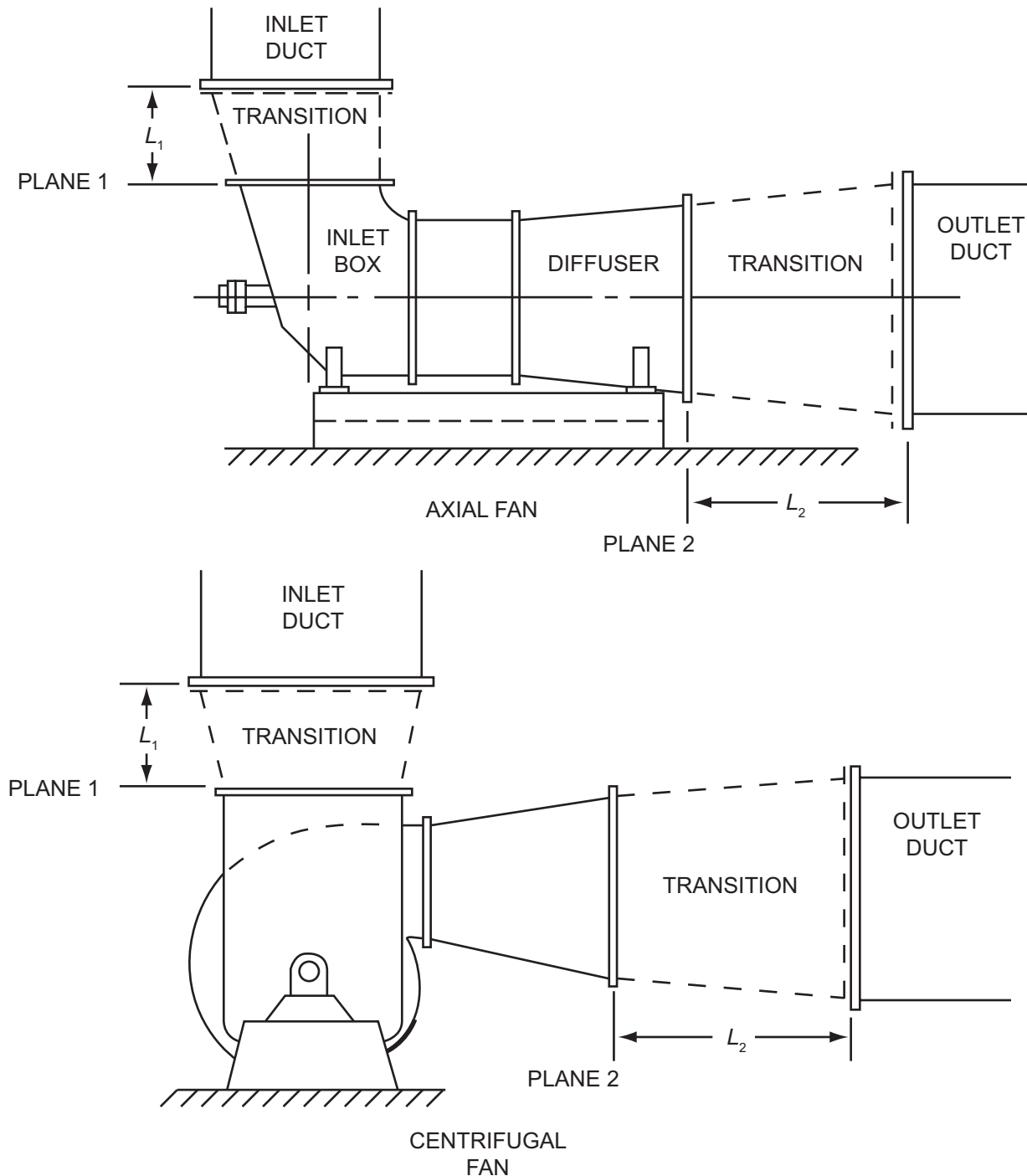
3.1.3 Fan outlet. The plane perpendicular to the airstream at the outlet opening of the fan or the outlet opening of the evasé or diffuser. In this publication, the fan outlet is indicated by "Plane 2" (see Figure 1).

3.1.4 Fan airflow rate. The volumetric airflow rate at fan air density at the fan inlet.

3.1.5 Total pressure. The air pressure that exists by virtue of the degree of compression and the rate of motion. It is the algebraic sum of the velocity pressure and the static pressure at a point.

3.1.6 Velocity pressure. The portion of the air pressure that exists by virtue of the rate of motion only. It is always positive.

3.1.7 Static pressure. The portion of the air pressure



The fan inlet and outlet locations are Plane 1 and Plane 2, respectively. The customer or consulting engineer does not know the fan inlet or outlet areas, and is, therefore, unable to accurately calculate the final static or total pressure corresponding to these planes. However, in most instances, the customer will know the velocity range or area associated with the ductwork. For this reason, information supplied to the fan manufacturer should be the duct system values. The fan manufacturer can calculate the required pressure at Plane 1 and 2 using the appropriate fan areas and the estimated length of the transition piece between the fan and the ductwork. (See AMCA Publication 801, Section 14).

Figure 1 - Fan Inlet and Outlet Planes

that exists by virtue of the degree of compression only. It may be positive or negative relative to the ambient static pressure.

3.1.8 Fan pressure relationships and interpretations. When applying the previous definitions to fan performance, there are distinct relationships that exist between each variable. This section describes these relationships.

