

## FIELD TESTING OF FAN SYSTEMS

### INTRODUCTION

A fan system may require field testing when the system is thought to be malfunctioning, needs modification or requires balancing of its volume and pressure characteristics.

When it has been determined that a field test is required, the test can provide a complete check on fan performance. This includes determination of air volume, fan static pressure and fan brake horsepower.

This Engineering Letter details the steps involved in performing a field air test. A field test sheet, which simplifies the recording of test data and the calculation of test results, is provided. A list of safety precautions to be observed while conducting the test is also included.

### INSTRUMENTS REQUIRED

1. The best method of measuring both air velocity and static pressure in the field is with a Pitot tube and manometer. The absence of moving parts, combined with fundamental simplicity, make this set of instruments accurate and nearly foolproof. Both instruments may be used in nearly any atmosphere and require no adjustments except for zeroing the manometer prior to testing. Figure 1 shows a Pitot tube cross-section. Figure 2 demonstrates how it is connected to the manometer to indicate pressures by measuring the difference in heights of water columns in the "U" tubes.

Most manometers, such as shown in Figure 3, read directly in inches of water column. Some manometers may have velocity graduations marked directly in feet per minute for use where barometric pressure and temperature corrections are normal (i.e., test conditions assumed to be 70°F. and 29.92 inches of mercury).

For greater convenience, a more compact Magnehelic pressure gauge may be used with a Pitot tube as a substitute for the manometer mentioned earlier. These gauges, illustrated in Figure 4, are available in a variety of pressure ranges.

2. A clip-on ammeter/voltmeter is used to obtain a reasonable estimate of fan motor horsepower.
3. A calibrated hand tachometer is used to determine the fan RPM.
4. An accurate temperature probe is used to measure temperature at each test location where volume or static pressure readings are taken.

Sometimes there are no accessible test duct locations suitable for use with the Pitot tube. In this case, the air volume can be determined at the system entrance or exit, or through a grille or coil by using an anemometer or velometer. This method, however, is not as accurate and readings should only be taken by experienced service personnel familiar with this type of testing.

### PERFORMING A PITOT TUBE/MANOMETER TEST:

1. Make a sketch of the system as a record and as a guide for selecting locations for taking test readings. Often this will call attention to poor system-design features. Include dimensions, such as duct diameters or areas, duct length, motor size, motor speed and sheave diameters on belt drive fans.

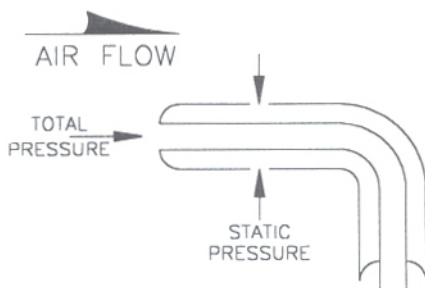


Figure 1 – Pitot Tube Cross-Section

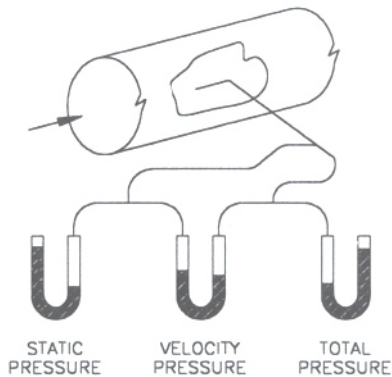


Figure 2 – Pitot Tube Connection

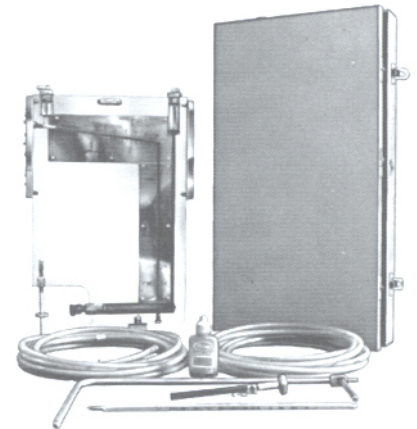
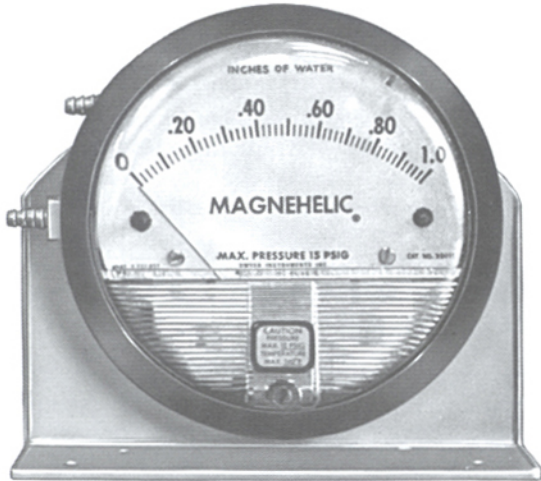


