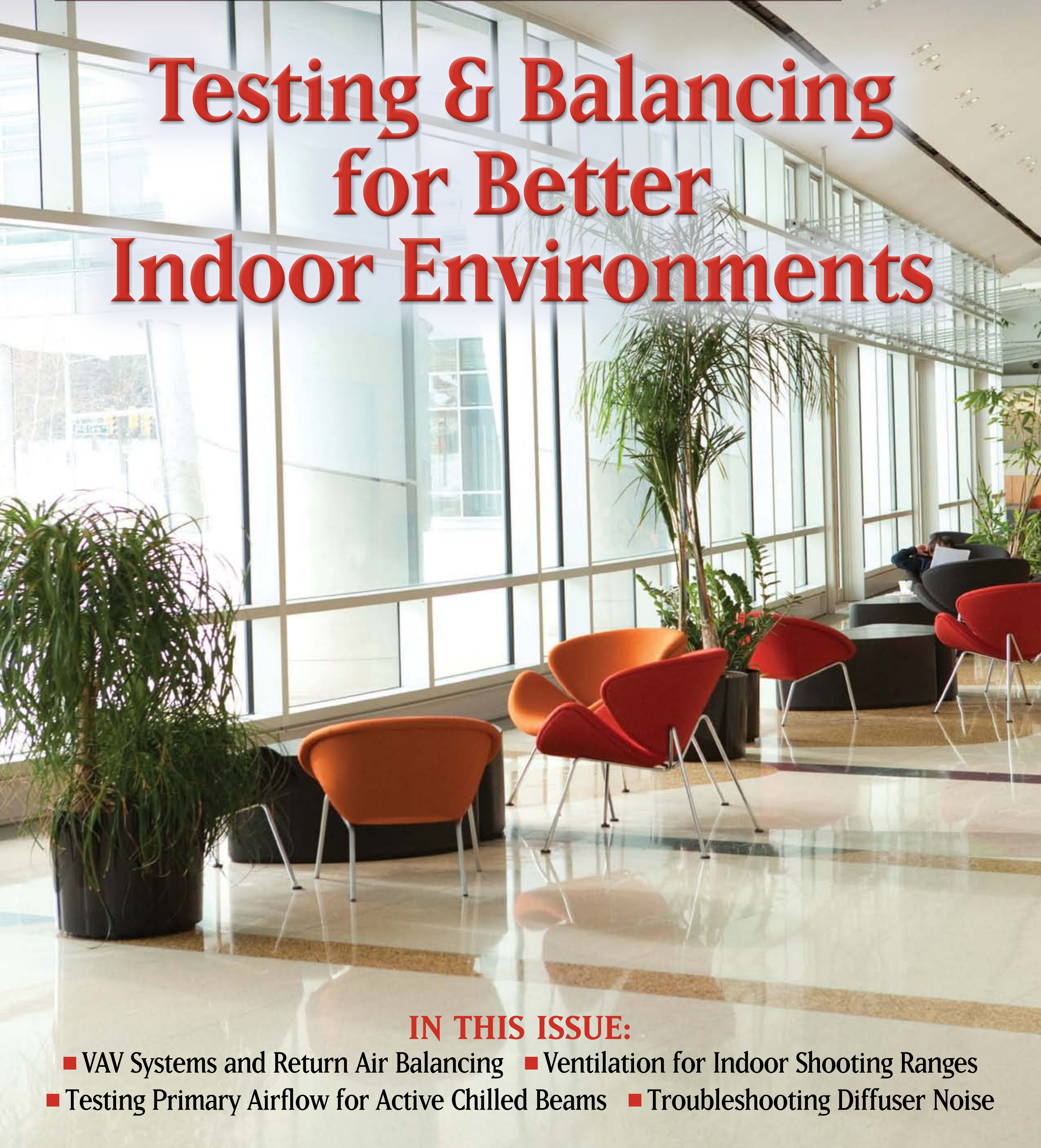
TAB Journal

AABC

THE MAGAZINE OF THE ASSOCIATED AIR BALANCE COUNCIL • SPRING 2012

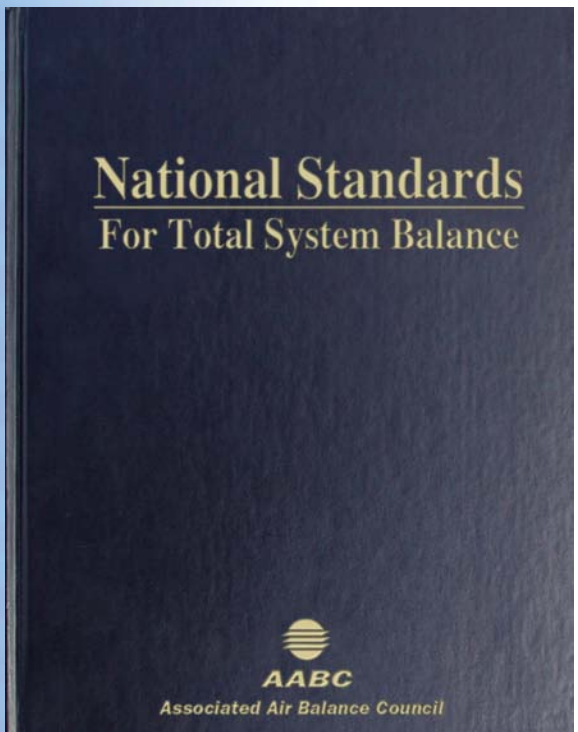


Testing & Balancing for Better Indoor Environments

IN THIS ISSUE:

A MUST-HAVE RESOURCE FOR INDUSTRY PROFESSIONALS!

The AABC National Standards for Total System Balance



OVER 350 PAGES OF STANDARDS FOR TOTAL SYSTEM BALANCING. ORDER YOUR COPY OF THE AABC NATIONAL STANDARDS FOR TOTAL SYSTEM BALANCE TODAY!

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

Each chapter covers a specific area in the test and balance process, enabling the design professional to select those items that are best suited for a particular project.

Additionally, the Standards will assist the design professional in achieving design intent, provide a better understanding of the scope of work required of the TAB agency, and ensure that proper methods and procedures are followed in the test and balance process.

Features of the Standards include:

- Illustrative tables and charts
- Equations and examples
- Sample specifications
- Expanded section of sample report forms
- New technologies, such as DDC
- Updated testing procedures
- Appendix with equations in both English and Metric formats

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.

For additional information on the Associated Air Balance Council or the new AABC Standards, visit our website at **www.aabc.com**, or contact AABC National Headquarters at **202-737-0202**.

Non-Member Cost: $75.00

AABC National Standards 2002 @ $75 each x _______= $__________

Payment Information

Payment Type (Check one)

❑ Check Enclosed ❑ MasterCard ❑ Visa ❑ American Express

Name

Company

Shipping Address

City State Zip

Phone Fax

Email

Card Number Expiration Date

Name on Card

Signature

Please complete order form and return along with payment to:

Associated Air Balance Council
1518 K Street, N.W., Suite 503 • Washington, D.C. 20005

Credit card purchasers may fax orders to: (202) 638-4833 or order online at www.aabc.com/publications

AABC

TAB Journal

Editorial Office
1518 K Street, N.W., Suite 503
Washington, D.C. 20005
(202) 737-0202 • FAX: (202) 638-4833
E-mail: info@aabc.com
Website: www.aabc.com

TAB Journal is published quarterly by the Associated Air Balance Council. It is distributed free to AABC members and by subscription to non-members at $24 per year. *TAB Journal* is an open forum for the free expression of opinions and information. The views expressed are not necessarily those of AABC, its officers, directors, or staff. Letters, manuscripts, and other submissions are welcome. However, *TAB Journal* accepts no responsibility for unsolicited material.

ECO BOX

TAB Journal magazine text and cover pages are printed on SFI-certified Anthem Gloss paper using soy ink.

SFI standards conserve biodiversity and protect soil and water quality, as well as wildlife habitats.

SFI forests are audited by independent experts to ensure proper adherence to the SFI Standard.

SFI participants also plant more that 650 million trees each year to keep these forests thriving.

From the Publisher

The Spring 2012 issue of TAB Journal touches on many aspects of the test and balance industry, including VAV systems, diffuser noise, and ventilation requirements.

"Variable Air Volume Systems and Return Air Balancing" by James E. Hall, P.E. and Odean H. Jukam, TBE, of Systems Management & Balancing, Inc., provides insight on return airflow balancing and how critical it is for system/building operation.

Brian Trogstad, TBE, of Design Control, Inc., discusses not so obvious issues that may arise when testing and balancing existing ventilation systems. He offers a solution that will require contractors and fabricators to be in agreement on label placement in "Troubleshooting Diffuser Noise and Low Airflow."

"Duct Smoke Detectors", written by Marcus Hill of TAB Services, Inc., walks through the process of testing these systems and the importance of measuring the air velocity across the censor head.

Alan Shamrock, TBE, from Engineered Air Balance Co., Inc., provides insight for when communication is lacking between contractors in "Equipment Startup Sheets and Pre-Balance Conference." His method ensures that each contractor has signed off on their responsibilities and the area is in fact ready for TAB.

"Ventilation for Indoor Shooting Ranges" by W. Carson Judge, TBE, from Bay to Bay Balancing, Inc., discusses the importance of testing and balancing these systems and the effects it can have on occupants' health if not done properly.

Kevin Wilson, TBE, of PHI Service Agency, Inc., explains how value engineering may cause problems and end up costing more money in the end in "Value Engineering Not Always Valuable."

"Testing Primary Airflow for Active Chilled Beams" by Ross Gerdon, TBE, and Chris Burnette, TBE, of The Phoenix Agency of North Carolina, Inc., reviews a manufacturer's method for testing chilled beams and subsequent testing done to verify the accuracy of that test method.

