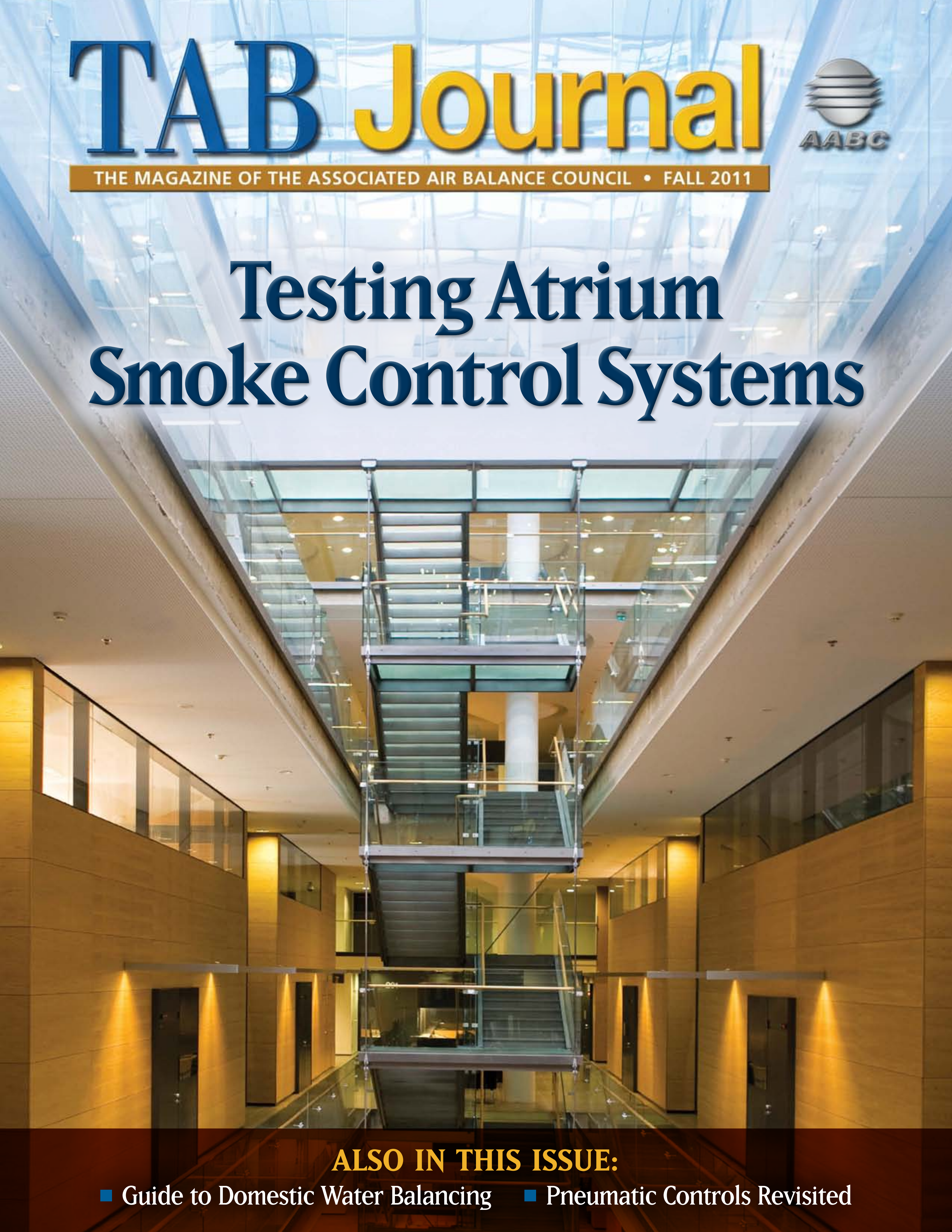
TAB Journal

THE MAGAZINE OF THE ASSOCIATED AIR BALANCE COUNCIL • FALL 2011

Testing Atrium Smoke Control Systems

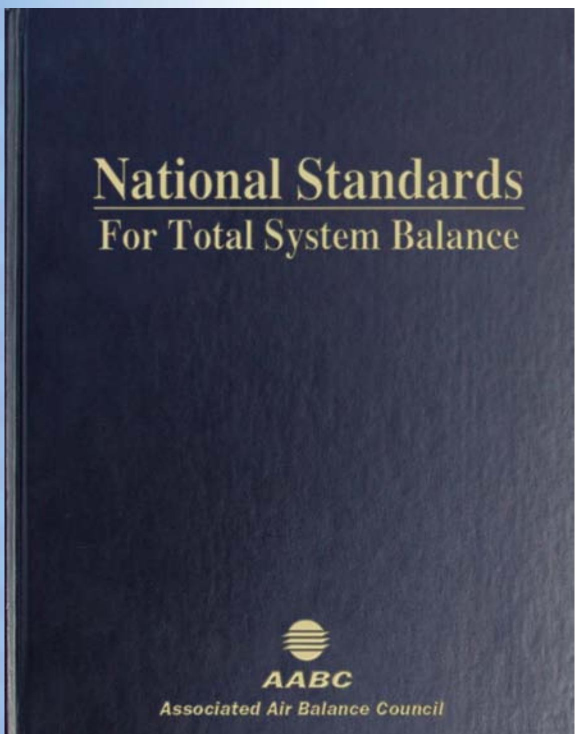


ALSO IN THIS ISSUE:

- Guide to Domestic Water Balancing
- Pneumatic Controls Revisited

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

Associated Air Balance Council

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.

From the Publisher

The Fall 2011 issue of *TAB Journal* touches on many aspects of test and balance, from testing smoke control and domestic water systems, to staying acquainted with older pneumatic controls, and troubleshooting rooftop units and kitchen hoods.

"Atrium Smoke Control Systems" by Justin Garner, P.E., TBE, of Engineered Air Balance Co., Inc., discusses the use of unique testing strategies and coordination between construction disciplines to accurately test smoke control systems.

David Harrell, TBE, also of Engineered Air Balance Co., Inc., wrote "Domestic Water Balance Preparation & Procedures" to provide insight on developing and following a detailed action plan for testing these systems that are increasingly part of the test and balance scope.

In "Pneumatic Controls: A Blast from the Past," David Kitts, TBE, of Baltimore Air Balance Co., talks about how changes in the economy have affected the decisions building owners are making, in particular the decision to refurbish existing controls rather than replacing them to cut costs.

Robert J. Wade, TBE, of CFM Test & Balance Corporation, examines what may cause rooftop HVAC unit issues and why replacing sheaves may not work in "Troubleshooting: Expect the Unexpected."

"Cross Drafts and Kitchen Hoods" by Jeff Wicka, TBE, of San Diego Air Balance Co., discusses the proper placement of air distribution to avoid unwanted cross drafts that can prevent a hood from capturing smoke and heat.

A question regarding static/dynamic flushing and strainers is addressed in this issue's *Tech Talk*, and a *TAB Journal* reader offers additional information on 2- and 3-way automatic control valves.

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!

ECO BOX

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