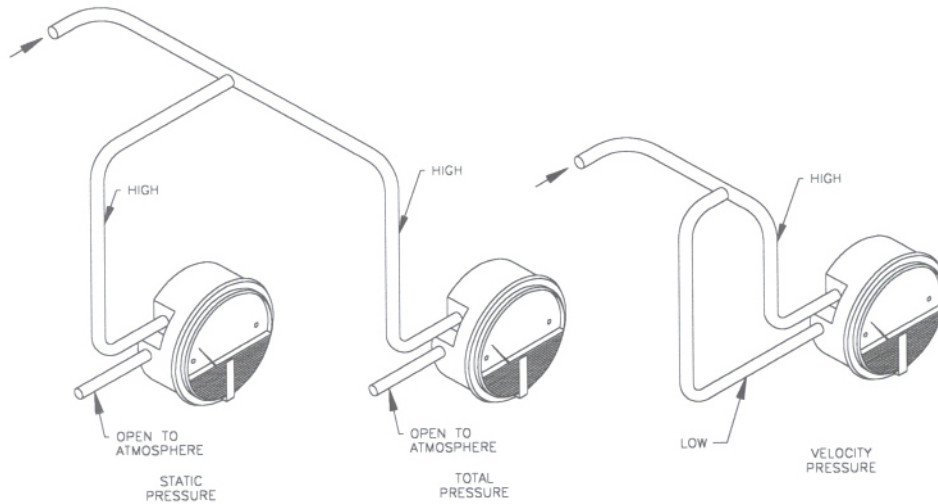
Figure 3 – Pitot Tube/Manometer Test Kit

2. Determine the best possible location for obtaining the air volume readings via a Pitot tube traverse (set of readings). The traverse location should not be directly after any turns, transitions or junctions. The traverse should be after a minimum of 2 1/2 duct diameters of straight duct. To obtain the correct air volume, the Pitot tube and manometer or gauge should be connected to display velocity pressures, not velocities (see Figure 5). The location of the test points within each traverse is shown on the field test sheet included with this letter.
3. Take static pressure readings several duct diameters from the fan inlet and outlet to avoid turbulence (see Figure 6). If the fan has either an open inlet or outlet, assume the static pressure to be zero at the opening. Record the airstream temperatures at each static pressure location.
4. Record the fan speed after measuring it with the tachometer. If a tachometer is unavailable, make sure you record the motor nameplate RPM and sheave diameters from which the fan speed can be calculated.
5. Read the voltage and amperes supplied to the motor and record the values for calculation of fan motor horsepower.
6. Measure the barometric pressure at the fan site with a portable barometer or obtain the pressure from the nearest weather station or airport. Be sure the barometric pressure is correct for your altitude and that it has not been corrected to sea level reference.
7. Determine whether the air being handled contains quantities of moisture, particulates and/or gases other than clean air. If so, obtain the concentrations and densities of the gases or mixture for use in making density corrections.

