TAB Journal

AABC

THE MAGAZINE OF THE ASSOCIATED AIR BALANCE COUNCIL • SUMMER 2011

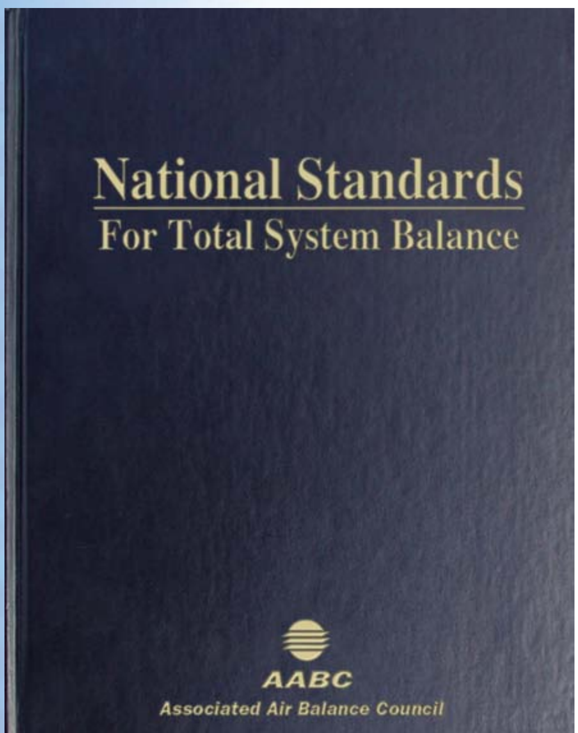
Still Independent After All These Years

Also in this Issue:

- Pre-T&B Inspection of Hydronic Systems
- HVAC System Pressure Sensing

A MUST-HAVE RESOURCE FOR INDUSTRY PROFESSIONALS!

The AABC National Standards for Total System Balance



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The AABC National Standards for Total System Balance, 2002 edition, is a comprehensive manual detailing the minimum standards for total system balance.

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AABC believes that by promoting the concept of Total System Balance, the industry will be encouraged to adopt more consistent practices, thus ensuring greater success for all parties involved in the design, installation, start-up, operation and testing of HVAC systems.

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TAB Journal

Associated Air Balance Council

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From the Publisher

The summer 2011 issue of *TAB Journal* focuses on the importance of independence and what it means to be a member of AABC. The issue also showcases the technical expertise of AABC test and balance engineers on a variety of subjects.

"Still Independent After All These Years" and "AABC at a Glance" are this issue's featured articles, explaining AABC's history and programs, and what sets it apart from other test and balance organizations.

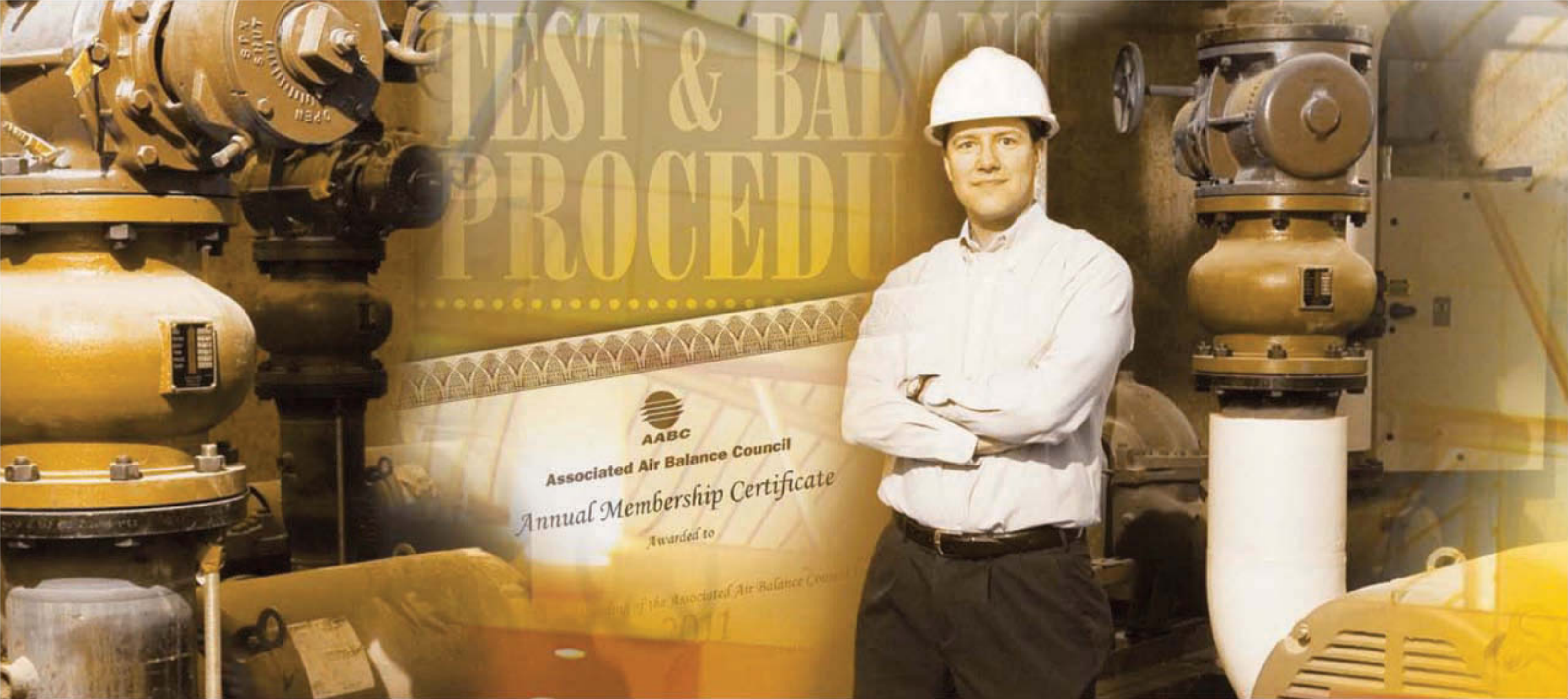
In other articles, "HVAC System Pressure Sensing" written by American Testing Inc.'s Michael S. Kelly, TBE, provides insight on how poorly located sensing devices can result in exaggerated system operating costs as well as poor performance. James E. Brennan, TBE from James E. Brennan Company, Inc., presents a case study of a rare residential test and balance project in "Combating Mold in a Large Residence."

