PRODUCT APPLICATION

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

Understanding Temperature and Altitude Corrections

Understanding how fan performance is affected by air density is critical for fan application and selection. Many fan and HVAC product manufacturers offer selection software as well as printed performance tables and curves. A user of product selection software that adjusts for air density must understand the selection data (output) that is generated by the program and can confirm that the data makes engineering sense. The information presented in this article provides fan engineering knowledge to assist with understanding a selection program's output.

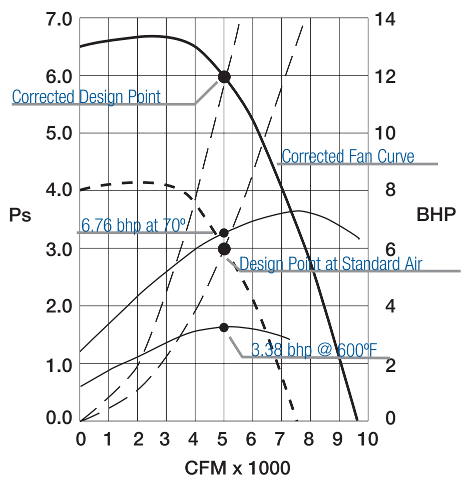
The most common influences on air density are the effects of temperature other than 70°F and barometric pressures other than 29.92 caused by elevations above sea level.

Ratings found in general printed fan performance tables and curves are based on standard air. Standard air is defined as clean, dry air with a density of .075 pounds per cubic foot, with the barometric pressure at sea level of 29.92 inches of mercury and a temperature of 70°F. Selecting a fan to operate at conditions other than standard air requires adjustment to both static pressure and brake horsepower. The volume of air will not be affected in a given system because a fan will move the same amount of air regardless of the air density provided that the required input power (HP, KW) is supplied. In other words, if a fan will move 3,000 cfm at 70°F, it will also move 3,000 cfm at 250°F. Since 250°F air weighs only 34% of 70°F air, the fan will require less BHP but also create less pressure than specified.

When a fan is specified for a given cfm and static pressure (Ps) at conditions other than standard, the correction factors (shown in the table on page 2) must be applied in order to select the proper size fan, fan speed and BHP to meet the new condition.

The best way to understand how the correction factors are used is illustrated in the following examples. The first example uses a specification for a fan to operate at 600°F at sea level. This example will clearly show that the fan must be selected to handle a much greater static pressure than specified.

Example #1: A 20-inch housed, backward-inclined, single width (BISW) centrifugal fan is required to deliver 5,000 cfm at 3.0 inches static pressure. Elevation is 0 (sea level). Temperature is 600°F.



Example 1: The fan curve represents the fan's operation at both the corrected and specified conditions. Curves are plotted at standard air.

1. Using the chart, the correction factor is 2.00.
2. Multiply the specified operating static pressure by the correction factor to determine the standard air density equivalent static pressure.

> Corrected static pressure = 3.0 in. wg x 2.00 = 6 in. wg
>
> Therefore, the fan must be selected for 6 inches of static pressure.

3. Based upon the printed performance table for a 20-inch BISW fan at 5,000 cfm at 6 in. wg 2,018 rpm is needed to produce the required performance. (This now requires a Class II fan. Before the correction was made it would have appeared to be a Class I selection.)
4. The BHP from the printed performance table for this fan at 3.0 in. wg at standard conditions is 6.76.
5. What is the operating BHP at 600°F?

Since the horsepower shown in the printed performance table refers to standard air density, this should be corrected to reflect actual BHP at the less dense air.

> Operating BHP = Standard BHP ÷ 2.00 or
>
> 6.76 ÷ 2.00 = 3.38 bhp

Important: We now know the operating BHP. However, what motor horsepower should be specified for this fan?

If a fan is selected to operate at high temperatures, the motor must be of sufficient horsepower to handle the increased load at any lower operating temperature where the air is denser. Assume the air entering the fan at start-up is 70°F, therefore no correction should be made. The starting BHP remains at 6.76 and a 7½ hp motor is required.

Note: BHP corrections are most commonly used for altitude corrections (see next example) or when the starting and operating temperatures are the same.

