How to Test and Balance Under Extreme Conditions

By Rob "Doc" Falke, President, National Comfort Institute

When air balancing or measuring the performance of an HVAC system at high altitudes or extreme temperatures, be aware that everything changes. Your success depends on your ability to adapt readings and calculations to changes in air density. Let's take a close look at how to accurately test and calculate under extreme conditions.

400 CFM Per Ton?

Or could it be 500 CFM per ton? As altitude increases, the density of air decreases. Because the air is thinner as altitude increases, it takes more CFM per ton at higher elevations to move the required system airflow. At an altitude of 5000 feet above sea level the nominal airflow per ton increases to 500 CFM.

Warmer air also decreases the density of air. As air heats up, its weight decreases. This is one of the reasons hot air balloons rise. Air density correction factors can also be applied when measuring at temperatures below or above standard air conditions, which is air at sea level and 70F.

One of the problems in balancing at higher elevations is determining if the system designer allowed for the air density changes. Your job is to determine if the published airflow values on the plans have been adjusted to compensate for air density or not. To be effective, review the plans for a reference to air density correction. If not, you have the obligation to ask the question directly to the designer. To adjust the system to optimize performance requires you know if the designer adjusted for air density.

Air Density Correction Factors

To correct airflow for elevation or temperature under non-standard conditions, multiply or divide the amount of standard air needed by the corresponding factor in this table.

AIR DENSITY CORRECTION FACTORS

Air Temp	Altitude (ft)							
(ºF)	0 (Sea Level)	1000	2000	3000	4000	5000	6000	7000
50	1.04	1.00	0.97	0.94	0.90	0.87	0.84	0.81
55	1.03	0.99	0.96	0.93	0.89	0.86	0.83	0.80
60	1.02	0.98	0.95	0.91	0.88	0.85	0.82	0.79
70	1.00	0.96	0.93	0.89	0.86	0.83	0.80	0.77
80	0.99	0.95	0.92	0.88	0.85	0.81	0.79	0.76
90	0.97	0.94	0.90	0.86	0.83	0.80	0.77	0.75
100	0.95	0.93	0.88	0.85	0.81	0.78	0.75	0.73
110	0.94	0.92	0.86	0.83	0.80	0.77	0.74	0.72
120	0.93	0.90	0.85	0.82	0.79	0.76	0.73	0.71
130	0.91	0.88	0.83	0.81	0.78	0.75	0.72	0.70
140	0.89	0.86	0.81	0.80	0.77	0.73	0.71	0.68
150	0.87	0.84	0.80	0.79	0.75	0.72	0.70	0.67
CFM/ton	400 CFM	415 CFM	430 CFM	430 CFM	465 CFM	480 CFM	500 CFM	520 CFM

How to Use this Air Density Correction Table

1. Identify the altitude at which you are testing. (The best way to do this is to use an Altimeter. The next best is to Google the town name and altitude or use a smartphone app.)

2. Measure the appropriate air temperatures of the system.

3. Plot on the table where the appropriate altitude column and the temperature row intersect.

4. Use this correction factor as described below.

Required Heating Airflow Problem

1500 CFM of standard air is needed for the system to operate properly.

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But, field conditions show air that is 100F at an elevation of 5000 feet above sea level. Using a non-compensating balancing hood, how much extreme air will be required for the system to operate properly?

Solution

1500 CFM of standard air / 0.78 (the appropriate factor from the table) = 1923 CFM of extreme air.

Airflow Correction Problems

Some air balancing hoods and anemometers do not compensate for air density variations. To these instruments every cubic foot of air appears to be the same as any other regardless of its density.

To determine the actual amount of air being delivered, under non-standard conditions, multiply the airflow reading taken under the extreme conditions by the corresponding factor found in the Air Density Correction Table.

If 1200 CFM of air is measured at 40F at an elevation of 7000 feet above sea level using a non-compensating anemometer to perform a duct traverse, what's the actual amount of air in the duct?

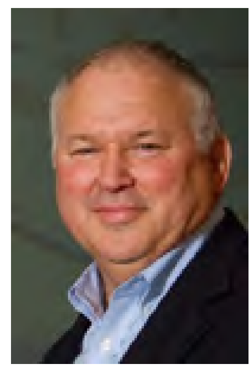
Solution

1200 CFM x 0.82 (the factor from the table) = 984 CFM of air passing through the duct.

By adapting these examples, you will enable yourself to compensate for air density changes as you test and balance.

Depending on how critical the testing is that you are engaged in, you'll be the one that determines when to apply these correction factors. Typically, air density correction is applied only above 1500-2000 feet elevations or when air temperature exceeds 100F in most situations.

When accuracy is critical or when the conditions demand increased accuracy, air density correction factors will often provide the solution you need to assure your reporting and calculations are the best they can be.



Rob "Doc" Falke co-founded National Comfort Institute with Dominick Guarino in the early 1990's and leads the technical training and curriculum development teams of the company. NCI's training mission is driven by Rob's vision that the performance of an HVAC system can be effectively measured and diagnosed under live operating conditions in the field. Rob's continuing role is to set the direction for the company's technical training programs, continually improve NCI's measurement methods, forms and procedures, and explore new technologies to help improve the quality, speed and effectiveness of our methods and training technologies.

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