3.1.8.1 Fan total pressure (P_t). The difference between the total pressure at the fan outlet and the total pressure at the fan inlet.

$$P_t = P_{t2} - P_{t1}$$

3.1.8.2 Fan velocity pressure (P_v). The pressure corresponding to the average velocity at the specified fan outlet area.

$$P_v = P_{v2}$$

3.1.8.3 Fan static pressure (P_s). The difference between the fan total pressure and the fan velocity pressure. Therefore, the fan static pressure is the difference between the static pressure at the fan outlet and the total pressure at the fan inlet.

$$P_s = P_t - P_v$$

and $P_t = P_{t2} - P_{t1}$

and $P_v = P_{v2}$

then $P_s = (P_{t2} - P_{t1}) - P_{v2}$

$$P_s = P_{t2} - P_{v2} - P_{t1}$$

and $P_{s2} = P_{t2} - P_{v2}$

so $P_s = P_{s2} - P_{t1}$

3.1.8.4 Illustration of fan relationships. Pressure relationships are illustrated in Figure 2 for a fan with both inlet and outlet ducts. It should be noted that there is a distinct difference between an entrance loss and the acceleration energy when using static pressure nomenclature.

Total pressure nomenclature should be used when discussing fan performance; however, from past practice, static pressure terminology is still used. It is most important to recognize the interdependence between total and static pressure in a typical system.

3.1.9 Motor power. The power delivered from the output shaft of the motor.

3.1.10 Bearing losses. The power losses resulting from friction in the main bearings.

3.1.11 Fan shaft power. The power delivered to the input end of the fan shaft and does not include any drive losses other than the fan bearings.

3.1.12 Fan impeller power. The power delivered to the fan impeller, specifically, the fan shaft power minus the bearing losses.

3.1.13 Fan power output. The useful power delivered to the air being handled. This output is proportional to the product of the fan airflow rate, the fan total pressure, and the compressibility coefficient (K_p).

3.1.14 Similarity. Two fans that are similar and have similar airflow conditions will have similar performance characteristics. The degree of similarity

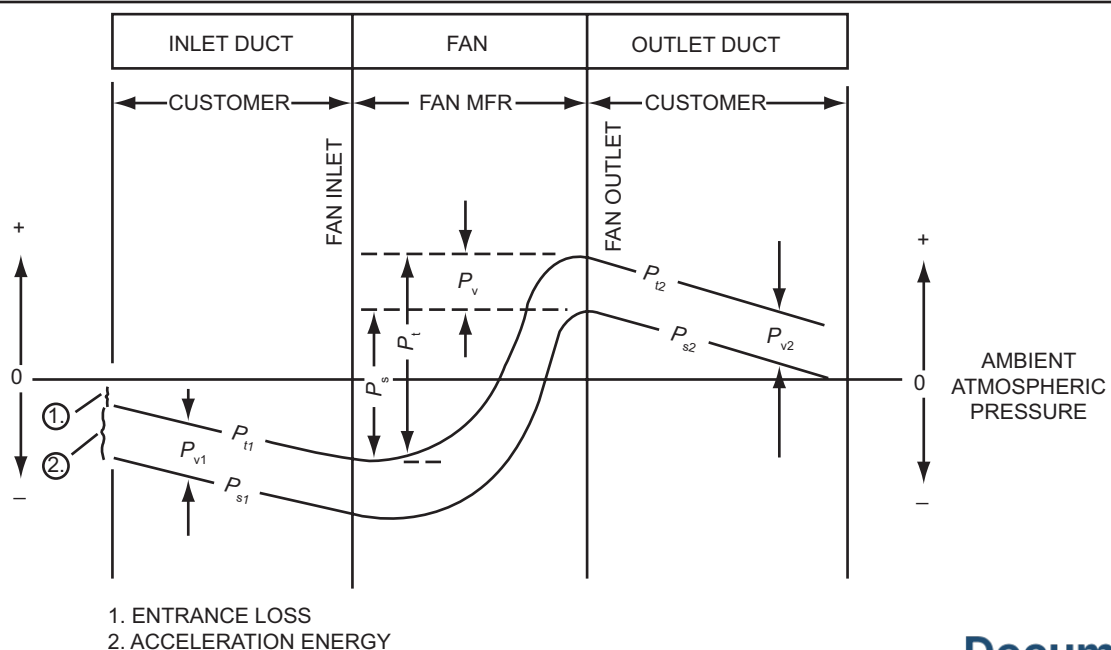


Figure 2 - Interpretation of Fan Pressures for Rating Purposes



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of the performance characteristics depends on the degree of similarity of the fans and the airflow through the fans.

3.1.15 Geometric similarity. Complete geometric similarity requires that the ratios of all corresponding dimensions for the two fans be equal. This includes ratios of thickness, clearances and roughness, as well as all the other linear dimensions of the airflow passages. All corresponding angles must be equal.

3.1.16 Kinematic similarity. Complete kinematic similarity requires that the ratios of all corresponding velocities for the two fans be equal. This includes corresponding velocities of the air and corresponding peripheral velocities of the impeller. The directions and points of application of all corresponding vectors must be the same.

3.1.17 Dynamic similarity. Complete dynamic similarity requires that the ratios of all corresponding forces in the two fans be equal. This includes ratios of forces due to elasticity, viscosity, gravity, surface tension and inertia, as well as the pressure force. The directions and points of application of all corresponding vectors must be the same.

