Set Up and Verify Airflow Measurement Device Operation

by Len Damiano, *EBTRON, Inc.*, February 2015

It should never be assumed that upon comparison of measurements with handheld instruments, that the AFMS is responsible for the difference and must be adjusted to match the "actual" duct average flow reported.

There are not only wide ranges of quality in the field AFMS (Unit-Under-Test or UUT in this case) being evaluated, but also a wide range of possible sources for the differences reported. Therefore, it is strongly recommended that time be used to evaluate and eliminate most alternative causes before concluding that adjustment of the UUT output to match the reference, is your only remedy. The potential impact from the adjustment should be considered, by comparing the statistical uncertainty of the field reference being used to that of the permanently installed AFMS.

Proposed ASHRAE Standard 215, titled "Method of Test to Determine Leakage Airflows and Fractional Leakage of Operating Air-Handling Systems" provides us with additional information on measurement with permanent instruments in Annex B.

The following outline is provided to help users evaluate AFMS performance before deciding to adjust the output.

Inspect

- Actual placement/installation, duct conditions vs factory guidelines
- Area entered/recorded (in transmitter or host controls) is correct?
- Confirm that field adjustment has not already been made.
- Check wiring and functionality

Evaluate

- Use a sound method to assess performance
- Determine verification method, instrumentation and technique
- Determine the flow rates are within capabilities of selected instruments
- Is comparative reference at least 4:1 greater accuracy than the UUT airflow station?

Verify

- Confirm the signal conversion at BAS
- Airflow determination must be based on a sound verification technique
- Understand the uncertainties of the devices involved and the technique used

Adjust? Not Always.

- Uncalibrated devices must be manually set up and adjusted in the field
- Factory calibrated devices that are installed properly DO NOT need to be adjusted
- Factory calibrated devices that are installed in poor locations may need some output adjustment
- Adjust previously calibrated devices only when you are certain the airflow measuring device is inaccurate (not just because it differs from a duct traverse or TAB indirect method used for comparison)

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With stable sensors, reliable calibration standards and laboratory measurement conditions, much better than found on any site; field adjustment to these instruments will generally degrade the performance of factory calibrated products. However, adjustment may be necessary when you are certain the airflow measuring device is inaccurate and that deviations cannot be attributed to any other source.

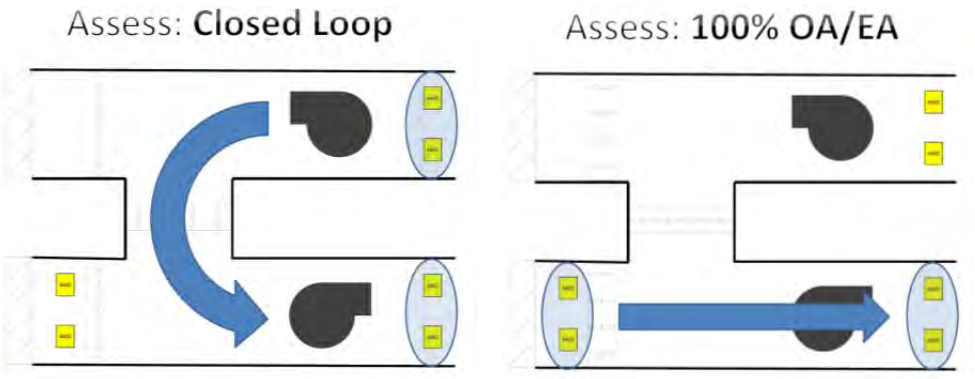
To make assumptions without verifying the performance of the devices and method, is akin to chasing your own tail or following shampoo instructions. "Shampoo, Rinse, Repeat" or "Traverse, Adjust to match, Repeat in future." The AFM device is being adjusted to match a much less repeatable instrument and using a less reliable method, where a recurring traverse usually provides different results.

Suggested Methods of Verification for *EBTRON* Sensor Arrays

The following are some of the methods and comparison references recommended for use in the adjustment of factory calibrated Thermal Dispersion arrays or high precision velocity pressure metering systems, both having NIST-traceable performance and duct placements "better than" recommended in factory guidelines. It is only then that both the absolute and field performance can be reliably used with the following suggestions.

Ducted AFMS in Supply or Return/Exhaust

1. The BEST way to verify and adjust an *EBTRON* pre-calibrated thermal dispersion array is to compare one AFMS to another in a closed loop, when properly functioning low leakage dampers are present. An assumption of some system or duct leakage is usually needed.



