GREENHECK

Fan Application

FA/105-00

PRODUCT APPLICATION GUIDE

A technical bulletin for engineers, contractors and students in the air movement and control industry.

Inlet Pressure Correction

A fan rating consists of five different interdependent variables - flow rate, pressure, speed, power and density. However, it isn't always recognized that flow rate and density are based upon fan inlet conditions. When the inlet pressure exceeds 10 inches in suction, the density at the fan inlet should be corrected. *(With suction pressures less than 10 inches, this correction is typically ignored.)*

Items like the type of gas, temperature, barometric pressure, elevation, and moisture content change the inlet density from that of standard air.

Standard air has a density of .075 lbs/ft^3 at 68° F, 29.92 inches Hg (sea level), 50% RH, 1.4 specific heat and a viscosity of 1.22 X 10^{-5} lb ft-s. What is not readily apparent is that the pressure distribution across the fan has an impact upon the inlet density. This occurs when the fan is physically located internal to a system, or when it is exhausting with only ductwork on the inlet side. For example, a fan with an inlet pressure of –10 inches SP_{INLET} effectively lowers the inlet density 2.5 percent. This means that the fan must now run slightly faster than if the entire design pressure was on the fan discharge. If this correction is not taken into account, the fan will be low in performance when installed in the system. This correction is called "inlet pressure correction".

By calculating the fan inlet density for a fan rated for 5800 CFM at 14 inches SP with the pressure on the discharge and with the pressure on the inlet, we can see the impact this correction has on a specific fan.

The following formula illustrates where and how this inlet pressure correction takes place in the calculation process. The formula consists of a set of ratios modifying standard air conditions to other conditions.

A B C D E F

$$d = .075 \times SG \times \left(\frac{Bar}{29.92}\right) \times \left(\frac{407\text{-}SP_{INLET}}{407}\right) \times \left(\frac{460+68}{460+T}\right)$$

Definition:

A: d = new calculated inlet density (lbs/ft^3)

B: .075 = standard air density (lbs/ft^3)

C: SG = specific gravity is the ratio of the density of any dry gas to the density of dry air at the same pressure and temperature

D: $\left(\frac{Bar}{29.92}\right)$ = ratio of the actual barometer to the barometer at sea level. This is a function of elevation, not daily fluctuations.

E: $\left(\frac{407\text{-}SP_{INLET}}{407}\right)$ = inlet pressure correction for the effects of a negative pressure on the barometric pressure. The 407 number is 29.92 inches Hg expressed in inches of water.

F: $\left(\frac{460+68}{460+T}\right)$ = the effects a change in temperature has on density. The temperature is expressed in degrees Rankine which is obtained by adding 460 to degrees fahrenheit.

Input variables in blue

Example:

The following example applies to any fan application, whether HVAC or industrial. An industrial process fan (IPW) was selected because this fan type can develop pressures up to 30 in. SP. Especially on an industrial process fan, if the inlet pressure is not taken into consideration, there could be a significant negative impact on the system.

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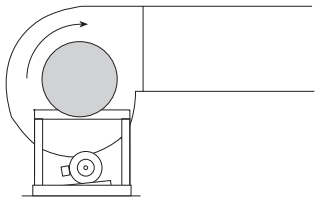
Selection:

17 IPW fan for 5800 CFM, 14 in. SP, 2000 ft elevation, 150 F

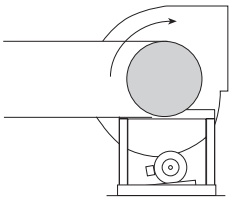
With the pressure on the discharge:

$$d = .075 \times SG \times \left(\frac{27.8}{29.92}\right) \times \left(\frac{407-0}{407}\right) \times \left(\frac{460+68}{460+150}\right) = .0605 \text{ lbs/ft}^3$$



With the pressure on the inlet:

$$d = .075 \times SG \times \left(\frac{27.8}{29.92}\right) \times \left(\frac{407-14}{407}\right) \times \left(\frac{460+68}{460+150}\right) = .0584 \text{ lbs/ft}^3$$



Results from Greenheck CAPS program

	Density (LBS/ft^3)	Pressure ("SP)	Inlet Pressure	Speed (RPM)	Power (HP)
Rated with the pressure on the discharge, the actual condition is:	.0605*	14.00*	0.0*	1905	20.2
Rated with the pressure on the inlet, the actual condition is:	.0584*	14.0*	14.0*	1937	20.2.

*values entered into CAPS program

Summary:

As shown at the right, at 5800 cfm the 17 IPW will be short .5 inches SP if the inlet pressure correction is not used. This is a result of the fan being selected at a density of .0605 lbs/ft^3 with a resulting 1905 fan rpm. When the fan is installed in the system the density will actually be .0584 lbs/ft^3 with the same 1905 fan rpm. (*curve 1)*

At 5800 cfm the difference in pressure is -13.5 inches SP or -.5" SP short of the desired -14 inches SP. However, the ultimate final operating point in the system will be where the system line and the fan curve cross at a flow rate somewhat less than the 5800 cfm. Therefore, the flow rate as well as the pressure will be low compared to design. If the inlet pressure correction had been used up front, then the system line and the fan curve would cross at 5800 cfm at -14 inches SP but with a 1937 fan rpm. (*curve 2*)

When designing your system, be sure to look at all the variables...flow rate, pressure, speed, power and density. Factor in all the elements and your system will perform at peak efficiency for many years. For the right products for your application, use Greenheck's Computer Aided Selection Program (CAPS), to walk you through this process.