3.1.18 Point of rating. The specified fan operating point on its characteristic curve.

3.2 Gas properties

3.2.1 Static temperature. The temperature which exists by virtue of the internal energy of the air only.

3.2.2 Total (stagnation) temperature. The temperature which exists by virtue of the internal and the kinetic energy of the air. If the air is at rest, the total (stagnation) temperature will equal the static temperature.

3.2.3 Absolute pressure. The value of a pressure when the reference pressure is absolute zero.

3.2.4 Barometric pressure. The absolute pressure exerted by the atmosphere.

3.2.5 Gauge pressure. The value of a pressure when the reference pressure is the barometric pressure at the point of measurement. It may be negative or positive.

3.2.6 Air. A mixture of various gases commonly used to denote any gaseous medium measured, moved, or controlled, which may include solid or liquid particulates.

3.2.7 Air density. The mass per unit volume of the air.

3.2.8 Fan air density. The density of the air corresponding to the total pressure and the total (stagnation) temperature at the fan inlet.

3.2.9 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, a viscosity of $1.819 \times 10^{-5} \text{ Pa}\cdot\text{s}$ ($1.222 \times 10^{-5} \text{ lbm/ft}\cdot\text{s}$). Air at 20°C (68°F), 50% relative humidity, and 101.325 kPa (29.92 in. Hg) has these properties, approximately.

3.2.10 Airflow rate. The volumetric airflow rate at a specific air density.

3.2.11 Fluid viscosity. The characteristic of all fluids to resist flow.

3.2.12 Absolute viscosity. The proportionality factor relating to shearing stress (force per unit area) and rate of shear (incremental velocity per incremental distance).

3.2.13 Kinematic viscosity. The absolute viscosity divided by mass density.

3.2.14 Compressibility. The characteristic of a gas to change density as a function of pressure.

3.2.15 Compressibility coefficient. A thermodynamic factor used to determine the fan total efficiency from fan airflow rate, fan total pressure, and fan power input. It is the ratio of the mean airflow rate through the fan to the airflow rate at the fan air density. It is also the ratio of the fan total pressure that would be developed with an incompressible fluid to the fan total pressure that is developed with a compressible fluid.

3.2.16 Specific heat at constant pressure. The quantity of heat required to increase the temperature of a unit mass of substance one degree at constant pressure.

3.2.17 Specific heat at constant volume. The quantity of heat required to increase the temperature of a unit mass one degree at constant volume.

3.2.18 Specific heat ratio. The numerical ratio of the specific heat of a gas at constant pressure to that of the same gas at constant volume.

3.3 Aerodynamic definitions

3.3.1 Reynolds Number. A dimensionless number representing the ratio of inertial forces to viscous forces at a particular point of a fluid in motion. Its value is calculated as the flow velocity at the point of interest multiplied by a characteristic linear dimension and divided by the fluid's kinematic viscosity.

Table 1 - Symbols and Subscripted Symbols

Symbols	Description	SI	I-P
C_p	Specific heat at constant pressure	J/kgK	BTU/lbm°F
C_v	Specific heat at constant volume	J/kgK	BTU/lbm°F
D	Diameter	mm	inches
H	Fan power	W, kW	hp
K_p	Compressibility coefficient	Dimensionless	
M	Mach number	Dimensionless	
N	Rotational speed	rpm	rpm
P_s	Fan static pressure	Pa	in. wg
P_{sx}	Static pressure at plane X	Pa	in. wg
P_t	Fan total pressure	Pa	in. wg
P_{tx}	Total pressure at plane X	Pa	in. wg
P_v	Fan velocity pressure	Pa	in. wg
P_{vx}	Velocity pressure at plane X	Pa	in. wg
Q	Fan airflow rate	m ³ /s	ft ³ /min
Re	Reynolds Number	Dimensionless	
t_d	Dry bulb temperature	°C	°F
t_w	Wet bulb temperature	°C	°F
t_t	Stagnation (total) temperature	°C	°F
γ	Specific heat ratio	Dimensionless	
ΔP	Pressure differential	Pa	in. wg
μ	Gas viscosity	Pa•s	lbm/ft•s
ρ	Fan air density	kg/m ³	lbm/ft ³

3.3.2 Fan Reynolds Number. A criterion for judging airflow properties in a fan. Fluid velocity is defined in this case to be the peripheral velocity at the tip diameter of the fan (tip speed). The tip diameter is also used as the linear dimension. Fan Reynolds Number is discussed further in Section 7.3.

3.3.3 Mach Number. A dimensionless number representing the ratio of the fluid velocity to the speed of sound.

3.3.4 Tip speed mach parameter. A dimensionless number expressing the ratio of the fan peripheral velocity (tip speed) to the local velocity of sound at the fan inlet. The tip speed mach parameter is discussed further in Section 7.3.

3.4 Geometric definitions

3.4.1 Tip speed. The peripheral velocity at the impeller blade tips.

3.4.2 Absolute roughness. The distance between the high and low points of a surface.

3.4.3 Relative roughness. The absolute roughness of a surface divided by a dimension (i.e., length, diameter, etc.)

3.5 Symbols and subscripted symbols

See Table 1

4. Fan Performance Data Base

The consulting engineer, system designer, or ultimate customer provides fan specifications to the manufacturer so that the manufacturer may prepare a fan proposal. In general, though, fan specifications do not sufficiently detail fan performance requirements.