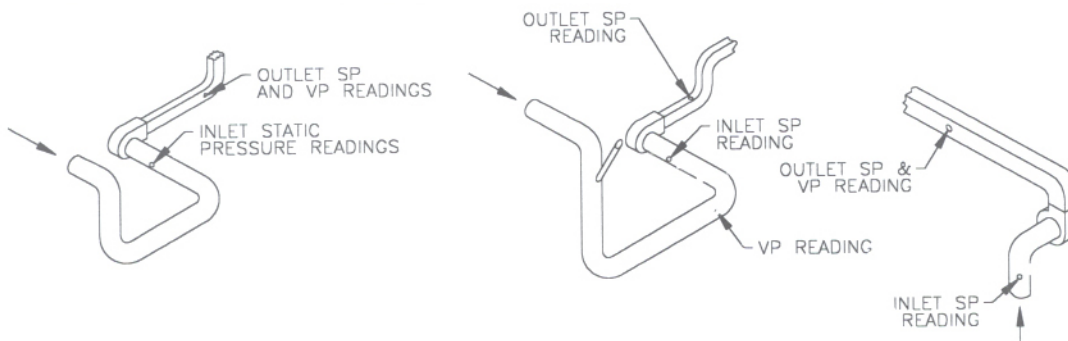


**Figure 4 – Magnehelic Gauge**

The attached test sheet is used to calculate flow through a fan. For additional information on conducting field tests of fan systems, AMCA Publication 203, Field Performance Measurements of Fan Systems, is recommended.



**Figure 5 – Air Flow Pressure**



**Figure 6 – Static Pressure Readings**

## CALCULATING FAN PERFORMANCE

The following steps explain how to calculate density, CFM, SP, and BHP using the acquired test data.

1. Determine the density of the airflow through the fan during the test by using the dry-bulb temperature at the fan inlet and the barometric pressure. Density in pounds per cubic foot is determined by:

$$\text{Density}_{\text{inlet}} = 0.075 \left( \frac{530}{460 + ^\circ\text{F.}} \right) \left( \frac{\text{Barometric Pressure}}{29.92} \right)$$

2. Determine the density of the airflow at the CFM test location (if different from inlet density) by:

$$\text{Density}_{\text{CFM}} = 0.075 \left( \frac{530}{460 + ^\circ\text{F.}} \right) \left( \frac{\text{Barometric Pressure}}{29.92} \right)$$

3. Calculate fan inlet air volume in CFM as measured with the Pitot tube and manometer/gauge as follows: First, take the square roots of the individual velocity pressures and compute the average of the square roots. Then:

$$\text{CFM}_{\text{inlet}} = [ 1096 \times \text{test duct area (ft}^2) ] \times$$

$$\left( \frac{\text{Avg. of Sum of } \sqrt{\text{VP's}}}{\sqrt{\text{Density}_{\text{CFM test}}}} \right) \times \left( \frac{\text{Density}_{\text{CFM}}}{\text{Density}_{\text{Inlet}}} \right)$$

The above calculation gives air volume in actual cubic feet per minute (ACFM) which is the conventional catalog rating unit for fans. If standard cubic feet per minute is desired, it may be calculated as follows:

$$\text{SCFM} = \text{ACFM} \times \left( \frac{\text{Actual Inlet Density}}{\text{Standard Density}} \right)$$

4. Determine the fan static pressure (SP) by the following formula:

$$\text{SP}_{\text{fan}} = \text{SP}_{\text{outlet}} - \text{SP}_{\text{inlet}} - \text{VP}_{\text{inlet}}$$

Where:  $\text{VP}_{\text{inlet}} = \left( \frac{\text{CFM}_{\text{inlet}}}{1096 \times \text{inlet area in sq. ft.}} \right)^2 \times \text{Density}_{\text{inlet}}$

NOTE: Correct inlet and outlet static pressure to standard values by the following formula before summing.

$$\text{SP}_{\text{standard}} = \text{SP}_{\text{actual}} \left( \frac{\text{Actual Density}}{\text{Standard Density}} \right)$$

5. Fan motor horsepower may be determined in several ways. The best is to read the volts and amperes supplied to the motor and apply the formula:

For single phase motors:

$$\text{Fan BHP} = \frac{\text{Volts} \times \text{Amps} \times \text{Power Factor} \times \text{Motor Eff.}}{746}$$

For three phase motors:

$$\text{Fan BHP} = \frac{\text{Volts} \times \text{Amps} \times \text{Power Factor} \times \text{Motor Eff.} \times \sqrt{3}}{746}$$

This method requires power factor and motor efficiency data, which may be difficult to obtain.

Another method is to draw an amps versus horsepower curve, (see Figure 7). This is done by plotting a rough horsepower versus amps curve for the motor as follows:

- a. Establish no-load amps by running the motor disconnected from the fan (point a).
- b. Draw a dotted line through one-half no-load amps, at zero HP, and nameplate amps, at nameplate HP (points b).
- c. At one-half nameplate HP, mark a point on this line (point c).
- d. Draw a smooth curve through the three points (a, c, b).
- e. Determine running HP by plotting running amps.

