

Using K-Factors with the ACCUBALANCE® Air Capture Hood

Application Note TI-137

Capture Hoods and Correction Factors (K-Factors)

In an ideal world, all capture hoods would provide accurate readings in all flow conditions. This would be true regardless of diffuser size, shape, throw pattern or delivery duct parameters such as shape, size, construction material and proximity of dampers or elbows. In the real world, however, all of these variables can affect the performance of a capture hood. To obtain the most reliable measurements with a capture hood, therefore, it is necessary to use correction factors, or K-Factors, to account for these varying flow effects.

The need for K-Factors has been recognized by the most respected organizations in the Heating Ventilating and Air-Conditioning profession, who recommend¹⁻⁵ the use of correction factors when using any capture hood. ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.) recommends¹ that, “All flow measuring instruments should be field verified by running pitot-tube traverses to establish correction and/or density factors.” ASHRAE also recommends^{2 & 3} comparing duct traverses to capture hood readings for performance checks in the field. Similarly, AABC (Associated Air Balance Council) recommends⁵, “take a traverse of the duct and determine correction factors as necessary.”

The Importance of K-Factors

If measurement accuracy is important, then the use of K-Factors is imperative. As stated earlier, it is well known that many factors affect readings taken with capture hoods. The uncertainties introduced by the wide variety of possible flow conditions make K-Factors vital in achieving accurate capture hood measurement results.

K-Factors also become extremely important when comparing the performance of two different capture hoods. It is generally accepted that the best accuracy that any capture hood can offer is 5% of the reading. Ideally then, when comparing two different capture hoods that have the best possible accuracy of 5%, there could be up to a 10% difference in readings between the two instruments. But in the non-ideal flow conditions encountered in the real world, this level of agreement between different capture hoods can

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only be expected *after* an appropriate K-Factor has been applied to each hood. In fact, any comparison between different capture hoods is meaningless without the inclusion of the appropriate K-Factor for each hood.

Determining and Using K-Factors

A K-Factor for a capture hood is defined as the ratio of the “true flow” to the “measured flow.”

$$\text{K-Factor} = \text{True Flow} / \text{Measured Flow}$$

The best way to determine the “true flow” is to perform an accurate duct traverse with a pitot tube or thermal anemometer in the duct upstream of the diffuser (make sure the duct only serves one diffuser). TSI maintains that the accurate methods for traversing ducts are the Log-linear method for round ducts and the Log Tchebycheff method for rectangular ducts⁶. The “measured flow” is the capture hood reading at the diffuser.

Determining K-Factors: An Example

Suppose you complete a velocity traverse of a 10” round duct leading to a particular diffuser and obtain the following numbers:

Position of measurement relative to inner duct wall (inches):	Velocity measurements:		
	Traverse #1 (ft/min)	Traverse #2 (ft/min)	Traverse #3 (ft/min)
0.2	575	725	535
0.8	590	730	575
1.5	595	790	625
2.2	605	770	640
3.6	665	785	685
6.4	795	815	790
7.8	790	790	775
8.5	750	760	740
9.2	710	745	670
9.8	680	685	655

Total: (6,755/10) (7,595/10) (6,690/10)
 Average (Total/10): 676 760 669

Average air velocity = (676+760+669) / 3 =702 ft/min

To calculate the flow in the duct, it is necessary to multiply the average air velocity by the duct cross-sectional area as follows:

Average Velocity (ft/min)	x	duct cross sectional area (in ft ²)	=Flow (ft ³ /min)
Average Velocity (ft/min)	x	$\pi (r \text{ in ft})^2$	=Flow (ft ³ /min)
Average Velocity (ft/min)	x	$\pi [(5"/12") \text{ ft}]^2$	=Flow (ft ³ /min)
Average Velocity (ft/min)	x	$\pi [0.417 \text{ ft}]^2$	=Flow (ft³/min)
702 ft/min	x	3.14 [0.417 ft] ²	=Flow (ft ³ /min)
702 ft/min	x	0.546 ft ²	= 383 ft ³ /min

Continuing our example, let us say that the ACCUBALANCE[®] capture hood reading at the diffuser is 365 ft³ / min. Then, recalling that:

$$\text{K-Factor} = \text{True Flow} / \text{Measured Flow}$$

Then our K-Factor = (383 ft³ / min) / (365 ft³ / min) = 1.05

From this equation, you can see that the product of the ACCUBALANCE[®] capture hood reading (“Measured Flow”) and the K-Factor is the “True Flow”:

$$\text{Measured Flow} \times \text{K-Factor} = \text{True Flow}$$

From our example: 365 ft³/ min x 1.05 = 383 ft³ / min.

Now we could use this K-Factor whenever we use an ACCUBALANCE[®] capture hood to measure flow where the duct/diffuser combination and other factors are the same.

For example, suppose we use the ACCUBALANCE[®] capture hood to measure flow in a similar duct/diffuser combination and get a reading of 200 ft³/min. Because we have already done a duct traverse and K-Factor determination for that duct/diffuser combination, we simply multiply this reading by the same K-Factor to get the true flow. So, 200 ft³/min x 1.05 gives us our true flow of 210 ft³/min. The true flow of 210 ft³/min would be the value to record in a “Balance Report” or other documentation.