The fan manufacturer is prepared to guarantee that a fan will attain specified ratings. Using the fan with elbows, ducts and/or other items different from those used in the rating configuration, such as items that cause non-uniform velocity profiles or "swirl," can degrade fan performance. To avoid unexpected performance degradation, the purchaser and the fan manufacturer must both participate if optimum fan performance is to be established. The purchaser must recognize the general sequence of events used by most fan manufacturers in establishing the performance data base for fans.

4.1 Establishing fan data base

The procedure for establishing a fan data base is as follows:

- a) Using available techniques, establish an aerodynamic model based upon desired performance goals.
- b) Build and test a model fan of the proposed design, with modifications as necessary to achieve performance goals.
- c) When the model fan meets performance goals, conduct additional performance tests using other fan configurations and appurtenances.
- d) The collected performance data becomes the data base for sizing full size fans.

4.2 Rating tolerances and test uncertainties

Verification of the fan rating may be conducted in the laboratory using a model or in the field using the full size fan. The accuracy with which such tests are conducted is dependent upon various conditions, as follows:

a) ***Under controlled laboratory conditions*** the test uncertainties contained in ANSI/AMCA 210, Appendix E, can be met whether testing a model or full size fan. Based upon a 95% confidence level, the characteristic curve test uncertainty approaches 1% at the best efficiency point and approaches 2% at free delivery. If the power is measured within $\pm 1\%$, the fan efficiency uncertainty is about 2% near the best efficiency point.

b) ***Under special field test conditions*** with proper ductwork configuration, measurement locations, and calibrated instrumentation (including calibration of the driver), the field test accuracy can only approach that obtained under laboratory conditions. AMCA Standard 803 provides test requirements, procedures and the calibrations necessary to accurately determine fan performance under these special site conditions.

c) ***Field test conditions which do not approach laboratory conditions*** will have test uncertainties larger than those obtained in a laboratory. AMCA Publication 203 is a guide to the measurement of fan system performance in the field. Under the conditions outlined in AMCA Publication 203, and with a 95% confidence level, minimum test uncertainties are approximately 2% on airflow rate, 2% on pressure, and 3% on power, which corresponds to an efficiency uncertainty of 4%.

When test uncertainties are expected to be larger than the minimum field test uncertainties listed above, a model fan test in accordance with AMCA Publication 802 should be considered if verification of a fan rating is necessary.

Test tolerances are variances in measured parameters in a test that are mutually agreed upon by all parties involved in a test. Test tolerances are applied to the measured results of a test and are different than allowances for uncertainties referred to in the remainder of this document.

Unless otherwise agreed to by the fan manufacturer and the customer, minimum test tolerances and test uncertainties apply only to the specific rating points and not to other points on the fan characteristic curve that do not form part of the rating. There may be other rating points specified, commonly called part-load points. Tolerances associated with part-load operation must be agreed upon by all parties.

5. The Fan Performance Rating Process

Determining the performance of the fans requires knowledge, experience, and judgment. Fans often consume large amounts of power. Considering energy costs, it is imperative that fans for each application be properly sized and rated. This section is intended to present a detailed insight into the fan performance rating process. It correlates the general areas of responsibility between the architect, engineer, user, and fan manufacturer to ensure that fan equipment is properly selected, rated and evaluated. A logic flow diagram in Figure 3 provides an excellent checklist of all performance related variables for those who write fan specifications.

5.1 Information necessary to properly calculate fan performance

Basic information about the system and its components, operational load cycles, and elements of fan construction must be given to the fan manufacturer by the consultants and/or the user. AMCA Publication 801 contains a detailed checklist of all necessary information. AMCA Publication 802 covers only the performance-related variables necessary to properly determine a fan rating.

A fan rating must consist of five variables:

- 1) Air density
- 2) Capacity or airflow rate
- 3) Fan total or fan static pressure
- 4) Rotational speed
- 5) Power