Multiply fan horsepower by the "K" density correction factor to determine HP at standard conditions.

6. Locate volume, static pressure and horsepower on a performance curve drawn at the fan RPM. Curves can be generated using manufacturer's fan-selection software at specific densities, temperature and altitude.

The test plot values will probably not fall exactly on the curve. If the fan system has been designed and installed properly, the difference should be small, reflecting test accuracy. If the difference is great, the system should be analyzed as described in the next section. Figure 8 shows a typical fan curve and field test points which fall on the curve.

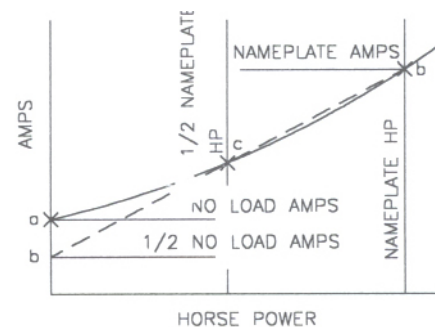


Figure 7 – Amperes versus Horsepower

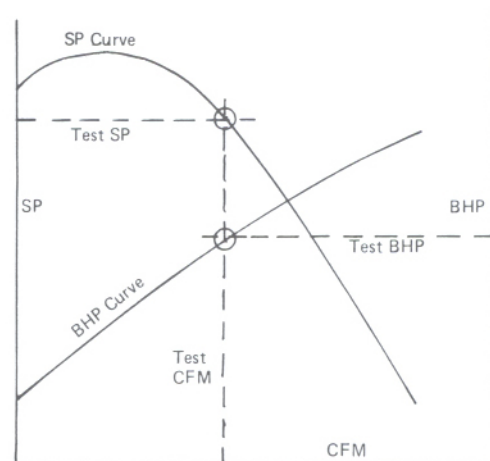


Figure 8 – Typical Fan Curve and Field Test Points

## POOR PERFORMANCE TEST RESULTS

If the test results indicate poor fan performance, a number of simple steps can be taken that could improve performance.

Be sure that any dampers at the fan inlet or outlet are set to the correct position and that no other system dampers such as fire dampers, smoke dampers or balancing dampers have been inadvertently closed.

A frequent cause of poor fan performance is the presence of poor inlet connections. Sharp elbows, inlet boxes without turning vanes and duct configurations causing the air to spin upon entering the fan, are examples of undesirable inlet connections.

Fan performance is also impacted by poor outlet conditions. Examine the outlet connection, keeping in mind that sharp elbows, rapid expansions, reductions or the absence of an outlet connection all together can reduce fan performance.

By connecting the Pitot tube and manometer/gauge to read velocity pressure and inserting the Pitot tube through a hole at the inlet connection (as illustrated in Figure 9), pre-spin can be

determined. Once inserted, slowly twist the tube. The angle at which air is entering the fan can be determined by observing the angle of the tube generating the highest gauge reading. If the angle deviates noticeably from being parallel to the fan shaft, the air entering the fan inlet may be spinning and therefore reducing fan performance.

Another reason for poor performance could be stratification of the air entering the fan. By taking four temperature readings ninety degrees apart in the inlet duct near the fan, the possibility of stratification can be determined. A temperature difference of 10 degrees or more in the readings indicates stratification exists. An illustration of stratification is shown in Figure 10.

Refer to Engineering Letters 5 and 6 for more detailed explanations of system effect and improving fan performance.

## SAFETY PRECAUTIONS

The included list of safety precautions should be observed whenever testing or servicing fan equipment.

