



Fundamentals of Test & Balance for Engineers, Cx & Energy Providers

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Course Description

This practical, information-packed session explains many of the key test and balance issues—from precise specifications, to duct leakage testing, to pump- and fan-curve considerations—that if properly addressed in cooperation with an independent TAB firm can ensure that any project goes smoothly.



Learning Objectives

At the end of the this course, participants will be able to:

1. Understand the proper use, application, and limitations of the TAB instrumentation.

2. Understand what is accurate, useful and meaningful data that is obtained in the field vs. laboratory data for use on their project.

3. Gain an understanding of HVAC systems and the TAB/measurement process; how can systems be set up to allow for proper data collection.

4. Promote a project team approach to address schedule challenges, design alternatives as it relates to balancing device locations, equipment usage and HVAC system operation.



This concludes The American Institute of Architects Continuing Education Systems Course

Contact Information







Test & Balance Primer for Engineers:

Recommendations for Optimum System Performance



Recommendations Overview

- Specification Issues
- Fan Curves
- Traverse Locations & Alternatives
- System Effect
- Pump Curves
- Pump Flow Measurement
- Equipment Considerations
- Project Issues



- The specification document indicates that an AABC-certified TAB agency must perform the work.
 - Only AABC requires that its members be **INDEPENDENT**, with no other ties to the project.
 List the TAB Agencies approved to bid the project.
- The specification clearly defines the systems to be balanced. List a schedule of equipment that requires TAB work.



- The specification clearly defines the scope of work pertaining to the systems to be balanced:
 - Create a performance specification that relates to the project and data required.



- Try to think of how data will be obtained and what data will be required before specifying the requirements.
 - Will the requested data be <u>accurate</u>, <u>repeatable</u> and <u>meaningful</u>?
- Avoid ±5% tolerances
 - For most projects, overly tight tolerances add to the cost, but not to system performance.
 - Reserve tight tolerances for special applications, not comfort cooling/heating.
 - The TAB Equipment manufacturer's tolerances sometimes exceed the specification tolerances.



Coordinate controls, sheet metal, and insulation specifications with TAB specification.

Insulation specification requires that:

- All water test ports are accessible.
- All balancing damper handles are exposed and visible on externally insulated ductwork.
- Water flow measuring stations need complete access from insulation to verify sizes and models. The tags sent with the flow measuring stations may be used, but verification of the correct tag needs to be verified (on the valve body), especially automatic balancing valves.



Control specification requires that:

 Access to the control system is made available to the TAB agency and any required hardware/software is provided by the controls contractor at no additional expense to the owner or TAB agency.



- Sheave changes are NOT automatically the responsibility of the mechanical contractor or TAB agency.
 - It is difficult to define who is responsible --Manufacturer, contractor, engineer? How many are required? At bid time, sheaves are an unknown cost and unknown quantity.
 - Sheave changes for fans should be included as an allowance in the project or handled as a cost plus change order.



- Avoid "catch-all" clauses.
 - Do: Clearly show the requirements for balancing dampers, balancing valves, and/or test ports on the plans and details.
 - Don't: Use a "catch-all" statement in the specifications to cover those requirements.
 - Note: Remember that furnishing and installing dampers and valves are NOT the responsibility of the TAB Agency.



- Calibration of instruments per manufacturer's recommendations. As a note, most manufacturer's are every 2 years.
- Identify each VAV box (Fans, AHUs, HPs, etc) with a separate identification number.
 - The DDC system should use same identification/number for each piece of equipment (VAV-1-1, VAV-1-2, etc.).



- Clarification on testing of domestic water, DI water systems, etc. is required.
 - Some TAB equipment manufacturers prohibit the use of their equipment on potable water systems due to potential contamination.
 - Consider installing temperature sensors on the domestic hot water recirculation loop that can report the temperatures to the DDC system.
- Plumbing pumps or fire pumps: If these are systems that cannot maintain an established water flow, then the water flow cannot be measured. (See previous note.)



 Duct leakage testing needs to be coordinated in the specification.

Who does it?

- □ How many tests are required?
- □ What standard is it done to?
- If required, be specific about what sound (& vibration?) data is required and where readings are to be taken.