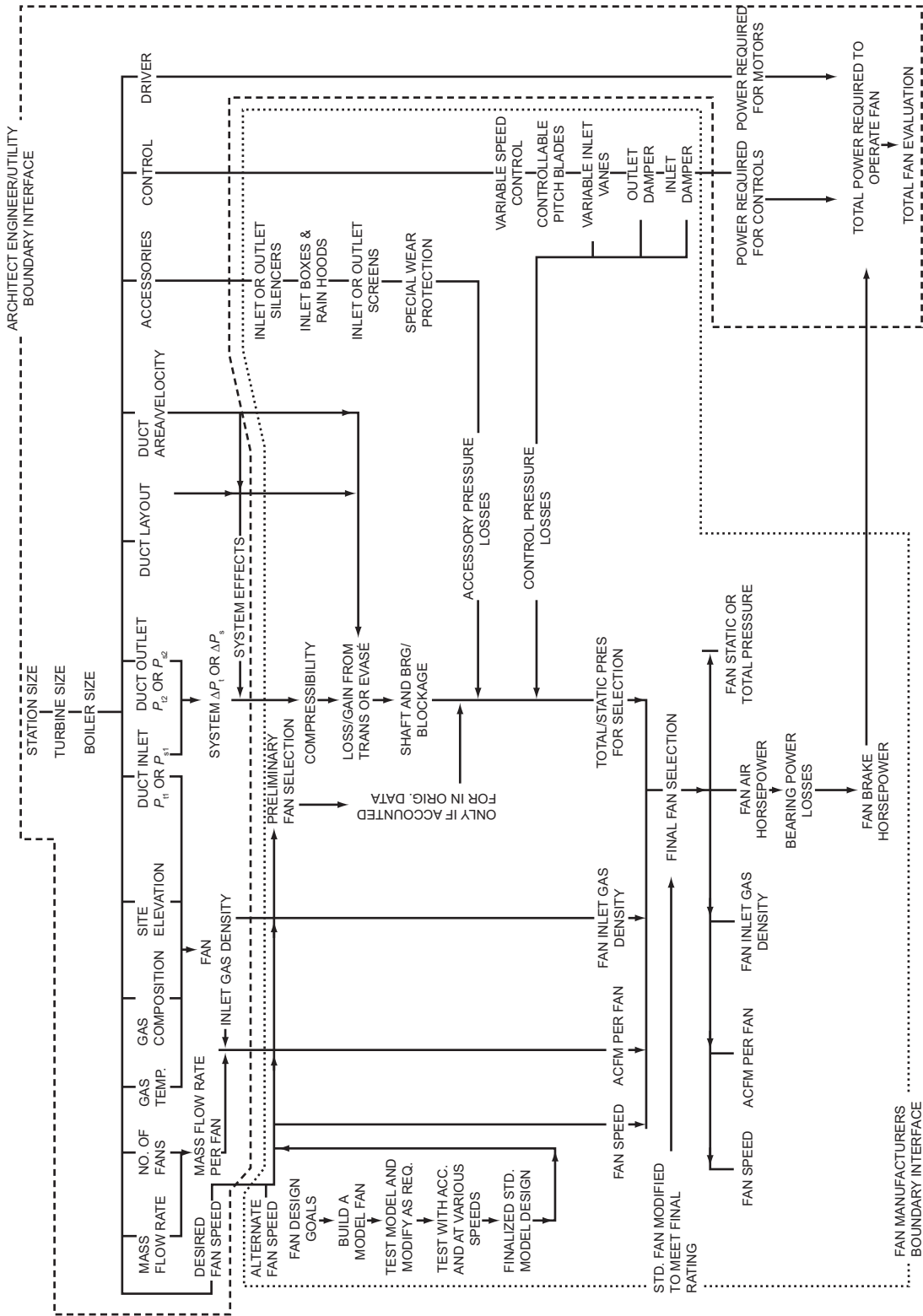


Figure 3 - Relationships and Responsibilities

The detailed relationships of each variable are shown on the logic diagram (Figure 3), and are individually discussed below.

5.1.1 Density. Fan performance depends on the air or gas density at the fan inlet. Air density is usually given by the consultant or user, but may also be calculated by the fan manufacturer, provided he is given all of the appropriate variables. The air density at the fan inlet depends upon:

- a) Inlet air temperature (wet bulb and dry bulb)
- b) Air composition
- c) Fan Inlet absolute pressure, which is a function of:
 1. Site elevation / barometric pressure
 2. Fan suction pressure, which causes a net reduction in the prevailing barometric pressure

The air density is one of the most important considerations in rating fans. If the density is not correct or varies with time, the fan performance will not be as expected. The fan inlet density can be calculated using the procedures outlined in AMCA Publication 203 and ANSI/AMCA Standard 210 and AMCA Standard 803.

5.1.2 Capacity of airflow rate. A given weight of air must be moved through the system and its related components, any pollution control equipment, and any connecting ductwork. This weight remains nearly constant except for leakage either into or out of the system. At any specific location within the system, the total required volumetric airflow rate can be determined by dividing the mass airflow rate by the density of the air. Then the number of fans required to deliver the total airflow rate must be determined. This must be determined for each fan application.

5.1.3 Pressure considerations

5.1.3.1 System pressure. In any system, the ultimate goal is to provide a desired amount of air to a certain location. Based upon the desired airflow rate through the various parts of the system it is necessary to calculate the required pressure that must be developed by the fan to move this amount of air.

This pressure must equal the various losses caused by the air moving through the ductwork upstream and downstream of the fan, as indicated in Figure 2. Based on system loss calculations and the desired location of the fan in the system, the consultant or user must specify the pressure values at the plane of both the fan inlet and fan outlet. Total pressure values are preferred when discussing performance,

however, conversions between static and total pressures can be made providing duct dimensions (area) and velocities are known.

Figure 4 compares two fans with inlet boxes, one with atmosphere inlet and one with ducted inlet, Case A and Case B. The absolute inlet total pressure for both cases is 96.3 kPa (28.45 in. Hg).

As can be seen by comparing the three calculated quantities in each case, the fan static pressure *rise* is not the same for both cases even though the fan power (or energy addition to the air) is the same. However, fan static pressure (P_s) and fan total pressure (P_t) remain consistent. The key feature is that fan static pressure and fan total pressure are both relative to the inlet total pressure (P_{t1}).

The user can specify the inlet static pressure providing the inlet area at which it is to occur is also specified. The fan manufacturer can then determine an inlet total pressure using the airflow rate and area to calculate the inlet velocity pressure and adding it to the inlet static pressure.

It is the responsibility of the consultant / user to determine the pressure at the plane of both the fan inlet and outlet. As stated before, if static pressure values are given, a duct area or air velocity must also be given at that plane.