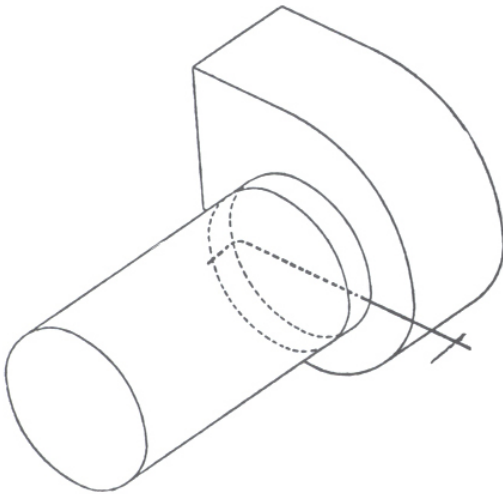


Figure 9 – Testing Fan Inlet for Spinning Airflow

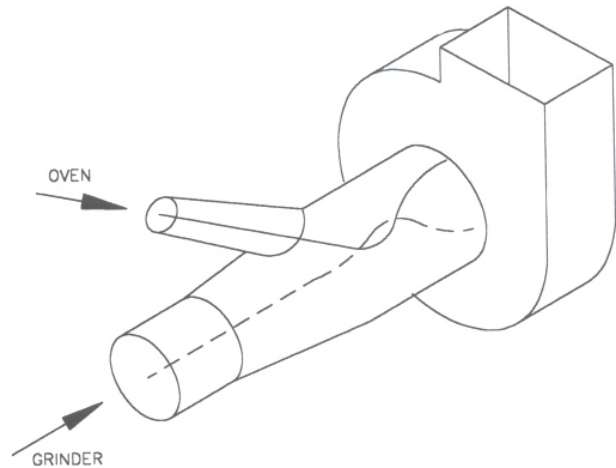


Figure 10 – Condition Causing Stratification

## FIELD TEST SHEET

Fan Owner \_\_\_\_\_

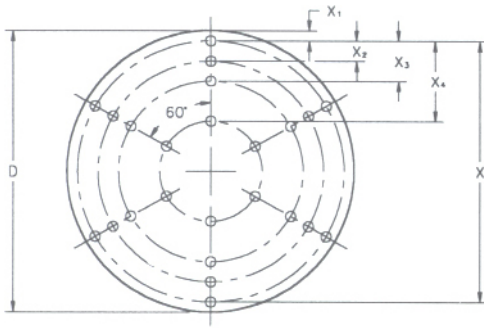
Fan Location \_\_\_\_\_

Fan Nameplate Data \_\_\_\_\_

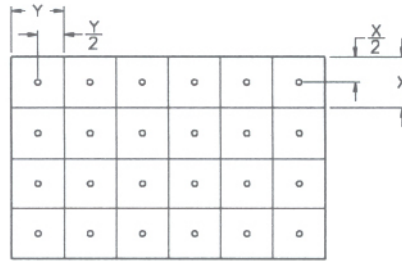
Fan RPM \_\_\_\_\_ Motor Nameplate Data \_\_\_\_\_

Motor Test Current \_\_\_\_\_ Voltage \_\_\_\_\_

Date \_\_\_\_\_ Tested by \_\_\_\_\_



**Traverse Points for Round Duct**



**Traverse Points for Rectangular Duct**

Test * Points	SP	VP	√VP
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
Sum of √VP's			
Avg. of Sum of √VP's			

Barometric Pressure	Average SP Inlet	Temperature °F. Inlet	Average Static Pressure Outlet	Temperature °F. Outlet

$$\text{Density}_{\text{inlet}} = \frac{0.075 \text{ lb.}}{\text{ft.}^3} \times \left( \frac{530}{460 + \text{°F.}} \right) \times \left( \frac{\text{Barometric Pressure}}{29.92} \right) = \text{lbs./ft.}^3$$

$$\text{Density}_{\text{outlet}} = \frac{0.075 \text{ lb.}}{\text{ft.}^3} \times \left( \frac{530}{460 + \text{°F.}} \right) \times \left( \frac{\text{Barometric Pressure}}{29.92} \right) = \text{lbs./ft.}^3$$

$$\text{Density}_{\text{CFM test}} = \frac{0.075 \text{ lb.}}{\text{ft.}^3} \times \left( \frac{530}{460 + \text{°F.}} \right) \times \left( \frac{\text{Barometric Pressure}}{29.92} \right) = \text{lbs./ft.}^3$$

$$\text{CFM}_{\text{inlet}} = 1096 \times \text{Duct Area} \times \left( \frac{\text{Avg. of Sum of } \sqrt{\text{VP's}}}{\sqrt{\text{Density}_{\text{CFM test}}}} \right) \times \left( \frac{\text{Density}_{\text{CFM test}}}{\text{Density}_{\text{inlet}}} \right) = \text{CFM}$$