Pre-determined K-Factor

Oftentimes it is not possible to do a duct traverse due to lack of access to the duct or lack of straight duct between elbows, take-offs or other air disturbances. In such cases, you may choose to use a pre-determined K-Factor or a K-Factor based on your previous experience with similar duct/diffuser combinations. In fact, you may find it helpful to keep a record of duct/diffuser combinations and their K-Factors as you measure them in the field. You could then refer to this record and choose an appropriate K-Factor whenever you encounter a duct which cannot be traversed.

K-Factors for 2' x 2' 4-way throw Diffusers Attached to Flexible Ductwork

TSI has done extensive testing with the typical 2-foot x 2-foot 4-way throw diffusers used in many offices, schools and other commercial buildings in the United States. We have determined a trend in the K-Factors for these diffusers when they are connected to round, flexible ducts of various sizes. In most cases, you can simply look up into the diffuser to determine what size flexible duct leads to the diffuser. Then you can refer to the chart below for the appropriate K-Factor*.

* These K-Factors will improve accuracy for the specified conditions in most cases. To achieve the best results however, an accurate duct traverse must be completed to determine a K-Factor.

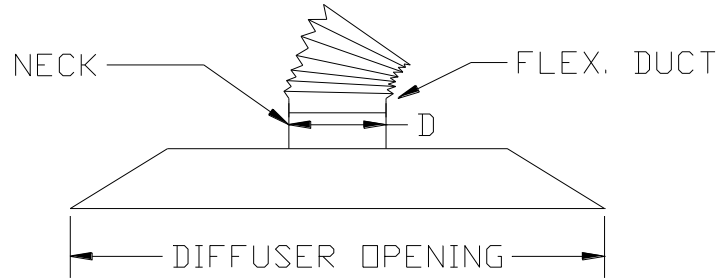


Figure 1: Duct collar and flex duct diameter

Table 1-1: Results from TSI's testing:

Size of round flexible duct leading to diffuser	K-Factor
8-inch diameter (D)	1.07
10-inch diameter (D)	1.05
12-inch diameter (D)	1.02
14-inch diameter (D)	0.99
15-inch diameter (D)	0.98

K-Factors and The New ACCUBALANCE® Capture Hood

Unlike other capture hoods which only offer air density corrections, the Model 8371, 8372 and 8373 ACCUBALANCE® Capture Hoods offer air density corrections *and* K-Factors for optimal convenience and accuracy for the user. In fact, the ACCUBALANCE® capture hood allows you to store and utilize five different K-Factors. This can be very helpful when you encounter several different duct/diffuser combinations, each needing a unique K-Factor for best measurement accuracy.

Implementing the K-Factor corrected reading on an ACCUBALANCE® capture hood is easy. To enter a K-Factor, simply press and hold the K FACTOR key on the instrument display panel. The last used K-Factor will appear on the display along with “K_f” and the number 1 for K-Factor #1. The default value is 1.00 with a potential range of K-Factors from 0.10 to 2.00. Press the ▲ or ▼ arrows to change the K-Factor value. Press ENTER to accept the value and return the display to reading flow values with the K-Factor engaged. Flow readings will now be a product of the uncorrected “measured flow” and the K-Factor.

To disengage the K-Factor, simply press the K FACTOR key and the small “K_f” will disappear from the display. Now the readings will not have the K-Factor applied.

To enter more than one K-Factor, press and hold the K FACTOR key. The first of five available K-Factors will appear on the display. Press the K FACTOR key to toggle to the second available K-Factor, and so on. At each K-Factor, you may use the ▲ and ▼ arrows to change the K-Factor value. Press the ENTER key to return to flow measurements. The most recently displayed K-Factor will be the K-Factor engaged. It will remain engaged until you disengage it.

Conclusion

When taking flow measurements with the ACCUBALANCE® capture hood (or any other capture hood), it is always best to correct the readings to an accurate duct traverse. When this is not possible, the K-Factors listed above can be used with the ACCUBALANCE® capture hood when measuring 2' x 2' 4-way throw diffusers connected to round flexible duct. For other duct/diffuser combinations, a separate K-Factor should be determined using the procedure described above.

References

- (1) ASHRAE, *1999 ASHRAE Handbook, HVAC Applications, I-P Edition*, Chapter 36.2.
- (2) ASHRAE Standard 111-1988, *Practice For Measurement, Testing, Adjusting, And Balancing of Building Heating, Ventilation, Air-Conditioning And Refrigeration Systems*. Section 8.6.5
- (3) ASHRAE, *1997 ASHRAE Handbook, Fundamentals, I-P Edition*, Chapter 14.21.
- (4) Associated Air Balance Council, *National Standards*, Chapter 8, p. 30.
- (5) Associated Air Balance Council, *Technician Training Manual*, Chapter 4, p. 60.
- (6) TSI Application Note, *Traversing a Duct to Determine Average Air Velocity*, TI-106.
- (7) TSI Application Note, *Experimental Determination of Correction Factors for Use with Capture Hoods*, TI-128.

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