The pressures at the duct connection do not necessarily represent the final pressures for selecting a fan. Losses for system effects and appurtenances must also be considered.

5.1.3.2 System effects. The consultant / user should calculate the duct friction and dynamic losses of the system. To these losses must be added the system effects due to elbows, duct connections, or other items that may cause non-uniform velocity profiles at the fan inlet and outlet. Such profiles may cause a severe reduction in fan performance.

For information on system effects, see AMCA Publication 201 and AMCA Publication 801. Using AMCA Publication 201 as a guide, the system designer should make appropriate allowances for system effects. A complete set of inlet and outlet duct configuration drawings should be made a part of any specification. In this manner, the fan manufacturer can visualize the duct configuration and make recommendations that might, in some cases, significantly reduce the magnitude of a system effect.

In cases where a model fan test is being contemplated as part of a fan rating specification, the magnitude of any system effect must be mutually

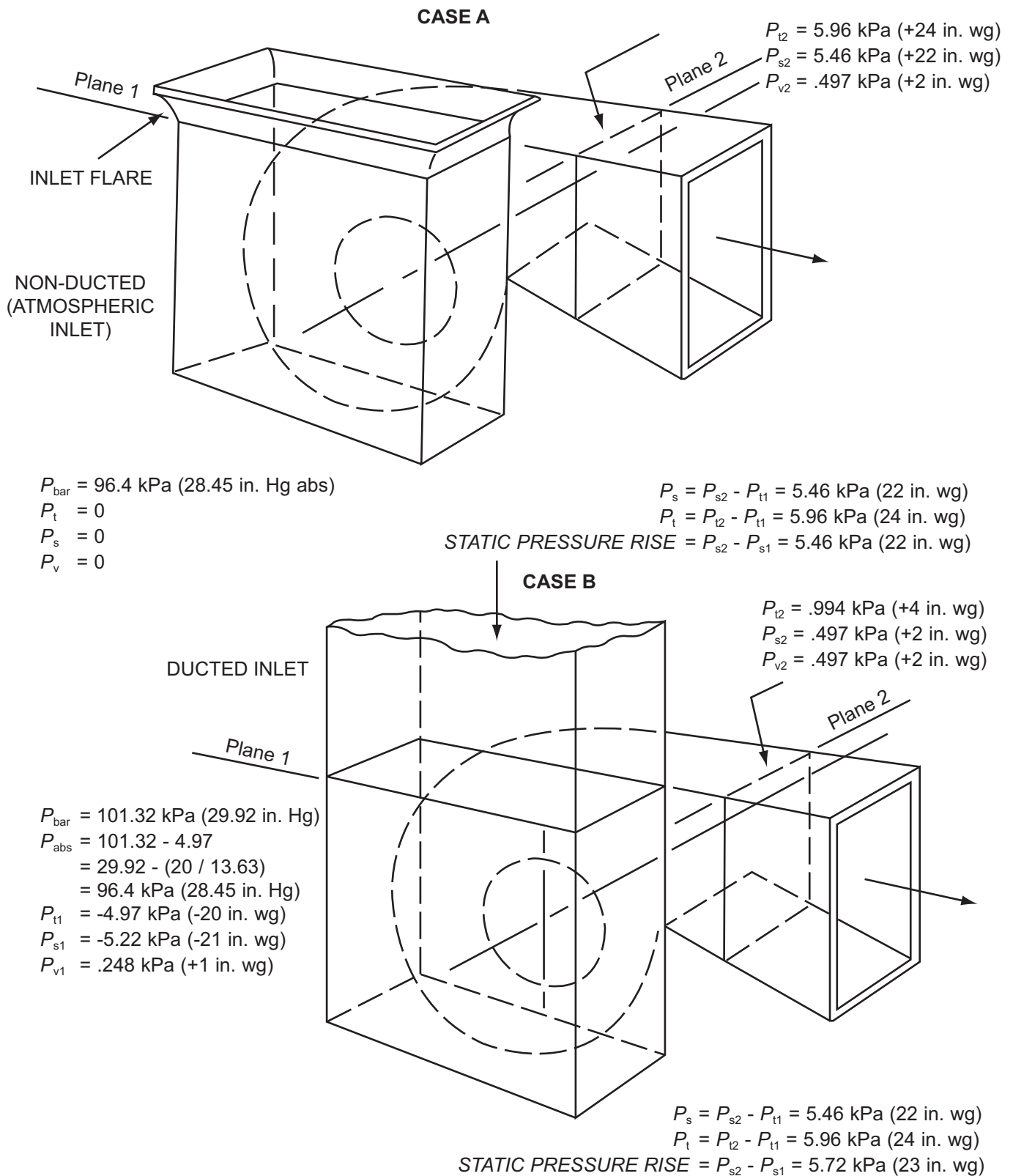


Figure 4 - Effect of Ducted Inlet on Fan Static Pressure Rise

agreeable to all parties. If it is not, then the duct configuration, elbows, and other items must be considered a part of the modeling process and included in a laboratory test. It may be necessary to test the model fan both with and without the duct configuration in order to determine actual system effect values.

5.1.3.3 Compressibility. Compressibility expresses the volumetric change in a gas due to changes in pressure, temperature, and composition. Compressibility corrections are necessary when predicting the performance of a high pressure fan.