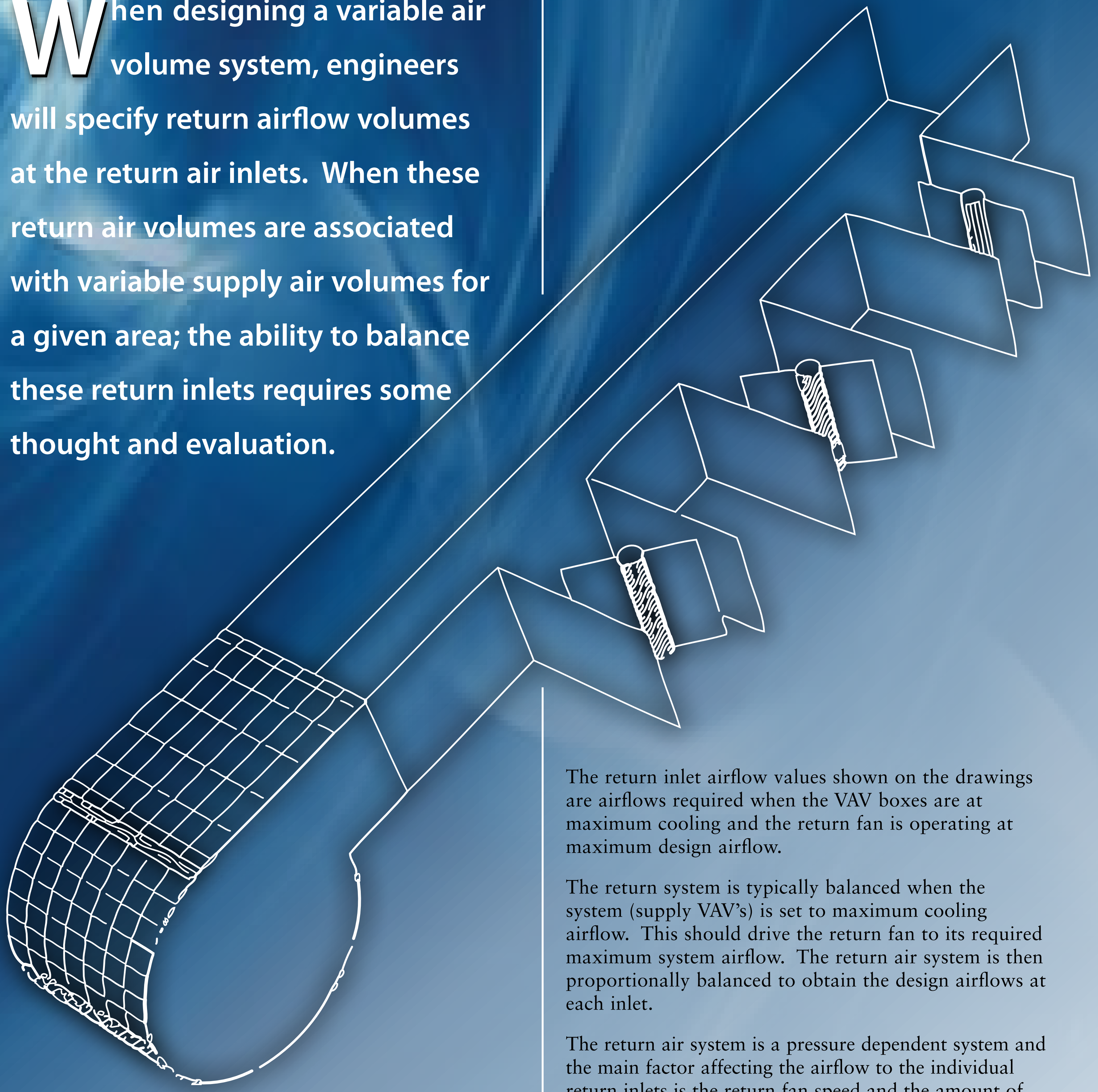
A question regarding how to access dampers for performing test and balance in a gypsum ceiling is addressed in this issue's Tech Talk.

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!

Variable Air Volume Systems

James E. Hall, P.E., TBE & Odean H. Jukam, TBE

When designing a variable air volume system, engineers will specify return airflow volumes at the return air inlets. When these return air volumes are associated with variable supply air volumes for a given area; the ability to balance these return inlets requires some thought and evaluation.



The return inlet airflow values shown on the drawings are airflows required when the VAV boxes are at maximum cooling and the return fan is operating at maximum design airflow.

The return system is typically balanced when the system (supply VAV's) is set to maximum cooling airflow. This should drive the return fan to its required maximum system airflow. The return air system is then proportionally balanced to obtain the design airflows at each inlet.

The return air system is a pressure dependent system and the main factor affecting the airflow to the individual return inlets is the return fan speed and the amount of airflow and pressure present in the duct system.

and Return Air Balancing

Systems Management & Balancing, Inc.

The return air system is designed and the ductwork is sized for "maximum" system airflow and the ability of the system to obtain design return airflow at all of the return inlets. The return airflow in the duct and at the inlets changes once the return fan speed is reduced from "maximum" airflow. The return fan speed is typically controlled by tracking the supply fan by an offset speed or airflow value; maintaining a plenum pressure; or maintaining a building pressure. It should be noted that none of these control scenarios are associated with maintaining the design return airflow at the individual return air inlets.

Myth 1 – Return airflow at the inlets changes exactly proportional with respect to a change in return fan speed.

The airflow at the individual inlets will not remain proportionally balanced exactly as the speed of the fan is decreased. If the return fan speed is reduced 25%, the return airflow at each individual inlet is not proportionally reduced exactly 25%. Originally the ductwork was sized for "maximum" airflow and now that the total system airflow has been reduced, it is "oversized" for the reduced airflow. At the reduced fan speed the following properties in the ductwork are reduced: air velocity, friction loss, velocity pressure and static pressure. It should be noted that the amount of "imbalance" will increase as the return fan speed is further decreased and it is possible that little or no airflow can be measured at a return inlet located a good distance from the return fan.

The following table displays the anticipated properties of air in a section of ductwork for a return air system at reduced fan speeds.

Myth 2 – The return inlet airflow changes as the associated supply VAV changes in airflow.

The amount of conditioned air supplied by a VAV box into a room will vary from maximum to minimum based on a thermostat setting change, change in occupancy, solar load, equipment operating conditions, etc. The amount of air returned from the room varies gradually as the building load changes and the return fan speed changes. Therefore, once the system is operating under control, the supply air to return air ratio for given areas is subject to constant change. The supply airflow and return airflow systems are not a closed coupled system.

Once the air handling system is put into operation under DDC system control, the return airflows originally reported cannot be repeated. In order to repeat airflow measurements at the return inlets, the system must be indexed to the mode that it was operating in during balancing. This operating mode is typically with all supply VAV's indexed to maximum cooling and the return fan at maximum airflow.

If return airflow balancing is required for the VAV system, then an evaluation should be performed on the requirements and approach to performing the air balancing.

1. Is individual airflow at each return inlet critical? Will system or building performance be affected if the airflow at these inlets is not obtained?
2. Can the return airflow be proportioned by area or floor (in lieu of individual inlets) and satisfy the system/building requirements? Are balancing dampers located in the key areas to allow this to happen?
3. If return airflow balancing is critical for the system/building operation, then the system should be made pressure independent and the use of VAV boxes on the return air system should be employed.

DUCT SIZE	36″ X 24″	36″ X 24″	36″ X 24″
AIR VOLUME	7500 CFM	5000 CFM	2500 CFM
AIR VELOCITY	1250 FPM	833 FPM	417 FPM
DUCT FRICTION LOSS	0.07″ / 100 FT.	0.035″ / 100 FT.	0.01″ / 100 FT.
STATIC PRESSURE	1.5″	0.67″	0.17″
VELOCITY PRESSURE	0.097″	0.043″	0.011″

TABPRO TRAINING SERIES

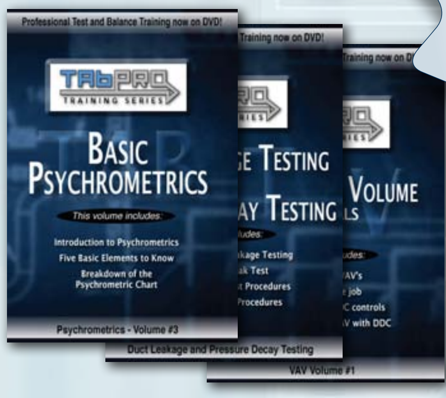
Bundle (VAV, Duct Leakage & Psychrometrics)

3 DVDs

Total run time 106 minutes
List price: $468.00
Member price: $351.00

Save 10% when you order all three TABpro DVDs!

You'll get lessons on standard VAVs, parallel fan-powered VAVs, standard duct leakage testing, pressure decay leakage testing, and basic psychrometrics.



Basic Psychrometrics

DVD format
Run time 19 minutes
List price: $120.00
Member price: $90.00

This volume contains one lesson on Basic Psychrometrics. This provides the viewer with an introduction to Psychrometric fundamentals and takes you through five of the basic elements found on the psychrometric chart. This lesson will break down these elements on the chart and provide fundamental concepts of chart usage.

Duct Leakage and Pressure Decay Testing

DVD format
Run time 42 minutes
List price: $200.00
Member price: $150.00

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
List price: $200.00
Member price: $150.00

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.

Quantity	Title	Price Non-Member	Price Member
_______	Psychrometrics	$120	$90
_______	Duct Leakage	$200	$150
_______	VAV Terminals	$200	$150
_______	Bundle of all 3 DVDs	$468	$351

Total: $____________

Payment Information

Payment Type (Check one)
❑ Check Enclosed ❑ MC ❑ Visa ❑ AMEX

Card Number ______________________

Expiration Date ______________________

Name on Card ______________________

Signature ______________________

Please complete order form and return along with payment to:

Associated Air Balance Council
1518 K Street, N.W., Suite 503
Washington, D.C. 20005

Credit card purchasers may fax orders to: (202) 638-4833 or order online at www.aabc.com/publications

Shipping Information

Name ______________________ Phone ______________________

Company ______________________ Fax ______________________

Shipping Address ______________________ E-mail ______________________

City/State/Zip ______________________

Troubleshooting Diffuser Noise and Low Airflow

Brian Trogstad, TBE
Design Control, Inc.