PRINTED WITH SOY INK™ SUSTAINABLE FORESTRY INITIATIVE Certified Sourcing www.sfiprogram.org SFI 00284

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.

"The design team and general contractor must ensure that architectural components do not interfere with proper operation of the system."

Testing Atrium Smoke Control Systems

Justin Garner, P.E., TBE, Engineered Air Balance Co., Inc.

On a recent hospital project, the test and balance agency was tasked with testing the functionality and performance of two large atrium smoke control systems. Smoke control systems often require unique testing strategies and involve a larger than usual coordination effort between construction disciplines.

These particular systems required coordination with the architect, design mechanical and electrical engineer, life safety consulting engineer, general contractor, mechanical contractor, electrical contractor, controls contractor, and the fire alarm contractor. Further, each piece of the system from each discipline required individual testing prior to the integrated test of the system. This article is a brief description of the total process involved in proving to the Authority Having Jurisdiction (AHJ) that the atrium smoke control systems were operational for the purpose of occupying the building.

Construction and Design Phases

During the design phase of the project, the architect hired a life safety consultant to perform smoke plume analysis and initial airflow calculations utilizing the methodology in *NFPA 92B, Standard for Smoke Management Systems in Malls, Atria, and Large Spaces*. The mechanical engineer then used the design airflows from the life safety consultant's calculations to design the fan systems for each atrium to provide the correct airflow.

The mechanical engineer also provided the required makeup air opening sizes to the architect and scheduled the appropriate DDC control sequences for the systems. The electrical engineer was tasked with including the smoke control fan systems, DDC controls, and fire alarm controls in the emergency power system, and incorporating the correct components into the fire alarm system schematics and specifications.