In "Balancing a Low Temperature Water-Glycol System," Craig Burrows, TBE, of National Air Balance Company LLC describes a creative approach to balancing a low temperature water-glycol system with both operating and ambient temperatures well below 40 degrees Fahrenheit.

Rick L. Cox, TBE, of Technical Air Balance, Texas, emphasizes the importance of periodic inspections of the entire HVAC system throughout construction in his detailed article, "Preliminary Inspection prior to Testing Hydronic Systems."

This issue's *Tech Talk* provides insight on 2- and 3-way automatic control valves pertaining to VAV heating coils, as well as VAV assemblies and choosing the correct duct size.

We would like to thank all of the authors for their contributions to this issue of *TAB Journal*. Please contact us with any comments, article suggestions, or questions to be addressed in a future *Tech Talk*. We look forward to hearing from you!



Still Independent

Independence Sets AABC Apart from

Most people in the HVAC industry understand the basic goal of test and balance, which is to methodically test and adjust HVAC systems to ensure that they are working properly and efficiently according to the design intent and the owner's needs. However there are several test and balance organizations, and not everyone may be familiar with the differences between them.

The Beginning

To understand the current state of affairs with respect to the test and balance industry and how AABC fits into the picture, you need to go back nearly 50 years, when AABC was originally formed as a non-profit association of independent test and balance companies. Back then, testing and balancing was something of a novelty, practiced by a few individuals who understood that HVAC systems seldom operated as designed—a situation they could help improve.

Testing and balancing began to evolve as a tool of the engineering profession, to determine whether systems were installed and operating properly. As the need for test and balance became more apparent, two different business models began to emerge. The first included those who believed that proper test and balance should only be performed by 3rd-party, independent companies. The second consisted of mechanical contractors who found it advantageous to do their own balancing on systems and components that they had installed—essentially evaluating their own work.

Recognizing the inherent danger of allowing contractors to do their own balancing, which largely defeated the purpose of the process, a handful of individuals decided to invest their time, resources and expertise into building an organization that promoted high industry standards and independent test and balance practices. Thus in 1965, the Associated Air Balance Council (AABC) was born. It was the first and only organization of its kind. To this day, it is the only test and balance organization that has ever committed to the principle of independence.

Declaration of Independence

Though AABC would go on to develop the first industry standards and certification program for qualified test and balance professionals, the founding members made independence the

After All These Years

Other Test & Balance Organizations

cornerstone of the association. From that point forward, all applicants for membership and certification had to meet the independence requirement, which states that members cannot be affiliated in any way with mechanical or other contractors, design engineers, manufacturers of equipment or system components, or any other entity that would present a potential conflict of interest.

While the engineering community applauded this development and began writing AABC into their specifications, the contractors who were "self-balancing" their own work took a different view and started a contractor-driven test and balance organization, which implicitly permitted this practice. This and other contractor organizations that were formed later still exist today.

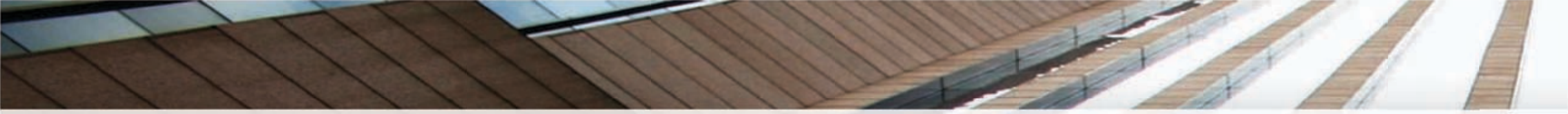
As systems became more complex with the advent of automatic temperature controls, the concept of independence has only become more valuable. The only way to ensure the integrity of the TAB report is to remove any potential conflict and rely on the agency's technical competence, objectivity, and accuracy of readings to determine how systems and components are operating under field conditions.