AIR DENSITY CORRECTION FACTORS

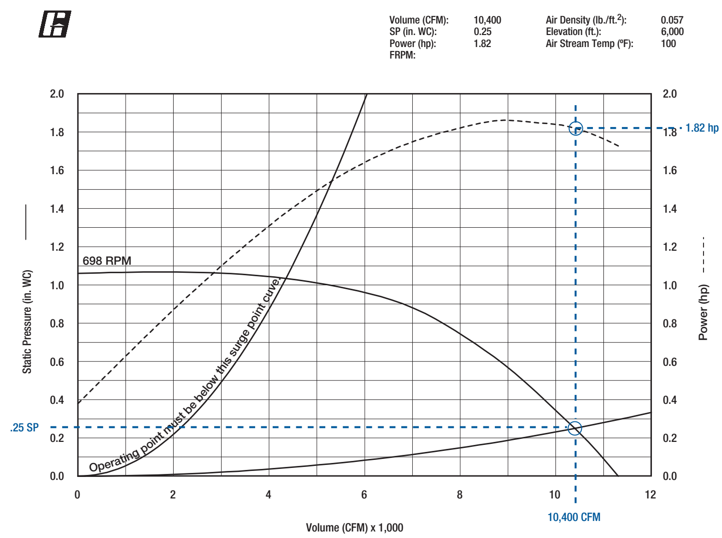
Air Temp. °F	Elevation (Feet Above Sea Level)															
	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000
0	0.87	0.90	0.94	0.97	1.01	1.05	1.08	1.13	1.17	1.22	1.26	1.31	1.37	1.43	1.48	1.54
50	0.96	1.00	1.04	1.08	1.11	1.15	1.20	1.24	1.30	1.34	1.40	1.45	1.51	1.57	1.63	1.70
70	1.00	1.04	1.08	1.12	1.16	1.22	1.25	1.30	1.35	1.40	1.45	1.51	1.57	1.64	1.70	1.77
100	1.06	1.10	1.14	1.18	1.22	1.27	1.32	1.37	1.42	1.48	1.54	1.60	1.66	1.74	1.80	1.88
150	1.15	1.19	1.24	1.30	1.33	1.38	1.44	1.49	1.55	1.61	1.67	1.74	1.81	1.89	1.96	2.04
200	1.25	1.29	1.34	1.40	1.44	1.50	1.56	1.61	1.68	1.75	1.81	1.89	1.96	2.05	2.13	2.21
250	1.34	1.39	1.44	1.50	1.55	1.61	1.67	1.74	1.80	1.88	1.95	2.02	2.10	2.20	2.28	2.37
300	1.43	1.49	1.54	1.60	1.66	1.72	1.79	1.86	1.93	2.01	2.08	2.16	2.25	2.35	2.43	2.53
350	1.53	1.58	1.64	1.71	1.77	1.84	1.91	1.98	2.06	2.14	2.22	2.31	2.40	2.51	2.60	2.71
400	1.62	1.68	1.75	1.81	1.88	1.94	2.03	2.09	2.19	2.27	2.37	2.45	2.54	2.66	2.75	2.87
500	1.81	1.88	1.95	2.02	2.10	2.18	2.26	2.35	2.44	2.54	2.63	2.73	2.84	2.97	3.08	3.20
600	2.00	2.07	2.15	2.23	2.31	2.40	2.50	2.59	2.69	2.84	2.91	3.02	3.14	3.28	3.40	3.54
700	2.19	2.27	2.35	2.44	2.53	2.63	2.73	2.83	2.94	3.07	3.17	3.31	3.44	3.59	3.72	3.88
800	2.38	2.48	2.57	2.67	2.76	2.86	2.98	3.09	3.21	3.33	3.45	3.59	3.74	3.90	4.05	4.21
900	2.56	2.66	2.76	2.87	2.97	3.07	3.20	3.33	3.46	3.58	3.71	3.87	4.02	4.20	4.35	4.53
1000	2.76	2.87	2.99	3.09	3.20	3.31	3.45	3.59	3.73	3.86	4.00	4.17	4.33	4.53	4.69	4.89

Note: It's acceptable to interpolate when exact temperatures or elevations are not shown in chart.

Example #2: A fan is used at 6,000 feet elevation to exhaust 100°F air from an attic space. A 30-inch roof exhaust fan is required to move 10,400 cfm at 0.25 inch static pressure.

1. Using the chart, the correction factor is 1.32.
2. Multiply the specified operating static pressure by the correction factor to determine the standard air density equivalent static pressure.

> Corrected static pressure =
> 0.25 in. wg x 1.32 = 0.33 in. wg
>
> The fan must be selected for
> 0.33 inch static pressure.



This curve represents the fan density correction for Example 2.

3. Based upon the printed performance table, for a 30-inch roof fan, 698 rpm is needed to produce the required performance.
4. The BHP from the printed performance table is 2.40.
5. What is the operating BHP at 6000 feet elevation in 100°F air?

Since the horsepower selected refers to standard air density, this should be corrected to reflect actual BHP at the lighter operating air.

$$\text{Operating BHP} = \text{Standard BHP} \div 1.32 \quad \text{or}$$

$$2.40 \div 1.32 = 1.82 \text{ bhp}$$

In this example, we can use the corrected BHP because the fan is located at a given elevation and will not be turned on until the attic temperature reaches 100°F. The result is a 2 hp motor can be specified in lieu of a 3 hp motor.

Communicate your corrections

When a specified fan appears on the fan schedule, it's important to determine if the specifier has already made the required corrections for temperature and altitude. Avoid confusion by specifying at what temperature or altitude (or both) the static pressure was calculated.

For example: 5,000 cfm at 600°F and 6 inches static pressure at 600°F (or 3 in. Ps. at 70°F).

Computer-aided fan selection programs, such as Greenheck CAPS®, are excellent tools to solve both the selection and specifying challenges of various fan applications.

CAPS prompts the user to enter the airstream temperature, the start-up temperature, and the altitude. The fan with the corrected conditions is then automatically selected.

Using CAPS will also guard against making selections for fan types or models that are not appropriate for the condition. This is especially important for selections at extreme temperatures that require special considerations for materials, motors, bearings, drives and speed derate factors.

As demonstrated in the above examples, for optimum system design and performance, it's important to understand and make the proper air density (temperature and/or altitude) corrections.

AMCA Certified Ratings

A manufacturer that participates in AMCA's Certified Ratings Program (CRP) assures the industry that the products and equipment will perform as stated by the manufacturer. The program stipulates the various rules and regulations for presenting cataloging data: AMCA 211 for aerodynamic performance and AMCA 311 for acoustic performance.

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