Fan Curves

Fan curves

- □ AMCA Tested
- Produced under laboratory conditions
- Free inlet
- Straight discharge
- Ideal traverse plane
- Multiple speeds-extrapolated data
- Standard temperature & pressure (STP)
- Normal manufacturing tolerances

Know the limitations of fan curves



Fan Curves

ASHRAE Journal Article, November 2005

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the test series, not all sizes and operating

By Kim G. Osborn, Associate Member ASHRAE

t happens occasionally that even after taking great care in design, the air handler turns out to be louder than expected or the airflow is less than design. This article examines some discrepancies that can occur between catalog data and the actual performance. At first it might seem strange that, expensive. It is generally not practical to with well-established testing standards, test all sizes or to test each size at a large number of speeds. Fan engineers strive

major differences can exist between the catalog data and the performance of the to present the most reliable selection fan in application. A number of reasons information they can, but due to gaps in exist for this. Not every wheel size is tested, and points may be reliable. The end result is About the Author

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those tested are run at a limited number of that you might take great pains to design Kim G. Osborn is CES laboratory manager at speeds. Fan testing is time consuming and an HVAC system with critical sound

Is What You See. What You Get?

and/or airflow issues, and substantially miss the design criteria because the fan data used was too optimistic. It is becoming more important to be able to predict and control HVAC sound. Key to this goal is knowing the sound power spectrum of the fans used in the equipment. The designers then must either depend on the catalog data for the fans selected or measure the fans' sound power themselves. For designers without an available acoustical laboratory, the latter option is often too costly. Therefore, the only option is to use the catalog numbers.

Governair Corporation, Oklahoma City.

ASHRAE Journal ashrae.org

November 2005

it is rare to find 25 ft (7.6 m) of straight duct on a fan in real-world applications. Most of the differences are probably the result of unidentified system effects and what is sometimes called manufacturing variances.

The most dramatic difference between the test data and catalog data is shown in Figure 2. This shows the measured airflow

data for two nearly identical 36.5 in. (927 mm) DWDI fans and compares these to the catalog data. The two test fans used the same size and design of wheels, inlet cones, and scrolls but had minor differences in the support frame design. Not only did these two "identical" fans have noticeably different airflow, but both fell substantially short of the cataloged airflow curve.



Figure 2: Measured fan airflow data compared to catalog data.



Traverse Locations & Alternatives

Ideal traverse plane:

AABC, AMCA & ASHRAE all identify as 2 ½ diameters from condition (discharge, elbow, etc.) for up to 2500 fpm. Add 1 diameter for each additional 100 fpm.

■ Rectangular Duct E_L= (4a*b/Π)^{0.5}, where "a" & "b" are the duct dimensions.



Traverse Locations & Alternatives

Example:

- 10,000 cfm, 30" x 20" duct, 2400 fpm
- E_L= (4a*b/∏)^{0.5} = 27.6″ 2 ½ * 27.6″ = 69.1″
- 69.1" (~ 6') straight duct required

Alternatives to Traverse:

- Face velocity reading of filters, coils, hood face, etc.
- Summation of airflows at individual outlets
- Summation of calibrated VAV boxes as read at the DDC computer



System Effect

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System Effect

ashrae.org

How it Affects Operating Cost

Unsurprisingly, the investigation revealed that at the speed measured the reported fan volume and static pressure

points did not intersect on the fan performance curve at the measured speed. A considerable difference existed between

the measured and true static pressure in-

dicated on the fan performance curve that could only be attributed to the presence of

a system effect factor (SEF) after all re-

corded data was checked for accuracy.

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School Board in Mississauga, ON, Canada. He is a member of ASHRAE Guideline Project

Committee (GPC) I, the HVAC Commissioning Process, and ASHRAE GPC 4, Preparation

February 2006

About the Author

of Operating and Mainter for Building Systems.

Factor

By Bernard Ratledge, Life Member ASHRAE

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For a building owner concerned with operating costs, the clearest way to document that the M&E consultant, mechanical contractor and testing, adjusting, balancing (TAB) contractor have achieved the design energy consumption is to compare the energy consumption given in the TAB equipment report with that specified in approved shop drawings.