Independence is an indispensable characteristic of the highest quality test and balance work, and that is why it is the cornerstone of AABC.

The Bottom Line

As noted, independence is not a new concept—it has been around since 1965. Nor is it going away anytime soon, as evidenced by the fact that the USGBC's LEED program requires independence as a condition for commissioning LEED-certified buildings. AABC is proud of the fact that other organizations such as the USGBC are on board with the importance of independence, and we hope that other organizations, such as engineering and building owner driven associations, will continue to understand the value of independence and support that requirement.

As awareness of the value of independent advocates for building owners continues to grow, momentum is beginning to build again to require independence for test and balance as well. This is as it should be, and building owners deserve no less.



AABC at a Glance

Association Founded:

1965

Membership:

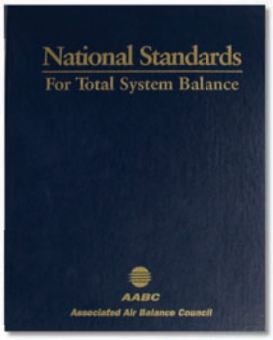
Limited to Independent Test & Balance companies that can demonstrate the ability to perform work in accordance with AABC Standards and that meet experience and certification requirements.

Certifications:

- **Test and Balance Engineer (TBE):** All agencies must have at least one TBE on staff. Qualifications: at least 8 years training and field experience working for a test and balance firm (up to 4 years credit given for mechanical engineering coursework from an accredited engineering school). The 8-hour exam that candidates must pass is the most rigorous and challenging in the industry.

- **Certified Test and Balance Technician:** AABC established the industry's first certification program for test and balance technicians, providing additional assurance that jobs are staffed with trained and experienced personnel. Qualifications: 3 years of test and balance field experience, with at least one year working for an AABC member firm. All eligible technicians must pursue certification by completing an intensive in-house training program including both field training and classroom instruction using the AABC Technician Training Manual. Candidates completing the training and passing an 8-hour examination are granted certification.

- **Cleanroom Certification Engineer:** Open to individuals who are qualified to perform clean room certification services in accordance with acceptable industry guidelines and practices, and who pass the cleanroom certification exam.



Standard:

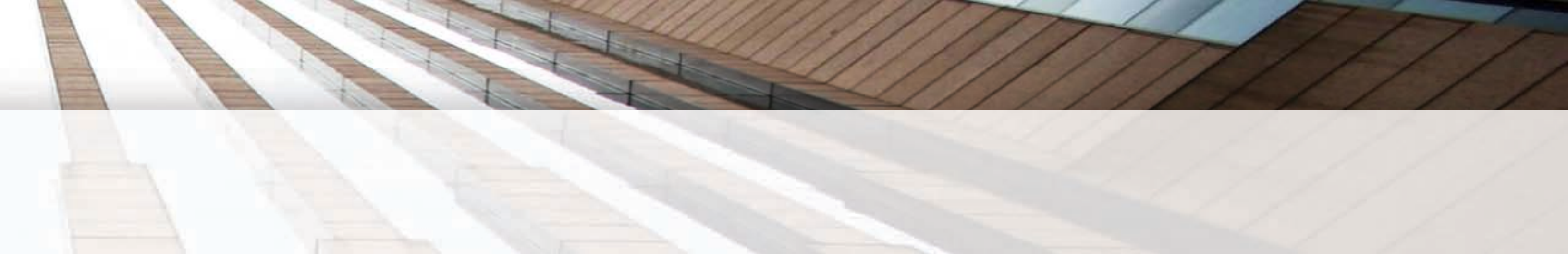
AABC National Standards for Total System Balance, 6th Edition. AABC published the industry's first standard in 1967. It has been updated 5 times since then and the 7th Edition is nearing completion. All members are required to perform work in accordance with AABC Standards.

Company Membership Requirements:

The most stringent in the industry, requiring significant comprehensive test and balance experience, demonstrated high level of technical competence, and above all Independence. Applications must be accompanied by letters of recommendation from professional engineers and two comprehensive test and balance reports. If companies pass this initial review, an onsite interview is conducted, including visits to ongoing or recently completed projects. Finally, at least one person from the company must pass the Test and Balance Engineer (TBE) examination.

Quality Assurance:

AABC National Headquarters sends a brief letter and questionnaire to the engineer of record for each project performed by an AABC member. The engineer is asked whether he or she is satisfied with the performance of the member agency—allowing AABC to monitor the work of its members.



The world's leading association of professional, independent test and balance agencies.

National Performance Guaranty:

AABC stands behind its' members work with the strongest Guaranty in the industry—all work performed by all members of the association is guaranteed by AABC. If a member fails to comply with the specifications for any reason other than termination of business, equipment malfunction, or inadequacy that prevents proper balancing of the systems, AABC will investigate and if warranted, will provide supervisory personnel—at no cost to the building owner—to assist the member company in completing the work.