2. The next BEST way is to compare 2 *EBTRON* pre-calibrated thermal arrays in the same air path (i.e. OA/Supply, or RA/Exhaust) adjusting only one. Low leakage dampers are needed to block returning/recirculated or outdoor air from entering the isolated path. Duct or system leakage within the path should still be evaluated before adjustments are made.

3. Another good way using an *EBTRON* fan inlet mounted devices is to follow these steps:
    a. position pre-calibrated thermal fan inlet sensors to the flange of an inlet cone with factory-supplied mounting template;
    b. record UUT response throughout fan range determined by a NIST-traceable lab tunnel with measurement uncertainty ≤0.25%;
    c. develop a K-factor and use it with factory calibrated units having same size inlet cone and fan type.
    d. Use the mounting template to install other fan inlet AFMS units in the field.

e. Subsequent fan inlet units should not need additional adjustment. If it is found that conditions differ enough to justify adjustment, then adjustment of subsequent AFMS units should use the reference UUT/AFMS within the closed loop or single path methods previously described.

It is <u>not recommended</u> that *EBTRON* airflow stations in the field be adjusted to match any of the following:

a. improperly employed or poorly calibrated handheld instruments
b. fan curves based on fan speed and pressure drop
c. temperature mixing methods for OA calculation
d. handheld measurements of total SA minus total RA, with calculated difference for OA

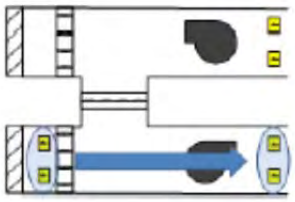
DO NOT ASSUME that a difference between hand-held and permanently installed devices measuring the same ducted volumes means that the AFMS output requires adjustment!

Real World Situation – Verification and Adjustment Example:

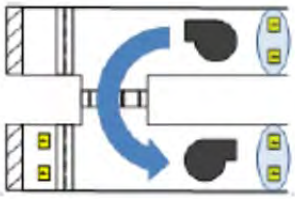
SA AMD was not installed properly and was in a marginal location.
OA AMD was also located in a marginal location.
RA AMD was in a very good location.
Areas in transmitter did not match area of duct.
All AMDs were field "calibrated" by the air balance contractor.
Dampers where good quality and low-leakage, thus allowing for closed-loop and 100% OA/RA evaluation

Our ASSESSMENT (using factory calibration and proper area):

100% OA/EA Test			
	EBTRON		
Speed	SA CFM	OA CFM	Diff.
100%	16190	18256	-11.3%
50%	8680	9723	-10.7%



Closed Loop Test			
	EBTRON		
Speed	SA CFM	RA CFM	Diff.
100%	16052	18260	-12.1%
50%	8494	9520	-10.8%



Our PLAN (*EBTRON* master/slave technique):

Since RA AFMS was in a good location, determine the gain and offset to match the SA AMD to the RA AMD.
Use the adjusted SA AFMS to verify the OA AFMS measurement. Adjust if necessary.

Step 1 – Calculate Gain Adjustment

	Meas ↘ Closed Loop Test ↙ Ref			
		EBTRON		
	Speed	SA CFM	RA CFM	Diff.
1	100%	16052	18260	-12.1%
2	50%	8494	9520	-10.8%

$$GAIN = \frac{RefCFM1 - Ref\ CFM2}{MeasCFM1 - MeasCFM2} = \frac{18{,}260\ CFM - 9{,}520\ CFM}{16{,}052\ CFM - 8{,}494\ CFM}$$

= 1.156 (dimensionless) K-factor or adjustment factor

Step 2 – Calculate Offset Adjustment

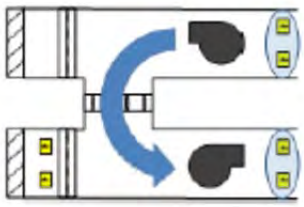
a. *OffsetCFM* = *-GAIN* x *MeasCFM1* + *Ref CRM1*

b. - 1.156 x 8,494 *CFM* + 9,520 *CFM* = - 302 *CFM*
Note: If the offset is entered in the EBTRON transmitter, it must be converted to velocity (FPM or m/s).

c. $OffsetFPM = \frac{OffsetCFM}{Area\ SqFt}$ or $OffsetM/s = \frac{OffsetL/s}{Area\ M^2 \times 1000}$
Note: Adjustments using metric units (SI) follow the recurring relationship between velocity, volume and area.