The architect was tasked to design the smoke barrier enclosure to the required fire and smoke ratings, as well as determining the doors, window panels and hardware required for operation of the system. This design of the smoke control system was included in the construction project documents.

During the construction phase of the project, all components of the system were installed as indicated on the construction drawings. During the initial TAB inspection of the system, it was noted that a sheetrock furr down (also known as a bulkhead) was installed, obscuring about one-third of the inlet duct for the larger smoke control fan.

Further, no access doors were provided for inspecting the fan equipment or dampers. The general contractor and mechanical contractor were consulted and they agreed to add access doors, but no action was taken on the obstructed ductwork.

The makeup air for the systems was to be provided by sliding electric entry doors and motorized panels at each exterior entrance to the main atrium smoke zone. The smaller atrium had motorized panel windows only.

After inspection, it was noted that the controls contractor did not have any provisions to command the doors and windows. The general contractor was consulted as well as the fire alarm contractor, and both the fire alarm and controls contractors thought the other trade was to control the doors and fans. Therefore, no controls had been installed by any contractor on the systems.

"Results of the calculations, when compared to the design airflows for each fan system, indicated that there were not enough makeup air openings for the larger atrium system."

A meeting was held with the design team, the owner, and the contractors involved to clarify the system operation. The life safety consultant indicated the design intent as listed in the code and the design basis of their model. The architect also commented on their part regarding the windows and doors. The mechanical engineer clarified that the DDC controls should operate the entire system, with an input from the fire alarm system and a status back to the fire alarm system. This was confirmed through the RFI process and the controls work proceeded.

Pre-TAB Review

A pre-TAB review of the systems was performed. During this review, the smoke control zones were identified using the architectural drawings, and the door and window openings for the makeup air paths were measured. The result of these calculations when compared to the design airflows for each fan system indicated that there were not enough makeup air openings for the larger atrium system.

The code specifies that the air velocity at the point of contact with the smoke plume cannot exceed 200 feet per minute. This issue was discussed with the design team and it was determined that one set of exterior doors was considered in the original calculation, but not scheduled for automatic opening hardware. The design team asked for a system performance test with the doors open and closed to determine if the code criteria could be met.

Testing Phase

The initial test of the system was scheduled for late in the evening. Since the controls were not installed, the entire system was manually commanded. The fans were operated at design speed and Pitot tube traverses were used to determine system airflows. All operating data was recorded.

The test of the larger system showed that the fan could not achieve design airflow due to the bulkhead obstruction. The general contractor promptly removed as much of the obstruction as possible and the system was retested. After the removal, the system could achieve design airflow.

During the second test, velocity profiles of each makeup air entrance were measured using rotating vane anemometers on grids laid out with tape. This testing determined that all exterior doors were required for makeup air to the larger atrium system. The design team and contractor determined and ordered the required hardware and the components for automatic opening.

Unfortunately, the door controls were a long lead time item and could not be procured within the time required for issuance of a temporary certificate of occupancy. Therefore, additional window panels on the interior vestibule of the large atrium were temporarily removed to create more makeup air openings. The smaller atrium system performed as scheduled with makeup velocities within the code limits.

The DDC and fire alarm system components were installed and tested individually. The DDC controls interface to the motorized doors and windows was problematic and required a great deal of troubleshooting from the general contractor and automatic access contractor. Once these issues were resolved, a final acceptance test was scheduled with the owner and design team to prove functionality a few days before the required temporary occupancy milestone.

A system airflow performance report was submitted to the design engineer for review prior to the acceptance test. It was also agreed that final velocity readings would be taken to prove the temporary makeup solution was acceptable.

To initiate the test with the building operating on normal power, the fire alarm contractor tripped a pull station in each atrium and the smoke control systems were activated. The automatic doors and window panels opened and the fan systems started and ramped to full airflow. Air velocities were measured at the main entrance doors to the large atrium, but the readings were affected by high winds and did not meet the code criteria. It was agreed to continue testing the functionality of the systems.

Next, normal power was de-energized to the building with the smoke control systems operating, and the emergency power system was activated. The smoke control system shutdown and restart on emergency power was timed and determined to be within acceptable limits.

The smoke systems were then deactivated manually at the fireman's smoke control override panel and verified for proper operation. After reactivation at the fireman's panel, the fire alarm system was reset under emergency power.

The design team requested that the smoke control systems be activated by a beam detector in each atrium. Using a rope connected to the atrium ceiling, each beam detector was tripped, initiating the respective smoke control system.