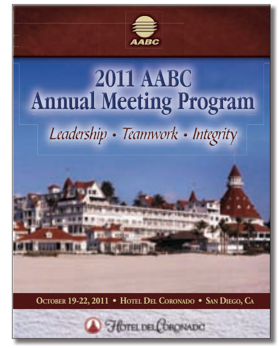
Lunch and Learn Presentations:

AABC members are always available to meet with your firm to discuss best practices for testing and balancing. Whether you would like a presentation covering a variety of the most important testing and balancing concepts for engineers, or a more specific topic, let us know and we will arrange for an AABC expert to address your team at no charge!

If you would be interested in such a technical presentation, or if you have any other questions or comments, please contact AABC headquarters at headquarters@aabc.com or 202-737-0202.

Annual Meetings:

AABC holds conferences each spring and fall for its members, who must attend one each year as part of their continuing education requirements. The programs are primarily composed of technical sessions, covering new technologies, methods, and standards in the industry, as well as detailed discussions of concepts central to testing and balancing.



TAB Journal:

The only publication in the industry devoted to test and balance, TAB Journal showcases the knowledge and expertise of AABC members.

Website:

Visit AABC.com to find an AABC member in your area, get additional information about AABC programs, browse the TAB Journal archive and more.

If you have questions about any aspects of AABC, please contact the headquarters office in Washington, D.C.:

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HVAC System Pressure Sensing

Michael S. Kelly, TBE
American Testing, Inc.

The intent of most HVAC air/hydronic pressure sensing devices is to monitor and maintain optimum system performance. In an air system, duct static pressure is monitored and maintained. In a hydronic water system, differential pressure between the supply and return piping is monitored and maintained.

In both cases, these are determined setpoints established through the testing and balancing process. The location of these sensing devices is critical to optimum performance and energy usage. A poorly located sensing device can result in exaggerated system operating costs and poor performance.

Most HVAC variable air volume systems requiring duct pressure monitoring are pressure independent. With such systems, the VAV terminals will modulate to maintain required airflow independent of the system duct static pressure. Some VAV/VVT or zone damper systems are pressure dependent. In this case, the airflow at the terminals will depend on the system duct static pressure.

The opposite is true for hydronic systems. Most are pressure dependent, and some with autoflow valves are pressure independent. All too often, the sensing devices are located conveniently, but in a place that will not be the most accurate.

Many times, this can be corrected to address both accessibility and accuracy by a test and balance design review or a field visit. Good practice is to very seldom install sensing devices at the source, but rather somewhere out in the system to monitor/sense the slightest system change and have the source equipment respond. The time-tested industry standard, which still holds true today, is to locate sensing devices 2/3 downstream. The exact placement requires a combination of system review, experience and common sense.

Just as accurately testing blood pressure is required for the human heart's performance, accurately sensing the pressure in an HVAC system will provide a valuable monitoring point to help track system performance.

"A poorly located sensing device can result in exaggerated system operating costs and poor performance."

Balancing a Low Temperature Water-Glycol System

Craig Burrows, TBE
National Air Balance Company LLC

A recent project required water balancing on a low temperature water-glycol system. Upon review of most of the electronic instrumentation typically used, it was discovered that the equipment was not specified for temperatures below 40 degrees Fahrenheit. This posed a problem, because the operating water temperature was specified to be 4 degrees Fahrenheit and the ambient temperature was 20 degrees Fahrenheit.

The instrumentation manufacturer was contacted in an attempt to confirm if the meter would read accurately at the low temperature. The manufacturer indicated they were unable to certify the readings because the equipment was not tested at those temperatures. Also verified was whether the specification was for the meter temperature or the temperature of the media being tested. The response was both.

This left a dilemma. The client required the readings and all of the manufacturers contacted stated that their meters were not designed to operate at the necessary temperatures. A creative solution was needed to come up with a system that would provide accurate readings in that environment.

Figure 1. The testing apparatus described in the article, showing the completed assembly with the case open *(left)*, and with the front closed to show the viewing window *(right)*.

"The client required the readings and all of the manufacturers contacted stated that their meters were not designed to operate at the necessary temperatures. A creative solution was needed..."

The solution was to take the meter and place it in an insulated case with a viewing window. Hand warmers, such as those available in ski shops, were used to keep the temperature inside the case above 40 degrees. To verify the temperature, the temperature probe on the meter was used to display the case temperature.

This left only one problem, the fluid temperature. This issue was solved by creating a “primary” and “secondary” loop on the meter. Two lines filled with the same fluid as that being tested were run inside the case as a primary loop. This allowed us to keep the temperature of the fluid to the meter over 40 degrees. On the outside of the case, the primary loop was connected to a bypass valve, allowing purging of the secondary loop that was connected to the cold media.

This apparatus enabled the testing of the low temperature system while still meeting the requirements of the meter specifications.

On a side note, the tests were also performed using the meter normally. The test results were found to be the same—as long as the electronic meter was not exposed to the cold environment for more than an hour.

Figure 2. Detail views of the apparatus, showing the "primary loop" assembly inside the heated case *(left)*, and the added bypass valve to purge the air from the secondary loop being plugged into the system *(right)*.