From energy bills received for 50 new ergs consumption and actual consumption schools in Ontario, Canada (part of the 137 schools in the Dufferin-Peel Catholic dis trict), it was evident that considerable difference existed between the predicted en

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ASHRAE Journal Feb 2006 Article

How to Avoid This Increased Operating Cost?

 By not trying to save dollars per square foot by reducing the size of the mechanical room. The increased operating cost of the poor installation is likely to be far greater than the cost of providing the space necessary to ensure a good ductwork installation.

The increase in fan bhp = 16.83 - 10.06 = 6.77 (12.55 kW - 7.5 kW = (5.05 kW).

Using the same operating parameters as Example 1:

Based on the fan operating 245 days \times 8 hrs/day \times 7.5 = 14,700 kWh \times \$0.06/ kWh = \$882 + 7.5 \times \$10/kW demand \times 12 = \$1,782/yr base electric cost. Revised operating cost with new motor = 245 days \times 8 hrs/day \times 12.55 = 24,598 kWh \times \$0.06/ kWh = \$1,475.88 + 12.55 \times \$10/kW demand \times 12 = \$2,981.88/yr or \$1,199.88/yr increase. A life-cycle analysis based on a school useful life of 25 years, annual energy cost escalation 5%, shows an estimated total additional operating cost of \$86,489.



System Effect

TAB Journal article Spring 2010



Rotation

Figure 15 illustrates a poor installation with an elbow directly at the fan inlet.



System Effect





Standard 17,500 CFM Packaged RTU









Pump Curves

Design Requirements:

 800 gpm @ 68'
9" Impeller, 20 hp motor, 5BC,1750 rpm (Point 1)

Field Measurements:

- Shutoff $\Delta P = 73'$ (Point 2)
- Operating $\Delta P = 70.0'$

Results:

- Actual: 700 gpm w/9" imp
- 12.5% below design
- Flat Pump Curve Hard to interpolate.
- Utilize measured flows at terminals or branches to determine pump total.





Pump Curves

Design Requirements:

 800 gpm@ 68' 10-3/8" Impeller, 20 hp motor, 4E, 1750 rpm

Field Measurements:

- Shutoff $\Delta P = 104'$
- Operating $\Delta P = 72'$

Results:

- Actual: 775 gpm w/10-3/8" imp
- 3.1% below design
- Steep Pump Curve Immediate Resolution.





Pump Flow Measurement

- Provide test ports/pump taps at the pumps (Extend outside of insulation).
- Provide a flow measuring device at the pump
 - Fixed orifice type device preferred, not MPVs, etc.





Scheduling Challenges

- There needs to be enough time allowed in the schedule for the TAB work to be completed.
- All work must be complete for TAB work to commence.
 - □ Clean air filters installed.
 - All strainers must be cleaned and start-up strainers removed.
 - □ All balancing dampers installed and 100% open.
 - All manual water valves and flow measuring stations should be 100% open.
 - Controls are complete and functional.



Scheduling Challenges

Phased projects:

- Remember that the TAB work is completed by HVAC system and NOT area.
- Very seldom does the HVAC system match the "Phasing Areas."
- Make sure that the Owner & Architect understand the possibility that the TAB work might be performed after occupancy. (Bid appropriately.)
- Variable volume systems (air and water) can have provisions to balance partial HVAC systems. For phased projects, constant volume systems are much more difficult to address.
- Water systems (heating & chilled) need to be reviewed for TAB scheduling.



Access Challenges

Proper clearance and access must be provided to all dampers, valves, equipment, etc. This includes the test ports on flow measuring devices and auto-flows.

□ Sheet rock ceilings, Architectural features, etc.

 Access to outlets, dampers, etc. in theatre type seating areas. How will this be accomplished? AHU is typically not in operation when scaffolding is installed.



Equipment Considerations

Examples of no access in Factory Package Automatic Balancing Valves











Why Specify AABC?

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Independence:

AABC requires its members to be 100% Independent.

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- Brian Venn Vice President CxA/TBE
- 51 years in business
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Questions?

Thank you for your time!

Additional Presentation Topics: Duct Leakage Testing Balancing Hydronic Systems Hot Water Reheat Balancing