Testing and balancing on existing ventilation systems usually uncovers many unexpected issues such as improper installations, dirty filters, no filters, dirty coils, missing endcaps, closed fire/smoke dampers, diffusers above ceilings, fans running backwards, and occupant installed deflection/damper systems. These items often take time to uncover, diagnose, and resolve so that the systems can be brought back to a "typical installation" and balanced effectively.



A recent project consisted of a large addition and remodel to a clinic. An existing air handling unit and return fan were given a controls upgrade and part of the duct system was removed. The remaining supply and return ductwork, terminal coils and diffusers were left in place. The system was originally installed in 2001.

Specifications called for a rebalance of the existing system to the new design airflow. The system was constant volume with approximately 30 diffusers and 20 terminal reheat coils.

Preliminary data was taken on the air handling unit and return air fan and their associated registers and diffusers. Actual total airflow was operating at about 120% of design because the system had been reduced during remodeling.

During preliminary testing at some diffusers, noise and proportionately low airflow were noticed. After further investigation, duct labels (much like a mailing label) were found.

These labels were attached in the fabrication shop to tell the fabricator how the fitting should be made and to help the installer place the proper fitting in the right location. The labels had come loose and ended up both inside the neck of the diffusers and perforated face. Over time, the labels had discolored which made them hard to see. The labels often lay on top or between the deflections in the diffuser neck, partially blocking airflow.

The test and balance agency proceeded through all of the diffusers and removed any labels or pieces of labels in the diffusers. For further investigation, they also did a visual examination of all of the terminal reheat coils and found between 1 and 4 duct labels covering portions of the coils. Any portion of the coil that is covered restricts airflow and reduces heat transfer. Labels were also found in the blades of the return fan. After removing all labels that were "loose" in the system they were able to reread it, slow the fan down, and balance proportionately.

While the results in this case ended well, the problem found is very important and somewhat troubling. Testing and balancing technicians are trained to search for the cause of problems and have all found "dirty" reheat coils that have collected material in and on the coil during 30 or more years of service. However, this system had only been in service for less than 10 years.

Contractors have estimated that they have used these labels for the past 15 years or so. This could be a big problem in the years to come. Duct labels are subject to warm, cold, humid and dry conditions inside the ductwork. The type of system involved may change, but duct labels in coils, fire/smoke dampers, turning vanes, diffusers & fan wheels could be a troubleshooting nightmare.

Engineers need to specify that duct labels be placed on the outside of ductwork, or specify a label that is proven to adhere under all conditions. While the quality of the label may prevent early loosening, placement outside the duct may be the best solution.

Through discussions with local contractors, fabricators prefer the label inside so it can be viewed while making the fitting. Two of the largest local mechanical contractors place the labels on the inside of the duct. Placement may be inconvenient to the fabricator, but will prevent bigger problems in the future.

DUCT SMOKE DETECTORS

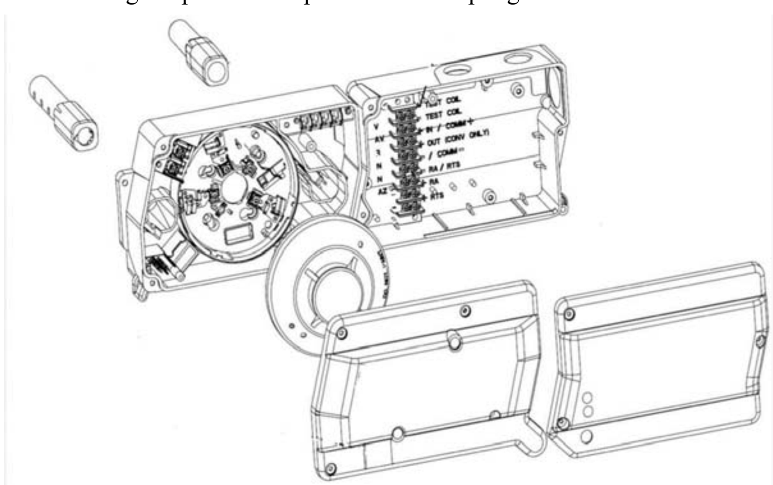
Marcus Hill
TAB Services, Inc.

The purpose of duct smoke detectors is to prevent the recirculation of smoke, toxic gases, and flames from one area of a building to another area. Generally, duct smoke detectors are required to be installed on the return duct of any recirculating HVAC equipment with a design capacity of 2,000 CFM or greater. They should be installed upstream of any filters, exhaust air connections, outdoor air connections or decontamination equipment and appliances (2009 IMC). Always check the adopted mechanical code in your jurisdiction for additional requirements.

Duct smoke detectors should always be tested before a building receives its certificate of occupancy. Always verify that the detector is installed in the correct location before testing.

Duct smoke detectors can be tested as follows:

- Using the built-in test feature on the duct smoke detector. This is generally a button located on the sensor cover that when pressed should activate the alarm and shut down the equipment.
- The use of smoke to test the duct smoke detector. It is not recommended to use smoke bombs while performing this test. The correct method is to introduce smoke directly to the sensor head. Note: while performing this test the sampling and exhaust ports should be closed off so that smoke is not introduced into the system.
- Measuring the pressure drop across the sampling tubes.



Test and balance technicians are being asked more frequently by fire marshals to measure the air velocity across the sensor head. Most duct smoke detector manufacturer's recommend that a velocity of 100 FPM to 4,000 FPM be maintained across the sensor head. Since there is no practical way to measure this velocity, manufacturers recommend a pressure drop range that corresponds with the required velocity range. This is generally between 0.01" of water to 1.11" of water.

The procedure for measuring the pressure drop across the sampling tubes is as follows:

- Remove the sensor cover.
- Place a hose into the sampling and exhaust ports.
- Block off the remaining area around the hoses so that air cannot leak by.
- Use your manometer to read and record your pressure drop.
- Check the manufacturer's recommended pressure drop range and confirm that your measurement falls in that range.

Equipment Startup Sheets and Pre-Balance Conference

Alan Shamrock, TBE
Engineered Air Balance Co., Inc.

On a recent large high school project, the general contractor had set up a building flow chart and schedule for how he wanted the building completed. When the test and balance agency arrived to begin their work, it initially appeared that the general contractor's scheme had been implemented. However, after some digging, it became apparent that very few of the HVAC systems were actually complete and ready for TAB.

The testing and balancing section of the project specifications called for a "Preliminary Test and Balance Conference." The TAB agency asked the general contractor for such a meeting, and for the mechanical, electrical, sheet metal, and control contractors to be in attendance so that all could determine what was ready for testing and balancing.

During the meeting, it became obvious that there had been a lack of communication between the contractors. When asked whether all contractors were complete on the science room exhaust systems, the electrical and sheet metal contractors indicated that they were done, but when the mechanical contractor was asked if he had started up the fans, he indicated that he couldn't because the control contractor had not installed the required relays. As we continued to discuss the various equipment in the area that test and balance was designated to start in, similar problems arose.

In preparation for the meeting, the TAB agency had created startup sheets for approximately 400 pieces of mechanical equipment, from duct heaters to chillers, describing each piece of equipment and providing a box for each contractor to sign indicating that the company had completed their required work. These sheets were now provided to each contractor, each of whom was asked to complete and return them to the general contractor as equipment was finished. The general contractor said he would then input the data from all the trades onto a master sheet showing which pieces of equipment had been completed by all contractors.

At the end of the meeting it was determined that weekly meetings would be held and that each contractor prior to the meeting would be responsible for providing information to the general contractor on what equipment had been started the previous week.

Of course, there is always the chance that someone signs off without confirming that the work is actually completed, but the TAB agency now has written documentation and, if necessary, an avenue to recoup lost time. More importantly, the equipment startup sheets and pre-balance meetings allowed for testing and balancing on the project to proceed much more efficiently.

"It became obvious that there had been a lack of communication between the contractors..."

Ventilation for Indoor Shooting Ranges

W. Carson Judge, TBE
Bay to Bay Balancing, Inc.

There are more than 1 million law enforcement officers in the United States. Over 20 million U.S. citizens are involved in target shooting. These officers and shooting enthusiasts are pursuing venues for training and practicing their skills in the shooting sports, and indoor firing ranges make up a large percentage of these venues.

These facilities, which vary from highly specialized training environments to leased warehouse spaces, must be able to provide a safe setting for the employees and the end user. Hazardous materials such as lead, carbon monoxide and dust are released during the combustion process that occurs when a cartridge is fired. Due to the health risk imposed by such byproducts, it is necessary to have an effective ventilation system to provide a safe environment.

OSHA has established limits for airborne exposure to lead. The standard creates the action level and the permissible exposure limit (PEL). The action level for airborne lead exposure is 30 micrograms per cubic meter of air (µg/m3) as an 8-hour time-weighted average (TWA). The OSHA PEL for airborne exposure to lead is 50 µg/m3 as an 8-hour TWA that is reduced for shifts longer than 8 hours. The NIOSH recommended exposure limit (REL) for airborne lead is 50g/m3 as an 8-hour TWA. Based on the seriousness of the issue, it is critical that the ventilation system be well-designed, properly balanced and commissioned.

Components of a well-designed system include:

- The range operates under a negative pressure to prevent the transfer of contaminated air to adjacent areas.
- Supply air be injected behind the firing line in a manner that will produce a non-turbulent flow across the area of the firing line.
- Air velocities at the firing line of 75 fpm (with a minimum of 50 fpm) in order to remove undesirable compounds from the breathing zone of the shooter. These velocities should be as laminar as possible as the shooting may be done in a prone or sitting position.
- Supply and exhaust fans should be interlocked with a visible alarm to indicate system failure.
- Space pressure alarms to notify if the negative pressure has been compromised.
- Energy efficient.
- Ease of access for maintenance.
- Opening of filter access doors should disengage the fan system.
- Filters that are exposed to contaminated materials should be gasketed to prevent bypass leakage.
- Filters should be upstream of equipment and as close to the range as possible to reduce the amount of duct that is contaminated
- Filter all exhaust air to meet Environmental Protection Agency (EPA) standards and best management practices.