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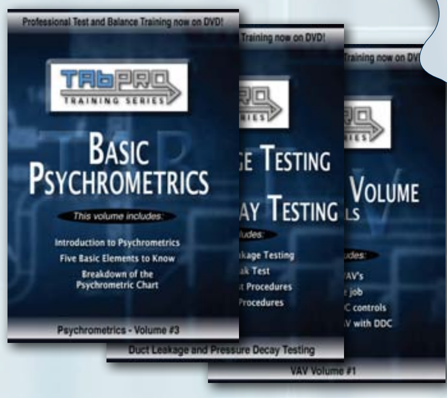

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List price: $200.00
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This volume consists of two lessons covering standard duct leakage testing and pressure decay leakage testing. These lessons take the viewer through an introduction to leakage testing, essential job preparation, instrumentation used during testing, general procedures for leakage testing, multiple calculations used during testing and final reporting.

Variable Air Volume (VAV) Terminals

DVD format
Run time 45 minutes
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This volume consists of two lessons covering standard VAVs and parallel fan-powered VAVs, both using DDC controls. These lessons take the viewer through an introduction to VAV terminals, essential job preparation, instrumentation used during testing, general procedures for testing and balancing, and final reporting.

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Combating Mold in a Large Residence

James E. Brennan, TBE
James E. Brennan Company, Inc.

A wealthy homeowner retained the services of a test and balance company to combat a mold problem at his 30,000 square foot home that threatened his collection of rare and valuable paintings, books, and antique furniture.

The original consulting engineer was given parameters that included maintaining 50% relative humidity to preserve his collections. The owner noted that several times each year, he invited guests for gatherings of up to 200 people.

The engineer designed the HVAC system to provide two CFM per square foot. Some mold occurred at various times, but during these large gatherings the mold grew more rapidly.

To meet the increased load conditions, the chiller would kick in, satisfy the areas rapidly because of the large volume of chilled air, and then shut down. This short cycling of the chiller resulted in insufficient dehumidification and the owner, very concerned about the possible damage to his collections, decided to bring in his own consulting engineer.

The second engineer reviewed the test and balance report and changed the design entirely. He gave instructions to install VFDs on all fans, with a starting point of 0.8 CFM per square foot delivered to the space. During the large gatherings, the VFDs allowed an increase in CFM as the load increased. Because the chiller could now cycle normally, there was proper dehumidification and the mold problem was eliminated.

Mold in many buildings is a common problem, sometimes resulting in loss of property.

Mold in many buildings is a common problem, resulting in a health hazard and sometimes loss of property. In this case, it was satisfying to witness how proper engineering analysis played an important part in the preservation of such valuable and irreplaceable treasures.

Preliminary Inspection Prior to

Rick L. Cox, TBE
Technical Air Balance, Texas

Testing and balancing of chilled and heating water systems is much more than simply obtaining a pressure drop reading across a coil, or from the connection of two hoses to the ports of a calibrated balancing valve. As a matter of fact, some of the most important work—ensuring the system is ready for test and balance—occurs before testing begins, especially when the system is quite large.

This is an area where the value of an experienced test and balance technician becomes very clear. A less experienced technician may not know of the many potential pitfalls that can be found, resulting in the possibility of performing the preliminary readings of an entire system only to find out at the end that the entire test and all of the readings are, for the most part, worthless.

> *"Some of the most important work—ensuring the system is ready for test and balance—occurs before testing begins."*

Yes, the test and balance agency may have been told that the system was ready to test, but an experienced technician is more likely to know how to properly determine if the system is in fact ready to test and balance. This saves time and money, and prevents the test and balance agency from becoming, in effect, an unpaid troubleshooter for the mechanical contractor.

It is imperative that the technician doing the testing get to know the system prior to starting the testing. This includes studying piping and control plans to understand how the system was designed to work, and physically walking and inspecting the system. This familiarization may reveal issues that must be addressed before beginning preliminary testing.

It is important to understand that there should be periodic inspections of the entire HVAC system during construction. However, these inspections are seldom done unless they are specifically required in the TAB specification. The inspections are useful to identify the following potential issues, to reduce or hopefully eliminate them altogether.

Mechanical and Control Subcontractor issues that can adversely affect a preliminary test reading. Here are just a few:

1. System has not been properly flushed to remove dirt and debris.

a. The source of dirt and debris is affected by the time of year, the location of the project, the conditions surrounding the job site, and the how the piping is stored. Pipes can accumulate significant dirt if they were lying in mud, silt, or dirty snow.

b. Pipes are often shipped with a small film of oil on them to retard rusting. Dirt on the pipe can mix with the oil, resulting in sludge that can clog in the toughest places to flush, such as smaller coils, valves and other places where the pressure drops in the system allow the sludge to fall.

c. It is not uncommon to find soda cans or other trash that someone on the jobsite stuck into the end of a 3", 4" or 5" pipe. The pipe can be picked up and be fitted into place with the can and dirt inside.

2. The piping system may not be properly piped, such as when a reverse return loop system is piped as direct return.

3. Coils piped backwards.

a. Although all coils should be piped properly, it is especially significant on chilled water coils. There is little to no tolerance for an incorrectly piped chilled water coil, as this would have a very negative affect on the overall performance of the coil and its ability to remove latent heat. In the case of the single row heating coil, this is of little significance.