For many years, the Fan Laws were based upon the assumption that air was an incompressible fluid. The effect of this was not significant as the majority of fans were low pressure. But as the size of applications increased, so did the pressure requirements for fans, making it essential that compressibility effects be incorporated into the Fan Laws to ensure a more accurate prediction.

The compressibility coefficient, K_p , is used to mathematically express the relationship between compressible and incompressible conditions. The ratio of K_p values existing for a model and the full size fan is applied to airflow, pressure and power terms in the Fan Laws. The use of the compressibility coefficient in no way changes the fan total efficiency. It can only reduce the size of the fan required to perform a specified duty.

For certain industrial and power generation fans, particularly induced draft fans, the gas being handled may deviate substantially from standard air due to differences in molecular weights, temperature, and entrained particulate matter. Compressibility effects due to differences in the specific heat of the air must be considered.

5.1.3.4 Diffuser / evasé considerations. The consultant / user should determine system losses and define the area or air velocity at the end of the duct connection to the fan. As long as the duct area or velocity of the air in the inlet duct is specified, the fan manufacturer can calculate the required pressures at the fan using appropriate fan areas and estimates of the length of the transition between the fan and the ductwork.

An evasé represents a loss in the total pressure. An evasé can be used to convert velocity pressure at a small area into static pressure regain at a larger area by slowing the air velocity. Fan manufacturers often use an evasé to reduce the fan requirements when ratings are based upon static pressure. This is a valid approach; however, confusion often results when

comparing fans because of differences in fan and evasé areas and differences in the estimated regain to be obtained from any particular evasé.

The figures and procedures outlined in Annex D can be used to determine realistic values of regains and losses for transitions and evasés. In model testing, all parties involved must agree on the values to be used prior to the start of a test. If not, the evasé should be included as part of the model fan test setup.

5.1.3.5 Shaft, bearing, and motor blockage. Very often, centrifugal fan ratings are calculated using information obtained from a fan in which the shaft diameter of the model is not proportional to the shaft in the full size fan. The fan manufacturer should include appropriate values for shaft blockage in his ratings. In any fan evaluation, the consultant / user should verify that this has been done.

Shaft and motor blockage losses for axial fans are normally included in a rating because the base model test has included these items. The consultant / user should still verify that these effects have been considered.

5.1.3.6 Appurtenance and control losses. The supplier of appurtenances and controls is responsible for calculating the losses of these items. Items often considered to be appurtenances or controls include: inlet boxes, inlet or outlet dampers, variable inlet vanes, silencers, screens, and other items such as wear protection located in the air stream that might cause a reduction in performance.

5.1.3.7 Final pressure determination. The final total or static pressure loss used to determine a fan rating is the algebraic sum of all pressure losses or regains discussed in the previous paragraphs. Failure to include any item may cause a significant discrepancy between the design pressure and the pressure actually obtained once the fan is installed in the field. Fan ratings should be based on fan static pressure or fan total pressure.

5.1.4 Fan rotational speed. A fan operating speed preference may be indicated by the customer; however, the actual fan speed should be determined by structural design, wear, and noise considerations.

5.1.5 Fan power. The power requirement for a fan is calculated using the fan capacity, compressibility, pressure and efficiency. The fan bearing losses should be considered part of the fan rating, but may be listed separately. Care should be used in sizing any motor so that all density changes, fan operating points, fan rotor inertia, and driveline losses have been considered.

5.2 Fan evaluation

Within recent years, an increased emphasis has been placed upon the cost of energy. Because of this, economic evaluations on fan input power requirements have become common. The customer should therefore ensure that all fan proposals are based upon comparable principles, e.g., fan static or fan total pressure versus static pressure rise, comparable evasé or diffuser areas, and realistic pressure losses for appurtenances.

For any particular application in which similar fan designs are being evaluated, fan rating data contained in proposals should be relatively consistent among manufacturers. A fan rating that is distinctly different from others being considered should be reviewed by the customer and fan manufacturer for accuracy. In an evaluation where differences in fan power are determined to be negligible, emphasis should be placed upon other factors such as construction details, fan reliability, and past history of the fan supplier.

The optimum fan is one that gives maximum fan duty with the best investment value, taking into account costs of operation, initial costs, maintenance, and replacement expenditures.

6. Laboratory Test

Laboratory tests represent the most accurate method of determining fan performance. Test results may form the basis for obtaining information used to rate full size fans or used to verify the performance of a full size fan. Because tests of large fans are usually very costly, and require large test facilities, laboratory tests of models should be considered as an alternative. Similarity requirements are outlined in Section 7.

This section discusses aspects that should be considered in conducting a laboratory test of a model fan.