Not all of these components are, or can be, incorporated into every system. Special project requirements, regional regulations, first cost budgets, local climate and availability of qualified installation and maintenance personnel all affect the decisions made in determining the scope and complexity of the project.

Documentation of health issues associated with indoor shooting ranges that have poor ventilation systems is clear. Lead and carbon monoxide toxicity have clear correlations to facilities with improper ventilation systems. While they are not the only factor in such illnesses they are one of the largest, if not the largest, contributor to the problem. It is also clear that these health issues can be prevented with a properly designed and functioning ventilation system.

Efforts to increase energy efficiency have caused the industry to move the historically 100% outside air systems to incorporate recirculated air as well. The recirculating systems are not allowed in all jurisdictions and have a higher first cost. These systems are also more complex.

The system is based on ASHRAE Standard 62, and its perception that dilution ventilation can be used to achieve an acceptable level of indoor air quality. This does provide a more energy efficient solution. Lead can be reduced to acceptable levels using proper filtration. This is typically done using a three filter bank of 4" MERV 7 or 8 pre-filters, 12" MERV 13 or 14 secondary filters, and 99.97% at 0.3 micron HEPA filters performing the final filtration.

Carbon monoxide however, cannot be removed by filtration and as such must be diluted to an acceptable level. The EPA standard for carbon monoxide in outside air is 9.0 ppm. ACGIH and OSHA have set guidelines at 25 ppm and 50 ppm respectively for an 8 hour exposure in the workplace. The exact ratio of fresh air to recirculated air will have to be maintained and the dilution rates will vary with the density of shooters using the line at any given time. Controls for these systems may incorporate real time monitoring systems that confirm the concentration of contaminants if the recirculated air falls below OSHA limits of exposure.

Once a system is properly designed and installed, testing and commissioning of these facilities is critical to assure the facility occupants that the system is functioning as designed, minimizing any life safety issues associated with toxic exposures as a result of a poor ventilation system. The testing and commissioning should focus on the system meeting the requirements defined in both the owner's project requirements and the basis of design. This should confirm that all requirements from the authorities having jurisdiction (AHJ) are met as well. Following an inspection of the system verifying proper installation and start-up having taken place, the airflow test and system balancing can occur.

Airflow test

- Examine all air distribution devices and complete a preliminary set-up of the room air dispersion pattern with the goal being to provide a smooth laminar flow over the firing line and to reduce jetting of air streams to the extent possible.
- Set total flow on each piece of equipment.
- Balance and set all individual air distribution devices within design tolerances.
- Go back and review the room air dispersion patterns and adjust as needed to achieve the goal of smooth laminar flow at the firing line.
- In each firing lane set up a grid cross section of the area (see figure 1 below) and take velocity readings at the one foot, three feet and five feet levels with three horizontal readings at each level. Measurements at this point should be between 50 and 90 feet per minute (fpm) with the theory being that velocities less than 50 fpm do not have the transport velocity to carry the contaminants away from the breathing zone, and velocities in excess of 90 fpm may lead to eddies and backflow currents that could bring contaminants back into the breathing zone.

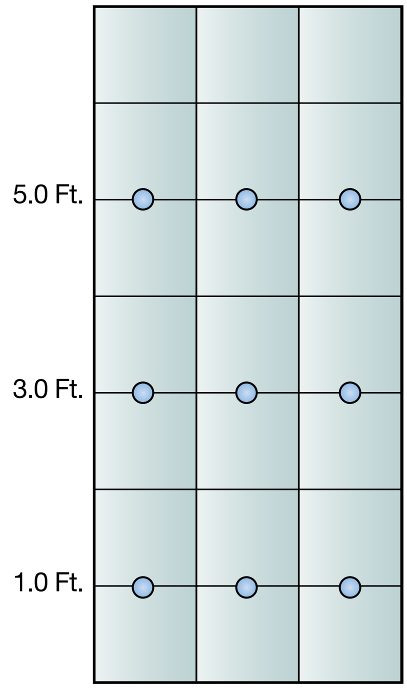
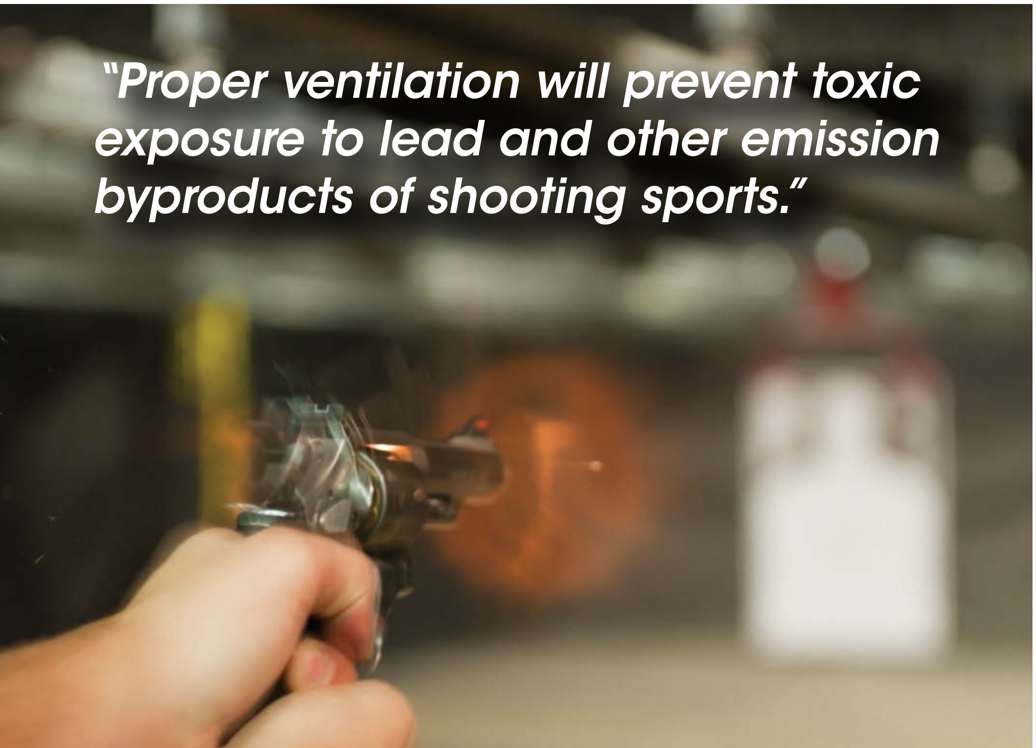


***Figure 1:** Firing line air velocity test points.*

- Take similar readings at the one third and two third marks downrange from the firing line. At this point, velocities should be between 2 and 50 fpm. This will depend on design as some designs allow a portion of the exhaust to be removed prior to the test point. MIL-HDBK-1027 suggests 20 fpm just for the clearance of smoke to allow adequate visibility. NIOSH suggest a 30 fpm minimum to prevent fallout of gun emissions downrange of the firing line.



- Many of the guidelines do not address the mass balance issue, where if the cross section of the building is constant then the flow down range should have the same average velocity as the upstream cross section. In some designs, about 25% of the air is exhausted between the firing line and the mid range point and the down range air velocities would then be approximately 75% of the firing line velocities.
- Once the building has been balanced, the differential pressure between the range and the adjoining spaces (both interior and exterior) should be measured using a micro-manometer. If the system has more than one operating condition, the space should be pressure mapped at all openings under each separate condition.

Commissioning considerations

Following the testing and balancing of the airflows, the remainder of the system should be commissioned. Emphasis should be on envelope integrity, control verification, system function and maintainability of the system. While each system will be unique, certain issues should be considered during the commissioning process.

- The building should be inspected for leaks as infiltration within the facility can result in disturbances of the airflow patterns that can reduce the efficacy of the system.
- The room layout should be conducive to the laminar flow effect being pursued. To that end, any obstructions that are not required should be eliminated or reviewed to evaluate if they can be reconfigured to reduce the disturbance they are creating.
- Control systems should be verified to ensure proper system operation.
- Monitoring systems should also be calibrated and verified to confirm accurate feedback to the system operators.

- If automated control and monitoring systems are not used, confirm there is a testing and monitoring plan in place to conform to OSHA mandates that require this verification every three months.
- If supply plenums are used, take note of the potential for obstructions to be placed in the path of the airflow and disrupt the flow patterns.
- Smoke testing should be performed releasing smoke at the one foot, three feet, and five feet points above the finished floor with all smoke moving downrange. Stagnant or backflowing smoke is unacceptable. This test should be repeated in all operating modes.
- A program should be in place to have the system re-evaluated within five days of any changes to the system.
- Fans should be interlocked with an audible/visual indicator of system failure.
- Filters should be equipped with differential pressure sensors that can signal an alarm when they have failed or require maintenance.
- Pressurization at all doors should be verified using a smoke pen or similar device to verify space negative pressure.
- The ventilation system should operate whenever the firing range is being used or undergoing maintenance.

Depending on the scope of commissioning, the process can be considerably more involved. The above looks primarily at the engineering controls in place within a facility. Administrative controls such as scheduling, exposure times, eating and smoking rules, maintenance, and the use of personnel protection equipment (PPE) such as gloves and respirators will all affect the overall exposure levels to the facility occupants.

Due to the widespread popularity of shooting as a recreational activity and the required training needs of the military and law enforcement, it is estimated that there are around 13,000 to 15,000 civilian firing ranges, with another 3,000 operated by the military. NIOSH clearly established, as early as 1975, that proper ventilation within these facilities can and will prevent toxic exposure to lead and other emission byproducts of shooting sports. Commissioning and TAB professionals are charged with the responsibility of testing and verifying these systems. Failure of these systems poses potential health risks to those who use and work in the facility.