Testing Hydronic Systems

4. Improperly placed reading ports on coils and pumps.

a. Port placement is very important and does affect the proper pressure reading across any particular item. Improper port placement on pumps prevents the plotting of true pump pressures on a pump curve.

5. Improperly placed balancing valves or the improper use of a valve for a balancing valve.

a. This is most important on pumps where the placement of the valve allows one to isolate or take shut-off head.

b. Gate valves cannot be used to balance flow.

6. The control system is not completed or functioning properly.

a. Often the system may have been physically completed, but the software download and system ID has not. The obvious result is the control system would not be functioning. Depending on the type of system, this may preclude beginning the test. Although it is best to begin the testing of any system after the system is 100% complete, depending on the type of system it may be possible to obtain a preliminary reading without a fully functional control system. Unfortunately, this belief winds up being applied to all systems where for the majority, it is impractical.

b. The TAB technician needs the ability to control all valves and pumps, especially if the pumps are wired through a VFD and system pressure and temperature driven to properly test the system.

c. It is essential to test for the proper operation of the control system as well as each individual thermostat. This is obviously not possible when the system is not fully operational. Unfortunately, the tenant is usually moving in, leaving no time to test the functional performance of these items.

"The TAB technician needs the ability to control all valves and pumps, especially if the pumps are wired through a VFD."

Other contractor type issues:

1. Accessibility to coils and ports.

a. This includes architectural issues where lights, structure and other items hinder the ability to take the necessary readings. Often, the placement of the coil is not an issue until after the installation of the ceiling grid and lights, which limit access to the coil. It is not uncommon to find a coil installed with its test ports obstructed.

b. No access to enclosed ceilings where coils are placed.

c. Test ports inadvertently covered by insulation.

2. Electrical issues.

a. Pumps running backwards.

b. Low voltage causing excessive amp draws on pumps and adversely affecting the windings of the motor.

c. Low control voltage where the loop for the control is so long that the voltage is not high enough to properly operate the controls.

d. High voltage can also reduce the motor life as it adversely affects the motor windings. Small motors tend to be more sensitive to overvoltage and saturation than are large motors. Single phase are also more sensitive to overvoltage than are 3-phase. U-frame motors are less sensitive to overvoltage than T-frame. Super-E motors are less sensitive to overvoltage than standard.

3. Fire and smoke detection system testing proceeding during testing of the hydronic system. This can interrupt proper testing, causing readings to change and fluctuate thus requiring a re-read.

4. Timing, such as seasonal testing and owner move-in:

a. Seasonal Testing: sufficient time should be given during construction to properly test for heating and or cooling performance under load. Heating or cooling loads can be temporarily induced to simulate summer or winter conditions. However most specifications call for opposite season testing, which is for the most part impossible once the tenant has moved into the facility.

If for example, the TAB procedures were performed during the winter, a significant issue may not be noticed until the facility is under a summer load condition and vice versa. This is why it is best to do all testing during construction.

b. Tenant Move-in: if sufficient time is not given to perform the proper temperature tests during the original TAB procedures prior to tenant move-in, there is seldom, if ever, time to do these once the tenants are occupying the space. This is especially true of hospitals, computer chip manufacturers, and other such type facilities.

Technician caused issues:

1. Hydronic system has not been properly set up via the control system prior to testing.

a. The pumps cannot be set for proper flow *unless* the system is being operated under the correct condition prior to the setting of the pumps.

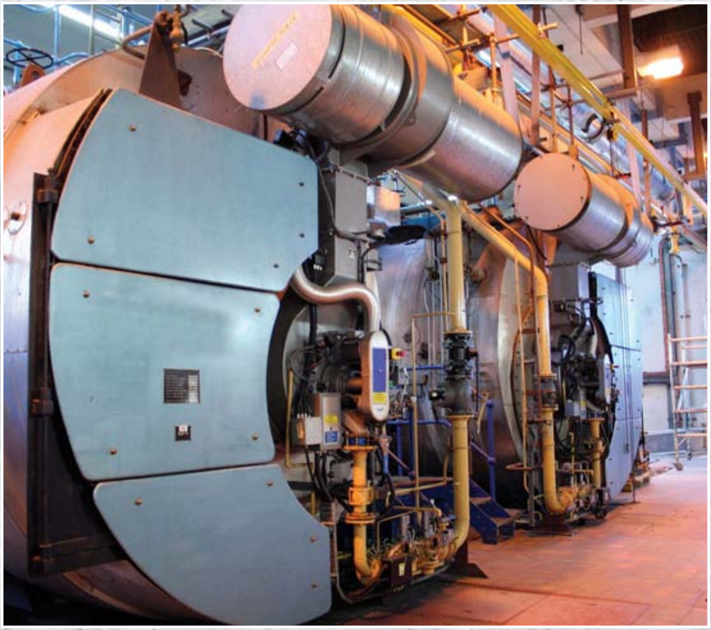
b. Depending on the type of system, all of the coils may need to be in a full flow condition. If the system has diversity, then only a certain percentage of coils would need to be in the 100% open position.

c. The system may also be affected because the bypass on the coils that are not in full cooling are allowing too much water to bypass, thus reducing the water available to the remaining coils. It is important to balance bypass flows

2. The necessary pumps are not running, causing insufficient flow; or too many pumps are running, thus increasing head pressures and restricting flow.