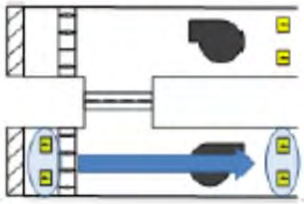
Data Analysis

Closed Loop Test Adjusted			
	EBTRON		
Speed	SA_{ADJ} CFM	RA CFM	Diff.
100%	18260	18260	0.0%
50%	9520	9520	0.0%



100% OA/EA Test			
Speed	OA CFM	SA_{ADJ} CFM	Diff.
100%	18256	18420	-0.9%
50%	9723	9735	-0.1%

DON'T ADJUST!



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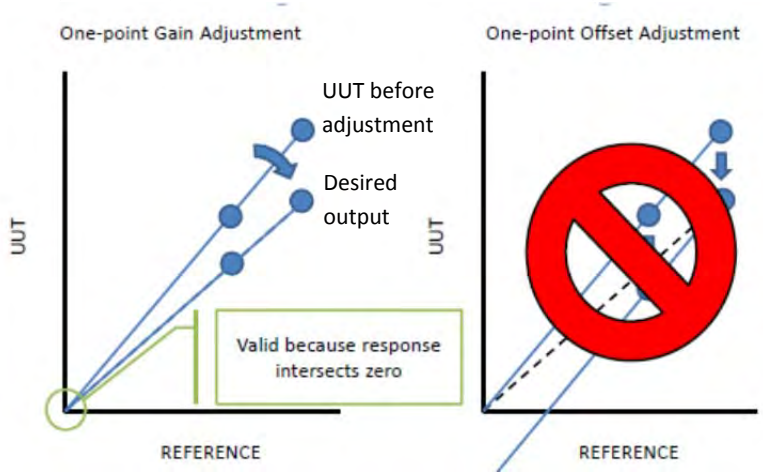
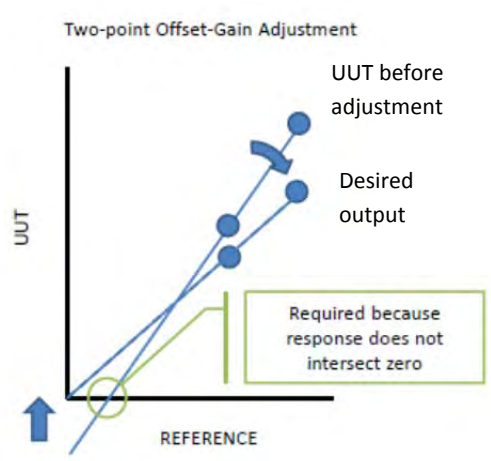
Proper adjustments for linear outputs



Gain-only.

Gain-only adjustments are proper when the UUT output intersects zero. Using a two-point offset and gain adjust when the UUT output intersects zero will only degrade UUT accuracy.



Offset and Gain.

Two-point offset and gain adjustment is appropriate only when the output of the UUT does not go through zero.

Making Adjustments with *EBTRON* transmitters

Because of design features and advanced capabilities, most EBTRON products make it easier to conform to the requirements of both the project conditions and the requirements of the project's engineer. When it is decided that the output of the measurement device should be adjusted, and the devices are EBTRON products, look to these three methods for making the necessary adjustments, in order of simplicity.

1. **Field Adjust Wizard** (EBTRON Gold & Hybrid)
   Transmitter prompts user for one or two point adjustment.
   Reference airflow rates are directly entered in transmitter by user when measurements are taken.
   Transmitter samples and automatically makes offset/gain calculations.
2. Enter **Slope and Intercept** (EBTRON Gold & Hybrid)
   Slope and intercept calculated by user is manually entered in transmitter (see Product Tech Manual).
3. At **Host Control System** (EBTRON Gold, Hybrid or ELF)

Bottom Line and Summary

- Airflow measurement devices can be used as a powerful diagnostic tool, improve building performance and save you (facility operators) valuable time and money on routine maintenance!
- Airflow measurement devices can save energy.
- Airflow measurement devices can assure and validate compliance with standards and codes.
- Airflow measurement devices can improve occupant comfort.

All *EBTRON* AFMS models are FACTORY CALIBRATED DEVICES! When devices are properly applied and installed, FIELD ADJUSTMENT is NOT required or recommended. Verification/validation SHOULD be conducted by a trained and certified independent contractor to ensure that the product is installed and operating properly. Only when there is sufficient evidence that field adjustment is necessary should the device be adjusted in the field.