AABC Lunch & Learn Presentations *For Engineers*

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!

TOPICS INCLUDE:

- Test & Balance Primer for Engineers
- Hot Water Reheat Balancing
- Duct Leakage Testing
- Control Point Verification

…Or Suggest another Topic!

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.

Value Engineering Not Always Valuable

Kevin Wilson, TBE, *PHI Service Agency, Inc.*

In mid-winter 2011, a TAB agency was contacted to investigate why the heating in a large number of units in a multi-story senior living facility could not maintain acceptable temperature conditions. Weather had been much colder in the southwest than seasonal norms. Outside temperatures were ranging from the 20s during the day to the teens at night.

Each living unit consisted of a thru-wall unitary HVAC unit to handle the heating and cooling requirements. The units were equipped with a small outside air damper assembly to provide ventilation (outside air) as required. Due to the heating problems that were being experienced, the engineering staff had gone through and closed these dampers in every unit. This was done under the assumption that too much outside air was being introduced into the building through the outside air openings. This did not resolve the problem.

The restrooms in each living unit were served by three exhaust fans on the roof. Each fan handled all of the restrooms in a given wing on all floors of the building. Based on the unit layout, some restrooms had one exhaust grille and others had two. The preliminary traverse total for all three fans combined indicated these three restroom exhaust fans were removing almost 11,000 cfm from the building. Building pressure readings at various egress locations around the building were obtained and showed the building to be extremely negative in relationship to the outside ambient pressure.

After determining the building pressure was extremely negative, site inspections and interviews with some of the people involved with the construction process were conducted. It was discovered that the energy recovery units that had been originally designed into the project to provide conditioned outside air to the living wings of the facility, to offset the exhaust air, had been value engineered out of the design. The air handling units that served the common areas of the facility on the first floor were equipped with outside air capabilities, but as a total, were too little to offset the amount of exhaust that was being removed from the building.

> "The energy recovery units designed to provide conditioned outside air to the living wings of the facility, to offset the exhaust air, had been value engineered out of the design."

After numerous conference calls and meetings, it was determined the original design MEP engineer had calculated the required restroom exhaust rates based on DAD's (Department of Aging and Disabilities) and ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) requirements for a staffed facility such as an assisted living or nursing home. Once the numbers were re-calculated based on the requirement for the type of facility this building actually is, design exhaust rates reduced from 75cfm per grille to 20 cfm per grille, except for a few of soiled utility rooms. The total exhaust capacity for the building reduced by 57%.

The challenge at this point was to determine how to reduce the fan capacities without changing out the fans. It was decided to replace the sheaves to achieve the lowest possible fan speed with a sheave set that would physically fit in the fan cabinet. This was done and further testing determined total flows from the fans were still excessive. After inspecting the fans and reviewing the manufacturer's information on the fans, it was determined the exhaust fans had non-overloading wheel characteristics. The contractor installed an opposed blade damper assembly at the discharge of each exhaust fan. The dampers were throttled to further decrease total fan capacities until the new total design volumes for each fan were achieved. At this point the TAB technicians completed balancing the grilles on each of the three exhaust systems.

Once the grille balance was complete and total fan capacities were re-verified, it was determined that the three fans were now exhausting a total volume of 4,475 cfm. New building pressure readings were obtained at the same egress points as before. The new pressure readings indicated the building was now operating at a neutral pressure relationship to outside ambient pressure. Although not requested to test or confirm outside air volumes on the units that had outside air capabilities, it was assumed that there must be sufficient outside air being introduced into the building to allow it to maintain a neutral pressure relationship.

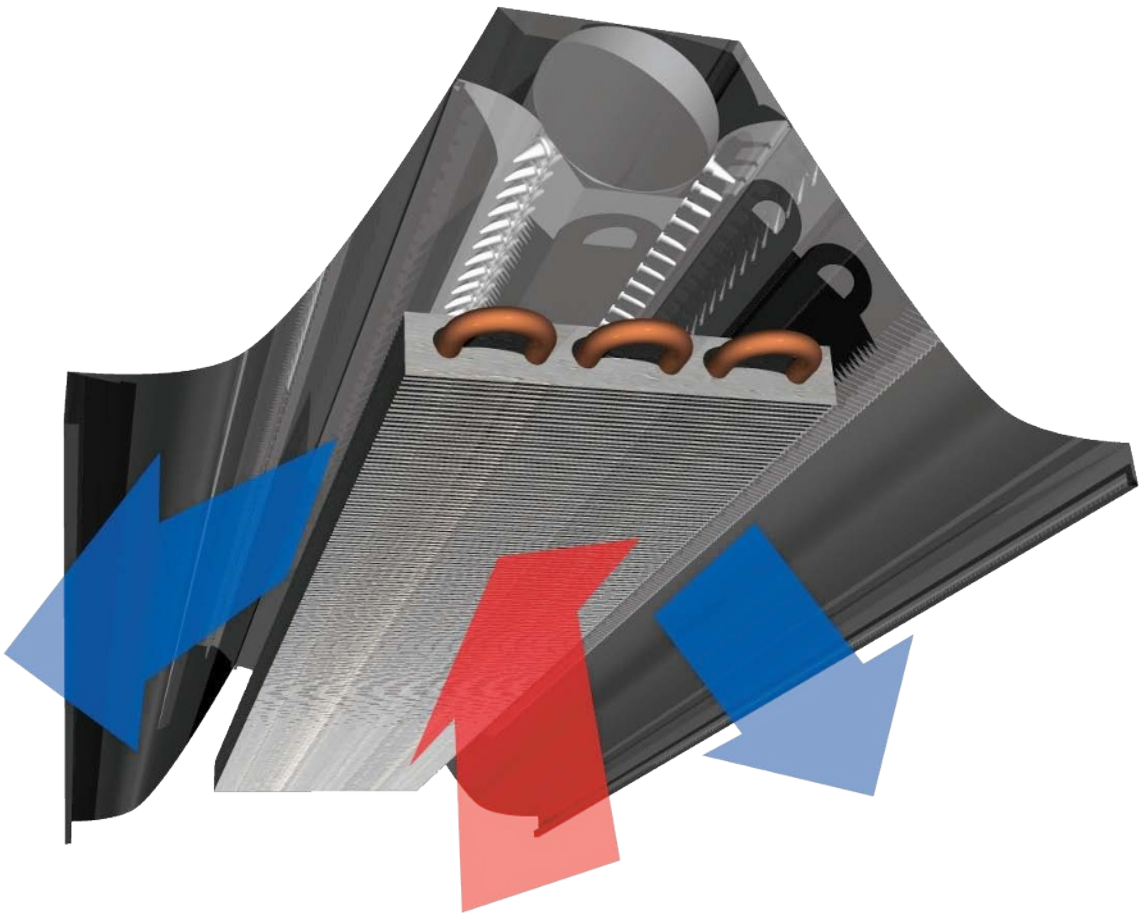
At the completion of a review of the final balance and pressure data, it was decided that no further action was going to be taken. The owner had no intention of spending any further money to add any additional outside air units to achieve a positive pressure relationship. No specific tests were requested to determine if the heating systems could function properly once the test and balance was complete, and there have been no complaints or service requests since. The owner indicated they were satisfied with the outcome.

In summation, had the outside air units that were part of the original design been installed and a proper TAB been performed, the problem of over-exhausting the building, manifesting in heating issues, may have never come to pass. Value engineering has become such an integral part of the construction mindset in today's marketplace, however, in this case, removing the outside air units to save money on the front end manifested in a large problem that cost a significant amount of money and aggravation to address and correct.

Testing Primary Airflow *for Active Chilled Beams*

Ross Gerdon, TBE and Chris Burnette, TBE
The Phoenix Agency of North Carolina, Inc.

This article reviews a manufacturer's method for testing chilled beams and subsequent testing done to verify the accuracy of that test method.