3. Secondary and tertiary pumps are not operating or are not set up properly prior to the reading of coils.

4. The make-up water pressure has not been properly set and is allowing air to infiltrate the hydronic system. This causes issues with air lock or the inability to get water to the highest coils in the system.



"It is important to understand that there should be periodic inspections of the entire HVAC system during construction. The inspections are useful to identify the following potential issues, to reduce or hopefully eliminate them altogether."

5. There may be a bypass valve at a strategic point in the system that is opened either manually or via the control system that is allowing the water to bypass the coils.

6. Setting and maintaining sufficient water flow through chillers, towers and boilers.

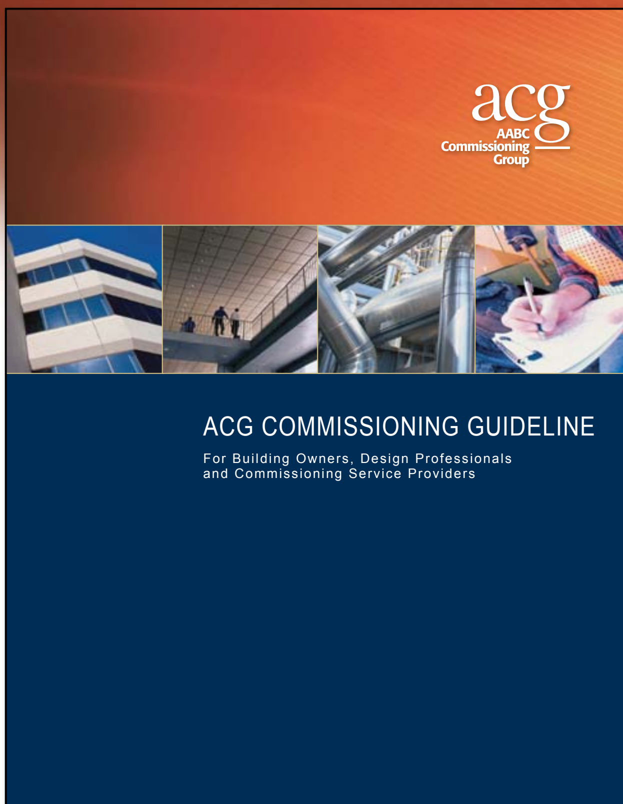
a. Failing to allow sufficient water to flow through the above equipment can result in expensive damage during the testing of the system. Once again, it is important to be well versed in what should and should not be happening during testing procedures.

All of the above items must become second nature to a TAB technician prior to starting the testing of a system. This is why it takes a good many years to properly train a TAB technician.

And once again, to emphasize: the test and balance agency may have been called to begin their work. The GC, the MC, and the control contractor may have said all was ready. None of this should preclude the agency from performing the proper inspections prior to testing. To do otherwise is to risk spending valuable time performing work for others for which you are not going to be paid.

"One of the clearest descriptions of the commissioning process that we've seen." —Environmental Building News

ACG COMMISSIONING GUIDELINE



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Tech Talk

Facilitating better understanding of proper balancing procedures has been part of AABC's mission for more than 40 years and helps to produce buildings that operate as designed and intended. Tech Talk is a regular feature in which AABC shares questions we've received and the responses from the association's experts. We hope that others have had similar questions and, therefore, will benefit from the answers. Readers are encouraged to submit their own questions about test and balance issues.

Have a Question?

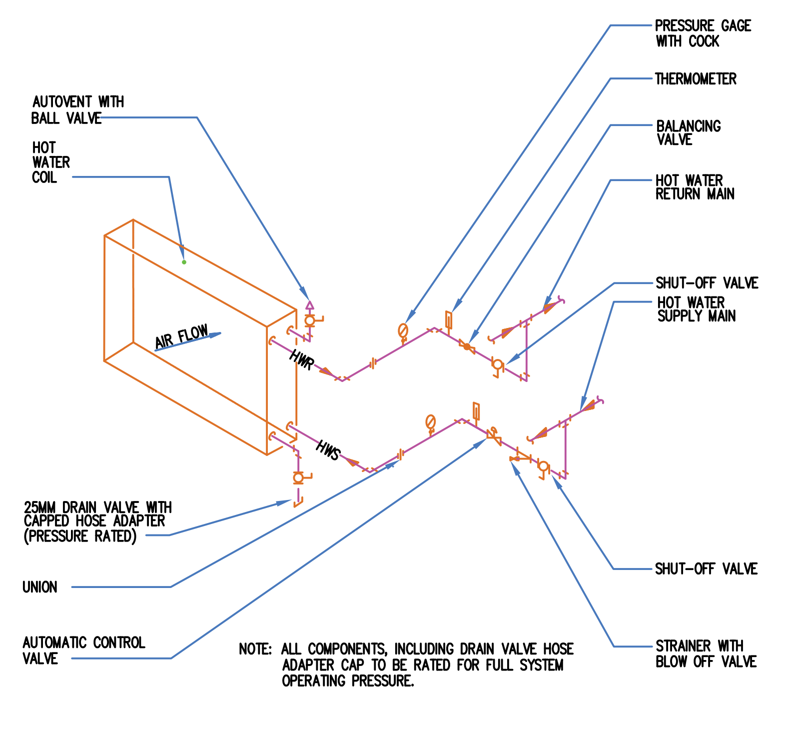
To submit a question for Tech Talk, email us at info@aabc.com

The Associated Air Balance Council frequently fields technical questions from engineers, contractors, owners and others regarding proper air and water balancing procedures.