$$\text{VP}_{\text{inlet}} = \left( \frac{\text{CFM}_{\text{inlet}}}{1096 \times \text{Inlet Area}} \right)^2 \times 0.075 = \text{“ W.G. ”}$$

$$\text{SP}_{\text{fan}} = \text{SP}_{\text{outlet}} \times \left( \frac{0.075}{\text{Density}_{\text{outlet}}} \right) - \text{SP}_{\text{inlet}} \times \left( \frac{0.075}{\text{Density}_{\text{inlet}}} \right) - \text{VP}_{\text{inlet}} = \text{“ W.G. ”}$$

$$\text{Single Phase BHP}_{\text{fan}} = \frac{\text{Amps} \times \text{Volts} \times \text{Power Factor} \times \text{Motor Efficiency}}{746} = \text{BHP}$$

$$\text{Three Phase BHP}_{\text{fan}} = \frac{\text{Amps} \times \text{Volts} \times \text{Power Factor} \times \text{Motor Efficiency} \times \sqrt{3}}{746} = \text{BHP}$$

\* A minimum of 24 test points is recommended for round ducts less than 8 feet in diameter and rectangular ducts with areas 24 square feet and less. For larger ducts, more test points are required.



## SAFETY PRECAUTIONS

### A WORD ABOUT SAFETY

Testing, adjusting, and maintaining fan equipment exposes personnel to potential safety hazards. Only experienced mechanics, who are aware of the safety hazards created by moving or rotating parts, should be authorized to work on fan equipment. The proper precautions must be followed to prevent injury from moving parts.



Beginning in June 2012, the above **WARNING** signage has been placed on all **nyb** fans, as specified by ISO and recommended by the European Union. Air moving equipment involves electrical wiring, moving parts, and air velocity or pressure which can create safety hazards if the equipment is not properly installed, operated and maintained. To minimize this danger, follow these instructions as well as the additional instructions and warnings on the equipment itself.

All installers, operators and maintenance personnel should study AMCA Publication 410 - Recommended Safety Practices for Air Moving Devices, which is included as part of every shipment. Additional copies can be obtained by writing to The New York Blower Company, 7660 Quincy Street, Willowbrook, IL 60527-5530 or can be downloaded from our web site at [www.nyb.com](http://www.nyb.com).

### ELECTRICAL DISCONNECTS

Every motor-driven fan should have an independent disconnect switch to isolate the unit from the electrical supply. It should be near the fan and must be capable of being locked by maintenance personnel while servicing the unit in accordance with OSHA procedures. **Do not attempt any maintenance on a fan unless the electrical supply has been completely disconnected and locked.**

### MOVING PARTS

**All moving parts must have guards to protect personnel.** Safety requirements vary, so the number and type of guards needed to meet company, local and OSHA standards must be determined and specified by the user. Never start a fan without having all safety guards installed. Check regularly for damaged or missing guards and do not operate any fan with guards removed. Fans can also become dangerous because of potential “windmilling”, even though all electrical power is disconnected. Always block the rotating assembly before working on any moving parts.

### AIR PRESSURE AND SUCTION

In addition to the normal dangers of rotating machinery, fans present another hazard from the suction created at the fan inlet. This suction can draw materials into the fan where they become high velocity projectiles at the outlet. It can also be extremely dangerous to persons in close proximity to the inlet as the forces involved can overcome the strength of most individuals. **Inlets and outlets that are not ducted should be screened to prevent entry and discharge of solid objects.**

### ACCESS DOORS



#### Danger: Do Not Enter/Confined Spaces

The above **DANGER** decal is placed on all **nyb** cleanout doors. **These doors, as well as access doors to the duct system, should never be opened while the fan is in operation.** Serious injury could result from the effects of air pressure or suction.

Quick-opening doors must have the door handle bolts securely tightened to prevent accidental or unauthorized opening. Bolted doors must be tightened for the same reason.

### MAXIMUM SAFE SPEED

Safe operating speed is a function of system temperature and wheel design. **Do not, under any circumstances, exceed the maximum safe fan speed published in the nyb bulletin,** which is available from your **nyb** field sales representative.