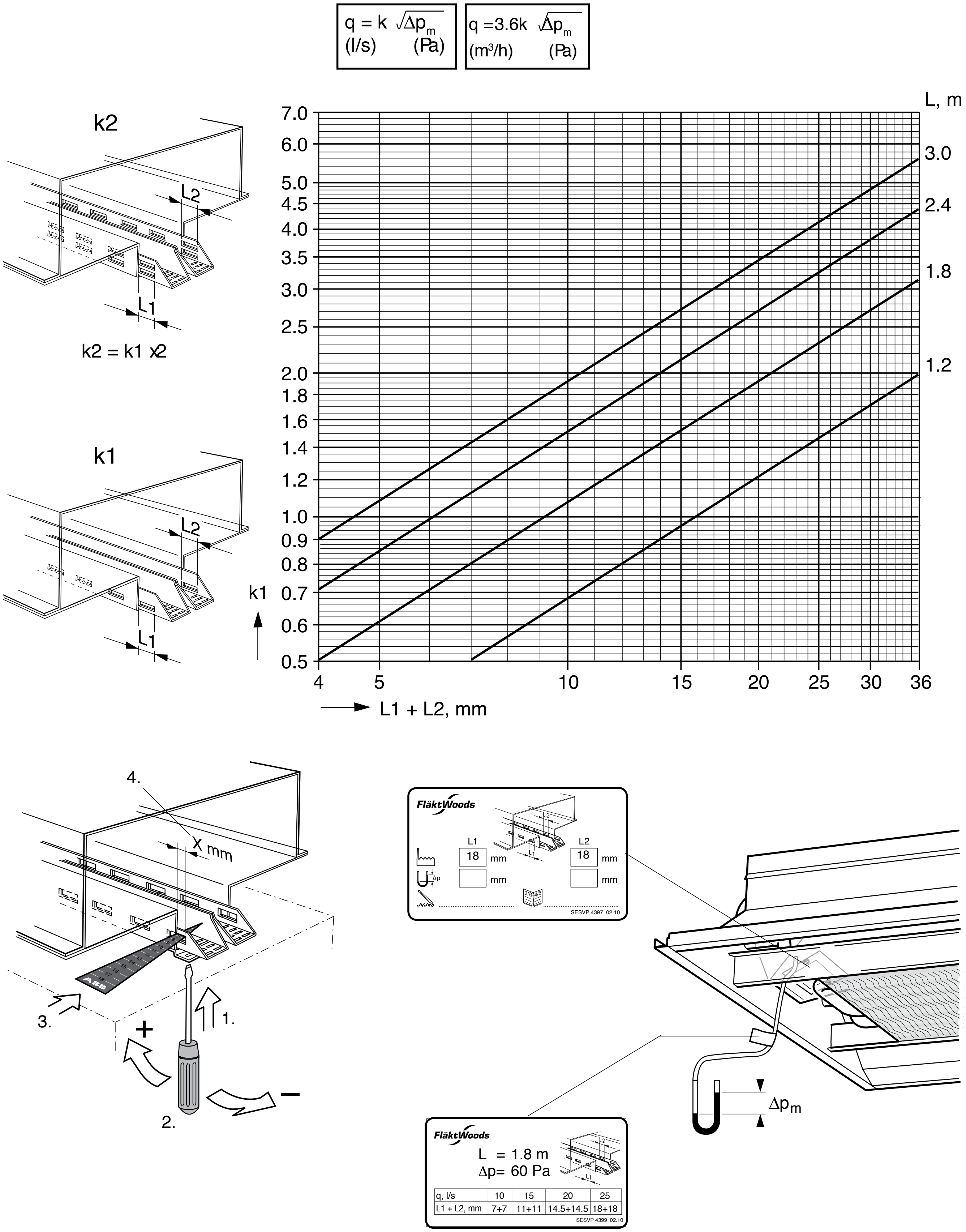


The manufacturer's procedure for balancing the beams was not particularly detailed or specific. These particular beams had two rows of single adjustable slots that controlled the size of the openings for the nozzle velocity and accordingly the induction air.

The manufacturer provided a chart to calculate the flow rate of the primary air. In the case of this manufacturer, the following needed to be done to determine the flow rate with the chart.

- Adjust the slot opening (nozzle size) to the setting specified in the submittal. This setting, along with the plenum pressure above the nozzles, is what determines the nozzle velocity and the amount of room air that is induced through the chilled beam's coil. Do not use the nozzle settings to adjust the primary CFM. Primary CFM is set by increasing or decreasing the plenum pressure above the nozzles using a balancing damper in the primary air duct.
- Measure the static pressure in the chilled beam plenum at the manufacturer's test port.
- Based on the slot opening and the plenum pressure, use the chart to determine the primary CFM flow. The chart

Figure 1 *Commissioning*



has curves for four sizes of chilled beams. These beams were 8 ft. (2.4 meters). The slot setting, “L,” was 18mm for each slot row. For the two slots, the total setting was L1 + L2 = 18 + 18 = 36. The chart gives the k factor for the various size beams at the various slot settings. The 8 ft beam with an L1 and L2 setting of 36 has a k factor of 4.22. Based on the manufacturers flow formula:

$$CFM = 2.12\ k\ \sqrt{\Delta\ PA}$$

The formula was simplified to:

$$CFM = 33.45\ k\ \sqrt{in.\ wc.}$$

In this case, with a measured plenum pressure of 0.85” wc:

$$CFM = 33.45 \times 4.22\ \sqrt{.85} = 130.1\ CFM$$

The primary airflow is adjusted, if necessary, via the inlet balancing damper.

These chilled beams were part of a system that had several chilled beams served by constant volume boxes *See Figure 1*. Extensive testing was conducted on these beams after the project engineers called into question the accuracy of the readings because the system required high static pressures to achieve the design primary CFM at the chilled beams. To obtain design primary CFM at the beams, over 1” of static was needed at the beam inlet, 2” of static at the CV box inlet, and 5” of static at the main supply duct near the AHUs.

The engineers suspected that the traverse readings and the flow readings calculated from the manufacturer’s flow charts were not correct. It was suggested to use a flowhood to measure the beam flow. The TAB contractor they used on their last job used the flowhood and they did not have any of the problems that were found. In theory, this should work because the induced air should recirculate within the flowhood and only the primary air should exit from the bottom of the hood. The 8 foot chilled beams were measured twice with one hood with a 1’ x 4’ top. They were also measured simultaneously with two hoods; non-back pressure compensated, and back pressure compensated. The flow hood always read a CFM higher than the traverse.

So now the question is “Which method is more accurate?”

Answer: “The pitot tube traverse.” The ducts to the individual beams were traversed as well as the duct serving the constant volume box. The CFM measured entering the CV box equaled the total of the branch duct CFMs for the chilled beams. It also was very close to the total CFM calculated using the manufacturer’s flow chart. Many tests were made and all supported the accuracy of the pitot tube traverses.

Keep the flowhood in the case for balancing chilled beams. Check the manufacturer’s flow charts for accuracy with duct traverses. Use the flow charts if you are satisfied they are accurate, but spot check with traverses now and then just to double check, or if something doesn’t add up.

Figure 2 *Manufacturer's Chart*

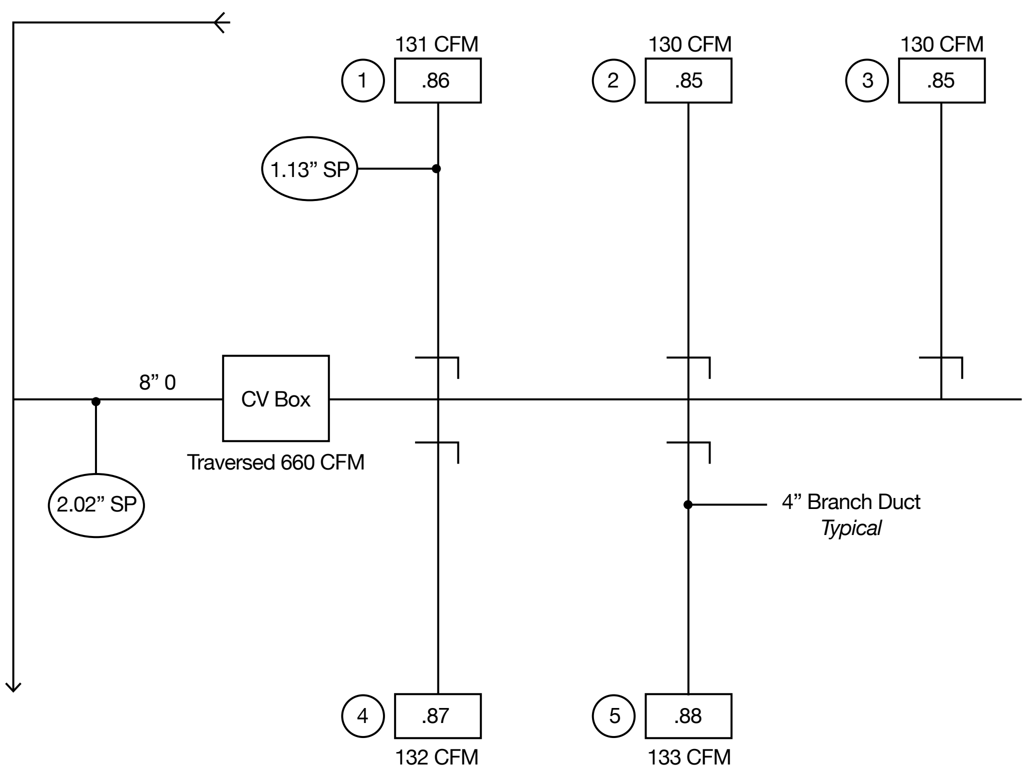


Figure 3 *Case Study*

1. CV Box

Duct Traverse

DUCT LOCATION:	CV Box Entering the Box				
DESIGN CFM:	650	DESIGN DUCT SIZE:	N/A	FPM:	-
ACTUAL DUCT SIZE:	8"Ø	DUCT AREA:	.35	DUCT SP:	+2.02"

POINT	1	2	3	4	5	6	7	8	9	10
A	1866	1805								
B	1918	1962								
C	1949	1967								
D	1962	1918								
E	1815	1855								
F	1791	1835								
AVERAGE VELOCITY		1887	X DUCT AREA		.35	= CFM		660		

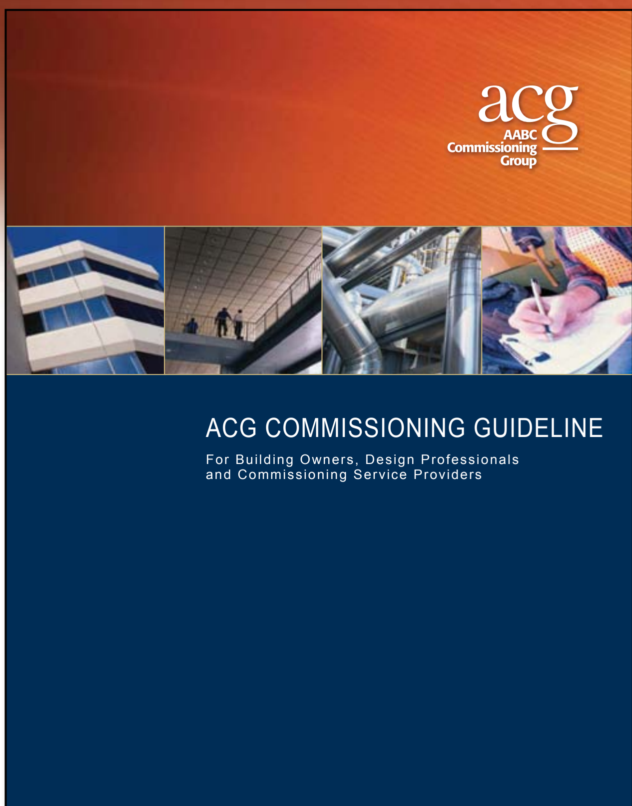
Computer CFM: 671; Box 100% open.