These questions are answered by the most qualified people in the industry: **AABC Test & Balance Engineers (TBEs).**

2- and 3-Way Automatic Control Valves

QUESTION: ***Our engineering experience says that 2-way automatic control valves are always installed on return and 3-way control valves are on supply. However, the detail below for a VAV heating coil shows the control valve on supply:***



Hot Water Heating Coil Piping

(Not to scale)

The U.S. Government spec also confirms this, saying: "Hot-Water Piping: In addition to requirements in Division 15 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange."

What is AABC's opinion and experience for this matter?

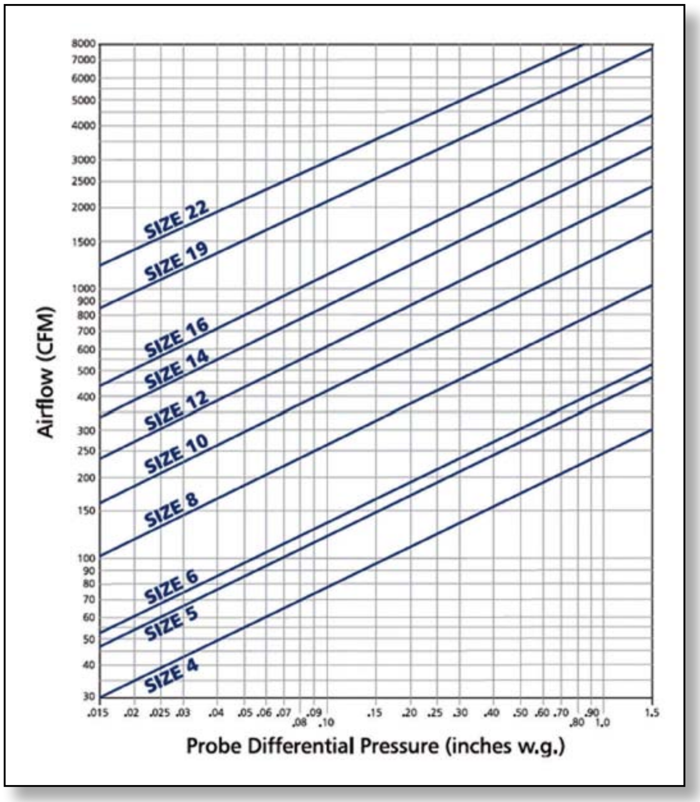
AABC: The reason they would put a 2-way valve on the supply is because they put a strainer ahead of it. A 2-way could also be on the return. That way both the coil and the valve are protected.

The only problem I see with the valve in front of the supply is if there was an auto-flow device in the return and the valve caused the flow device to start pulsating once it was throttling down. (In other words, in my opinion with any auto flow device you would want the flow device in front of the control valve.)

-Gaylon Richardson, Engineered Air Balance Co., Inc.

VAV Assemblies and Duct Sizes

QUESTION: ***I am designing a new variable air volume modular assembly (VMA), and am trying to determine what the minimum air flow is (as a percentage of the maximum flow) for a given duct size. The graph shows several duct sizes, along with their corresponding air flows given in cubic feet per minute:***



1) How is the duct size chosen? If a space requires a certain amount of air flow, I imagine that occasionally the duct will be oversized.

2) After the duct is installed, and the system is being verified, what is the flow set to in order to determine if it works? Is the duct completely open, completely closed, 50%, 35% etc.

3) Is there any general rule for a given duct size what the typical minimum amount of air seen is? For example, the 10 inch duct maximum airflow is ~1700 CFM, in a real application what would the typical minimum flow be?

Thank you for any help you can provide on this issue.

AABC:

1. The airflow is based on the inlet duct flow. The maximum airflow should not exceed 2000 FPM and the minimum airflow is usually 400 FPM. The minimum airflow depends on the sensor and transducer. The maximum airflow may have sound issues.
2. The terminal assembly should not exceed 0.15” SP at maximum airflow. If a hot water heating coil is added, the pressure drop should be tested at maximum airflow. The downstream ductwork will have varying resistances from 0.05" to 0.6".
3. Upstream of the terminal, the standard practice is not to exceed 2500 FPM and downstream a good practice is to keep neck velocities to diffusers below 1000 FPM.
4. I would suggest you refer to the ASHRAE Standard 130 Methods of Testing Air Terminal Units.
5. To maintain accuracy in the field Pitot tube traverses should be taken in ducts with 1200 FPM or greater.

-Gaylon Richardson, Engineered Air Balance Co., Inc.

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