6.1 Test setup requirements

To guarantee that a fan will perform as specified once it is installed in a system, the laboratory test setup should be as representative as possible of the actual fan installation. This means that the test setup must correspond physically and aerodynamically to this requirement, irrespective of the model size. Fortunately, for most applications, modeling of the entire fan system is not necessary and a laboratory test of the fan in accordance with ANSI/AMCA 210 is sufficient. However, in those cases where the fan system configuration is not finalized, the following is provided for guidance:

- a) If no installation details are available, the fan manufacturer and purchaser must assume that the duct system will not affect the fan performance. In this case, the fan inlet and outlet connections will correspond closely to the laboratory conditions outlined in ANSI/AMCA 210.
- b) When the duct system is known, AMCA Publication 201 provides guidance on system effects for a number of installations. The fan manufacturer may also be able to establish system effects based upon prior experience. A laboratory test may be conducted with and without the system ductwork connections to more accurately determine the final fan performance in the field.
- c) The test setup should include the fan and all other items in the air stream such as screens, silencers, dampers, etc. However, if the fan manufacturer and the purchaser agree, the time and cost of a test can usually be reduced by allowing mathematical corrections for losses/gains in transitions, evasés, or diffusers by using information published in textbooks and this publication. It should be verified that the physical dimensions used to make the mathematical corrections are representative of the actual installation.
- d) Fan orientations in many field installations do not lend themselves to laboratory tests. This would be particularly true of a fan having an inlet from below grade or outlet which is not horizontal. In most cases, an agreement should be possible which would allow changes in the fan orientation to facilitate testing of the model in the laboratory.
- e) The test setup should meet all geometric and dynamic similarity requirements outlined in Section 7. As indicated, geometric similarity between the model and full size fan is required for only those parts in contact with the air stream. Alternative materials of construction may be used, provided that there is no influence upon the fan performance, e.g., differences in surface roughness.
- f) Fan bearings and driveline component losses will be different on the model fan than on the full size fan. Those differences should be included in the analysis of the fan power requirements.

6.2 Test methods

All laboratory tests should be made in accordance with ANSI/AMCA 210 or with a test setup that gives the same test results and accuracy. It is most

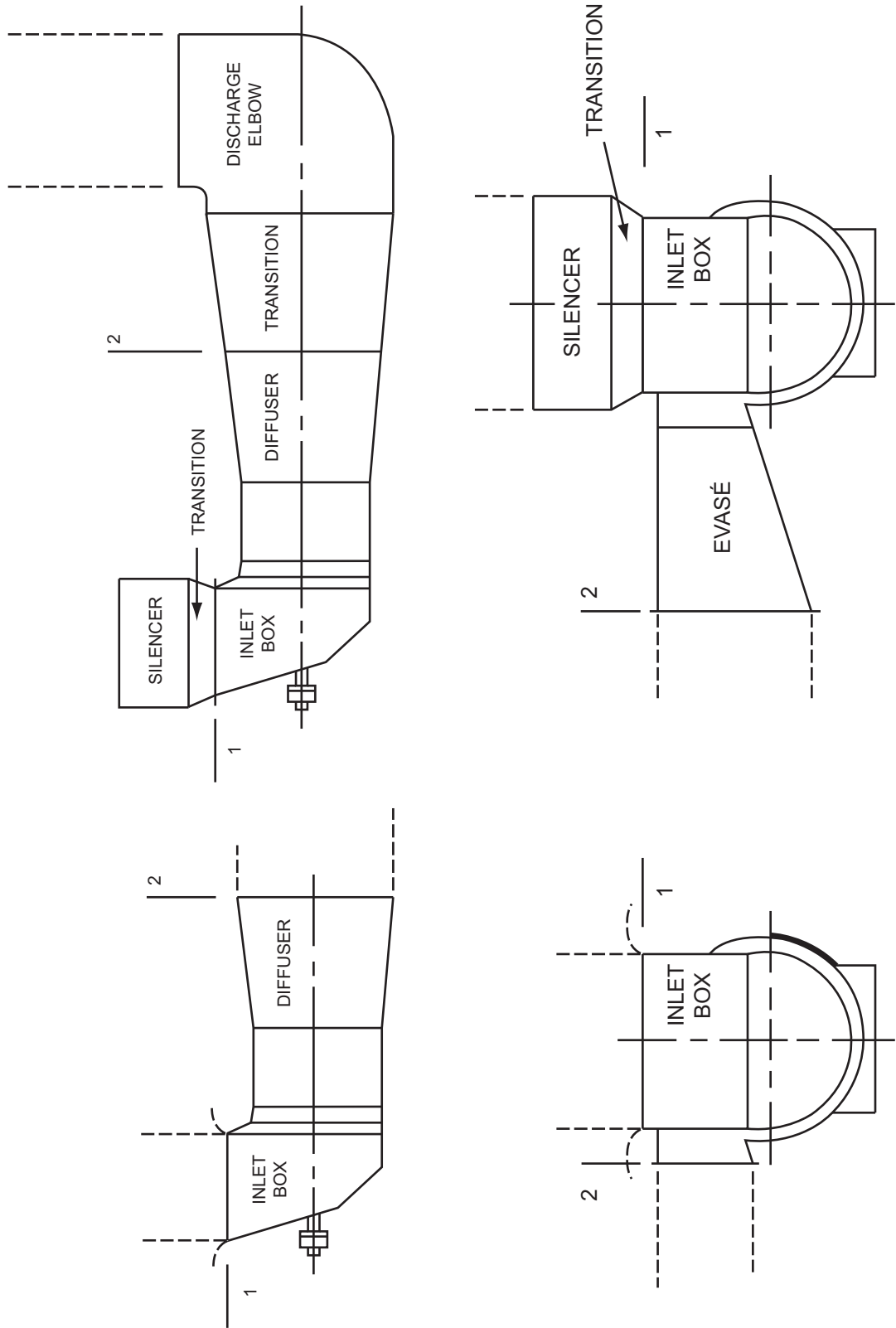


Figure 5 - Typical Test Setups

SETUP USING SYSTEM COMPONENTS

SETUP USING BASIC FAN