ACB – Air Distribution

AREA SERVED	OPENING		REQUIRED		PRELIMINARY				FINAL	
	NO.	SIZE	SP	CFM	SP	CFM	SP	CFM	SP	CFM
CV Box										
Chilled Beam	1	8'ACB	.85	130	.95	137	.865	131	.86	131
Chilled Beam	2	8'ACB	.85	130	.56	105	.85	130	.86	130
Chilled Beam	3	8'ACB	.85	130	1.20	154	.85	130	.85	130
Chilled Beam	4	8'ACB	.85	130	.79	125	.87	131	.87	132
Chilled Beam	5	8'ACB	.85	130	.80	126	.88	132	.88	133
Total				650						656

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

ACG COMMISSIONING GUIDELINE



THE ACG COMMISSIONING GUIDELINE provides a standardized methodology for everyone involved with the commissioning process to follow.

The Commissioning Guideline includes:

- Detailed, step-by-step methodologies for the various types of commissioning
- Roles and responsibilities of each commissioning team member
- The scope of services performed in commissioning
- The benefits of commissioning
- Sample forms, specifications and RFPs for commissioning services

The ACG Commissioning Guideline is designed to help fill the industry need for a single, standardized methodology for everyone involved with the commissioning process.

Order your copy of the ACG Commissioning Guideline today!

Name ______________________

Company ______________________

Shipping Address ______________________

City ____________ State ____________ Zip ____________

Phone ____________ Fax ____________

Email ______________________

Non-Member Cost: $50.00

ACG Commissioning Guideline @ $50 each x _______= $__________

Payment Information

Payment Type (Check one)

❑ Check Enclosed ❑ MasterCard ❑ Visa ❑ American Express

Card Number ____________ Expiration Date ____________

Name on Card ______________________

Signature ______________________

Please complete order form and return along with payment to:

acg AABC Commissioning Group

ACG
1518 K Street, NW Suite 503 • Washington, DC 20005
Phone: 202.737.7775 • Credit card purchasers may fax orders to (202) 638-4833 or order online at www.commissioning.org

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).**

Test & Balance and Gypsum Ceilings

Q

QUESTION: ***We are currently installing a ducted air conditioning system in a building with a gypsum ceiling.***

My concern is at the end of the project when the ceiling is up and the TAB exercise is in progress, how do we access the dampers to balance the system?

The architect is definitely not allowing access doors under each damper. Do we send a man in the ceiling with 2 way communication with a man on the ground? Do we need platforms within the ceiling space to allow for this exercise and rebalancing the system later on?

Please advise how the TAB exercise is normally executed with a gypsum or other solid ceiling.

A

AABC: There are several possibilities:

1. If the AHU serving the area can be operational prior to the ceiling installation, the area can be proportioned.
2. If the AHU cannot be operated prior to the ceiling installation, the regulators can be installed that have 5" discs with a cable to adjust the various dampers.
3. The last option is to obtain access to the ductwork above the ceiling with a catwalk.

— *Gaylon Richardson, TBE, Engineered Air Balance Co., Inc.*

A

AABC: I agree that the best option is to get the unit running prior to ceiling install and proportionately balance the open outlet connections. It is best to screw damper handles in place afterwards so they don't get moved.

I am not a fan of remote operated dampers, as I have had issues with cables breaking or other trades accidentally damaging them while their doing work above ceiling.

Another option is to provide dampers at the terminals and balance with them. This may create some noise, but outside of the above alternatives provides the only other means to balance the airflows.

— *Joe Baumgartner, TBE, Baumgartner, Inc.*

ALABAMA

Performance Testing & Balancing
Cleveland, Alabama
(205) 274-4889

Southeast T&B Inc.
Cleveland, Alabama
(205) 559-7151

Superior Tabs International, Inc.
Pelham, Alabama
(205) 620-2801

Systems Analysis, Inc.
Birmingham, Alabama
(205) 802-7850

ARIZONA

Arizona Air Balance Company
Tempe, Arizona
(480) 966-2001

ETB Arizona
Phoenix, Arizona
(602) 861-1827

General Air Control, Inc.
Tucson, Arizona
(520) 887-8850

Precisionaire of Arizona, Inc.
Phoenix, Arizona
(623) 580-1644

Systems Commissioning & Testing, Inc.
Tucson, Arizona
(520) 884-4792

Tab Technology, Inc.
Mesa, Arizona
(480) 964-0187

Technical Air Balance SW, Inc.
Scottsdale, Arizona
(623) 492-0831

CALIFORNIA

Air Balance Company, Inc.
Diamond Bar, California
(909) 861-5434

American Air Balance Co., Inc.
Anaheim, California
(714) 693-3700

Danis Test and Balance, Inc.
Yucaipa, California
(909) 797-4049

Los Angeles Air Balance Company, Inc.
Upland, California
(800) 429-6880

Matrix Air Balance, Inc.
Torrance, California
(310) 320-9020

MESA3, Inc.
San Jose, California
(408) 928-3000

MESA3, Inc.
Roseville, California
(916) 803-0268

National Air Balance Co., Inc.
Fremont, California
(510) 623-7000

Penn Air Control, Inc.
Cypress, California
(714) 220-9091

Penn Air Control, Inc.
Fallbrook, California
(760) 451-2025

Penn Air Control, Inc.
San Jose, California
(800) 370-5902

RSAnalysis, Inc.
El Dorado Hills, California
(916) 358-5672

RSAnalysis, Inc.
So. San Francisco, California
(650) 583-9400

San Diego Air Balance, Co., Inc.
Escondido, California
(760) 741-5401

Winaire, Inc.
Huntington Beach, California
(714) 901-2747

COLORADO

Proficient Balancing Company, LLC
Arvada, Colorado
(303) 870-0249

CONNECTICUT

CFM Test & Balance Corporation
Bethel, Connecticut
(203) 778-1900

James E. Brennan Company, Inc.
Wallingford, Connecticut
(203) 269-1454

FLORIDA

Air Balance Unlimited, Inc.
Sorrento, Florida
(407) 383-8259

Air Test Co.
Boca Raton, Florida
(561) 488-6065

Bay to Bay Balancing, Inc.
Lutz, Florida
(813) 971-4545

Bay to Bay Balancing, Inc.
Orlando, Florida
(407) 704-8768

Gregor Hartenhoff, Inc.
Pompano Beach, Florida
(954) 786-3420

Perfect Balance Inc.
Jupiter, Florida
(561) 575-4919

Precision Balance, Inc.
Orlando, Florida
(407) 876-4112

Southern Balance, Inc.
Milton, Florida
(850) 623-9229

Southern Independent Testing Agency, Inc.
Lutz, Florida
(813) 949-1999

Tamiami Air Balancing & Commissioning
Sarasota, Florida
(941) 342-0239

Test and Balance Corporation
Lutz, Florida
(813) 909-8809

The Phoenix Agency, Inc.
Lutz, Florida
(813) 908-7701

Thermocline Corp.
Merritt Island, Florida
(321) 453-3499

GEORGIA

Augusta Air Balance Company, LLC
Martinez, Georgia
(706) 799-2254

Southern Balance Company
Marietta, Georgia
(770) 850-1027

TAB Services, Inc.
Norcross, Georgia
(404) 329-1001

Test and Balance Corporation
Roswell, Georgia
(678) 393-9401

GUAM

Penn Air Control, Inc.
Tamuning, Guam
(671) 477-0325

HAWAII

Test and Balance Corp.
Honolulu, Hawaii
(808) 593-1924

ILLINOIS

United Test & Balance
Glen Ellyn, Illinois
(630) 790-4940

INDIANA

Fluid Dynamics, Inc.
Fort Wayne, Indiana
(260) 490-8011

IOWA

Systems Management & Balancing, Inc.
Waukee, Iowa
(515) 987-2825

KENTUCKY

Thermal Balance, Inc.
Ashland, Kentucky
(606) 325-4832

Thermal Balance, Inc.
Bowling Green, Kentucky
(270) 783-0002

Thermal Balance, Inc.
Nicholasville, Kentucky
(859) 277-6158

Thermal Balance, Inc.
Paducah, Kentucky
(270) 744-9723

LOUISIANA

Coastal Air Balance Corp.
Jefferson, Louisiana
(504) 834-4537

Tech-Test Inc. of Louisiana
Baton Rouge, Louisiana
(225) 752-1664

MARYLAND

American Testing Inc.
Ellicott City, Maryland
(410) 461-6211

Baltimore Air Balance Co.
Bowie, Maryland
(301) 262-2705

Baumgartner, Inc.
Hunt Valley, Maryland
(410) 785-1720

Baumgartner, Inc.
Easton, Maryland
(410) 770-9277

Chesapeake Testing & Balancing Engineers, Inc.
Easton, Maryland
(410) 820-9791

Environmental Balancing Corporation
Clinton, Maryland
(301) 868-6334

Protab Inc.
Hampstead, Maryland
(410) 935-8249

Test & Balancing, Inc.
Laurel, Maryland
(301) 953-0120

Weisman, Inc.
Towson, Maryland
(410) 296-9070

MASSACHUSETTS

Thomas-Young Associates, Inc.
Marion, Massachusetts
(508) 748-0204

MICHIGAN

Aerodynamics Inspecting Co.
Dearborn, Michigan
(313) 584-7450

Airflow Testing, Inc.
Lincoln Park, Michigan
(313) 382-8378

MINNESOTA

Air Systems Engineering, Inc.
Minnetonka, Minnesota
(952) 807-6744

Mechanical Data Corporation
Bloomington, Minnesota
(952) 473-1176

Mechanical Test and Balance Corporation
Maple Plain, Minnesota
(763) 479-6300

SMB of Minnesota
Blaine, Minnesota
(651) 257-7380

MISSISSIPPI

Capital Air Balance, Inc.
Terry, Mississippi
(601) 878-6701

Coastal Air Balance Corp.
Terry, Mississippi
(228) 392-8768

MISSOURI

Envirosystem Analysis, Inc.
St. Charles, Missouri
(636) 661-5252

Miller Certified Air, Inc.
St. Louis, Missouri
(314) 352-8981

Precisionaire of the Midwest, Inc.
Grain Valley, Missouri
(816) 847-1380

Senco Services Corporation
St. Louis, Missouri
(314) 432-5100

Testing & Balance Co. of the Ozarks, LLC (TABCO)
Ozark, Missouri
(417) 443-4430

NEVADA

American Air Balance Co., Inc.
Las Vegas, Nevada
(702) 255-7331

Mechanical Test and Balance Corporation
Las Vegas, Nevada
(702) 737-3030

National Air Balance Company, Inc.
Las Vegas, Nevada
(702) 871-2600

Penn Air Control, Inc.
Las Vegas, Nevada
(702) 221-9877

Raglen System Balance, Inc.
Reno, Nevada
(775) 747-0100

RSAnalysis, Inc.
Las Vegas, Nevada
(702) 740-5537

RSAnalysis, Inc.
Reno, Nevada
(775) 323-8866

NEW JERSEY

Effective Air Balance, Inc.
Totowa, New Jersey
(973) 790-6748

National Air Balance Company LLC
Paramus, New Jersey
(201) 444-8777

NEW YORK

Air Conditioning Test & Balance Co.
Great Neck, New York
(516) 487-6724

Mechanical Testing, Inc.
Waterford, New York
(518) 328-0440

Precision Testing & Balancing, Inc.
Brooklyn, New York
(718) 994-2300

NORTH CAROLINA

Building Environmental Systems Testing, Inc. (BEST, Inc.)
Wilson, North Carolina
(252) 291-5100

e-nTech Independent Testing Services, Inc.
Winston-Salem, North Carolina
(336) 896-0090

Palmetto Air and Water Balance, Inc.
Asheville, North Carolina
(336) 275-6675

Palmetto Air and Water Balance, Inc.
Charlotte, North Carolina
(704) 587-7073

Palmetto Air and Water Balance, Inc.
Greensboro, North Carolina
(336) 275-6678

Palmetto Air and Water Balance, Inc.
Raleigh, North Carolina
(919) 460-7730

The Phoenix Agency of North Carolina, Inc.
Winston-Salem, North Carolina
(336) 744-1998

NORTH DAKOTA

Design Control, Inc.
Fargo, ND
(701) 237-3037

OHIO

Air Balance Unlimited, Inc.
Gahanna, Ohio
(614) 595-9619

Heat Transfarr, Inc.
Columbus, Ohio
(614) 262-6093

Kahoe Air Balance Company
Cleveland, Ohio
(440) 946-4300

Kahoe Air Balance Company
Cincinatti/Dayton, Ohio
(513) 248-4141

Kahoe Air Balance Company
Columbus, Ohio
(740) 548-7411

PBC, Inc. (Professional Balance Co.)
Willoughby, Ohio
(440) 975-9494

Precision Air Balance Company, Inc.
Cleveland, Ohio
(216) 362-7727

R.H. Cochran and Associates, Inc.
Wickliffe, Ohio
(440) 585-5940

OKLAHOMA

Eagle Test & Balance Company
Cushing, Oklahoma
(918) 225-1668

OREGON

Pacific Coast Air Balancing
Newberg, Oregon
(503) 537-0826

PENNSYLVANIA

Butler Balancing Company, Inc.
Thorndale, Pennsylvania
(610) 873-6905

Flood and Sterling Inc.
New Cumberland, Pennsylvania
(717) 232-0529

Kahoe Air Balance Company
Pittsburgh, Pennsylvania
(724) 941-3335

WAE Balancing, Inc.
Mercer, Pennsylvania
(724) 662-5743

PUERTO RICO

Penn Air Control, Inc.
Naguabo, Puerto Rico
(787) 504-8118

SOUTH CAROLINA

Palmetto Air and Water Balance, Inc.
Greenville, South Carolina
(864) 877-6832

TENNESSEE

Environmental Test & Balance Company
Memphis, Tennessee
(901) 373-9946

Systems Analysis, Inc.
Hermitage, Tennessee
(615) 883-9199

United Testing & Balancing, Inc.
Nashville, Tennessee
(615) 331-1294

United Testing & Balancing, Inc.
Knoxville, Tennessee
(865) 922-5754

TEXAS

Aerodynamics Inspecting Co.
Weslaco, Texas
(956) 351-5285

Air Balancing Company, LTD
Fort Worth, Texas
(817) 572-6994

AIR Engineering and Testing, Inc.
Dallas, Texas
(972) 386-0144

Austin Air Balancing Corporation
Austin, Texas
(512) 477-7247

Delta-T, Ltd.
Garland, Texas
(972) 494-2300

Engineered Air Balance Co., Inc.
Richardson, Texas
(972) 818-9000

Engineered Air Balance Co., Inc.
San Antonio, Texas
(210) 736-9494

Engineered Air Balance Co., Inc.
Spring, Texas
(281) 873-7084

Online Air Balancing Company
Houston, Texas
(713) 453-5497

PHI Service Agency, Inc.
San Antonio, Texas
(210) 224-1665

PHI Service Agency, Inc.
Austin, Texas
(512) 339-4757

PHI Service Agency, Inc.
Alamo, Texas
(956) 781-9998

PHI Service Agency, Inc.
Corpus Christi, Texas
(361) 248-4861

Professional Balancing Services, Inc.
Dallas, Texas
(214) 349-4644

TAB Solutions, Inc.
Lakeway, Texas
(720) 220-1062

Technical Air Balance, Texas
Spring, Texas
(281) 651-1844

Texas Precisionaire Inc.
Houston, Texas
(281) 449-0961

Texas Test & Balance
Houston, Texas
(281) 358-2118

UTAH

RSAnalysis, Inc.
Sandy, Utah
(801) 255-5015

VIRGINIA

Arian Tab Services
Herndon, Virginia
(703) 319-1000

C&W-TESCO, Inc.
Richmond, Virginia
(804) 379-9345

Mid-Atlantic Test & Balance, Inc.
South Boston, Virginia
(434) 572-4025

WASHINGTON

Eagle Test & Balance
Bellevue, Washington
(425) 747-9256

TAC Services, LLC
Bellingham, Washington
(360) 224-8555

WISCONSIN

Professional System Analysis, Inc.
Germantown, Wisconsin
(262) 253-4146

AABC CANADIAN CHAPTER

MANITOBA

A.H.S. Testing & Balancing Ltd.
Winnipeg, Manitoba
(204) 224-1416

Air Movement Services Ltd.
Winnipeg, Manitoba
(204) 233-7456

AIRDRONICS, Inc.
Winnipeg, Manitoba
(204) 253-6647

D.F.C. Mechanical Testing & Balancing Ltd.
Winnipeg, Manitoba
(204) 694-4901

NEW BRUNSWICK

Controlled Air Management Ltd.
Moncton, New Brunswick
(506) 852-3529

Scan Air Balance 1998 Ltd.
Moncton, New Brunswick
(506) 857-9100

Source Management Limited
Fredericton, New Brunswick
(506) 443-9803

NOVA SCOTIA

Griffin Air Balance Ltd.
Dartmouth, Nova Scotia
(902) 434-1084

Scotia Air Balance 1996 Limited
Antigonish Co., Nova Scotia
(902) 232-2491

ONTARIO

Accu-Air Balance Co. (1991) Inc.
Windsor, Ontario
(519) 256-4543

Airwaso Canada Inc.
London, Ontario
(519) 652-4012

Caltab Air Balance Inc.
Tecumseh, Ontario
(519) 259-1581

Designtest & Balance Co. Ltd.
Richmond Hill, Ontario
(905) 886-6513

Dynamic Flow Balancing Ltd.
Oakville, Ontario
(905) 338-0808

Kanata Air Balancing & Engineering Services
Ottawa, Ontario
(613) 592-4991

Pro-Air Testing Inc.
Toronto, Ontario
(416) 252-3232

Vital-Canada Group Inc.
Mississauga, Ontario
(905) 848-1000

VPG Associates Limited
King City, Ontario
(905) 833-4334

AABC INTERNATIONAL MEMBERS

SOUTH KOREA

Energy 2000 Technical Engineering Co., Ltd.
Songpa-gu, Seoul
SOUTH KOREA
82-2-408-2114

Penn Air Control, Inc.
Gangbuk-gu, Seoul
SOUTH KOREA
82-2-982-0431

ITALY

Studio S.C.S. Ingegneri Scarbaci-Cuomo
Pordenone, ITALY
+39 0434-29661

Real-Time Solutions for HVAC Professionals

The full line of TSI and Alnor industrial ventilation test instruments are designed to accurately and reliably measure a wide variety of parameters important in monitoring and maintaining indoor environments.

Feature-Rich, VelociCalc® 9565 Multi-Function Ventilation Meters

- Accommodates a variety of plug-in probes
- Displays up to five measurements simultaneously
- On-screen messages and instructions
- Multiple data logging formats
- Bluetooth communications for transferring data or remote polling

Industry-Leading Alnor® EBT721 Capture Hood

- Ergonomic design and ultra light weight for easy one person operation
- Detachable digital manometer for use in other applications
- Use with pitot, air flow, temperature, or relative humidity probes
- Data logging for easy report generation

Highly Accurate PAN200 Series Duct Leakage Testers

- Positive and Negative Duct Leakage Testing in one system
- Generates a Pass/Fail result based on SMACNA's duct leakage test manual
- High accuracy gives confidence in measurements
- Pressurizes duct quickly, allowing testing to begin in minutes
- Includes TSI VelociCalc® Model 9565-P and DP-Calc™ 5825

TSI Incorporated
Tel: 1 800 874 2811 **Web:** www.tsi.com/vti