Finally, the building power was returned to normal. The shutdown and restarts of the systems were verified to be within acceptable limits. The only final hurdle for the system was proving the makeup velocities were acceptable.

After studying the weather forecast, the morning of the day for temporary occupancy was determined for a retest of the velocities. The wind was very calm, and the large atrium system was initiated and tested. The door velocities with the temporary panels removed were found to be within the code requirements.

The design engineer was able to write a letter to the AHJ certifying that the systems were operational and the facility was granted a temporary certificate of occupancy on schedule. The final verification of the system came weeks later when the door hardware for the final makeup door was installed and tested satisfactorily.

Lessons Learned:

- The design team members must coordinate and be very careful to include the appropriate components and sequences in the design documents for a functional system.
- The controls and fire alarm contractors must coordinate to provide integration between systems to meet the appropriate control requirements.
- The design team and general contractor must ensure that architectural components do not interfere with proper operation of the system.
- Finally, the TAB firm must be able to suggest and facilitate an appropriate test to verify system performance and sequencing through all operating modes of the system.

Figure 1: TAB verification of air velocities at a corridor entrance to the atrium.

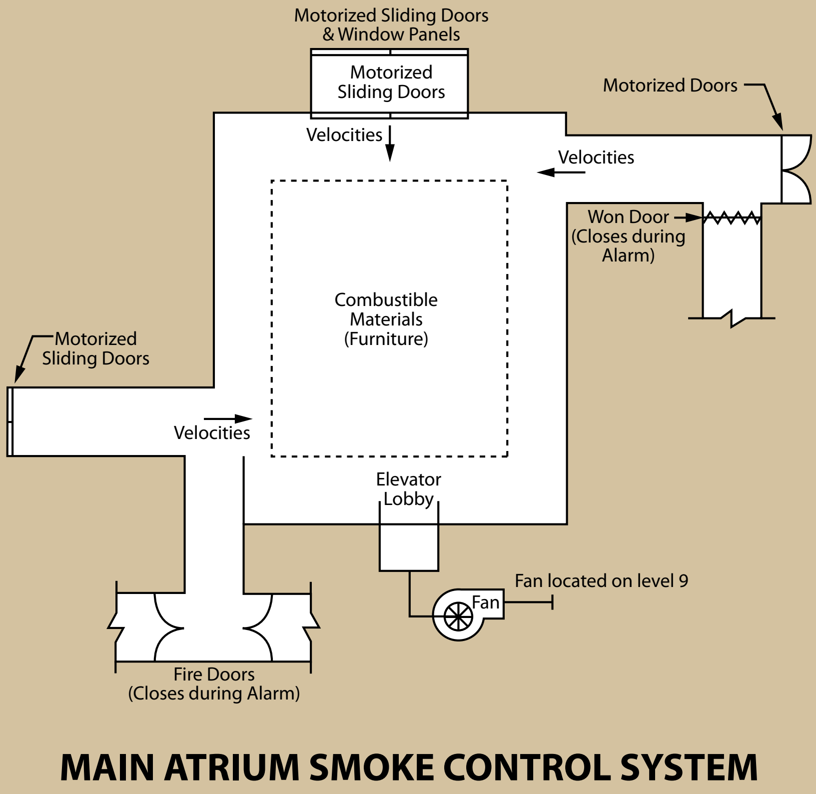


Figure 2: Drawing of Atrium.

Domestic Water Balance
Preparation & Procedures

David Harrell, TBE, Engineered Air Balance Co., Inc.

This article covers the preparation and procedures for balancing domestic water systems, a service that is increasingly requested of test and balance agencies.

Preparation prior to balancing procedures may include reviewing the project documents and setting up data sheets. Procedures will include conducting on-site inspections, gathering data during TAB procedures, and final field observations.

The typical domestic water system may include one or more of the following:

- Hot water heaters
- Hot water return circulation pump
- Thermal mixing valves
- Pressure reducing valves
- Return balancing stations

Review of Documents

The domestic water systems, specifically the hot water system, will be located in the plumbing section of the contract plans. The plumbing plans may include a plan view of the domestic piping layout as well as a riser schematic. Each plan should indicate the locations of all devices in the noted systems.

The specifications for the domestic water system may include hot water supply temperature set points and specific time frames for sensing hot water at each lavatory, lab sink, eye wash or emergency shower. The sections of the plumbing specifications that require review may include the following:

- Plumbing equipment
- Plumbing specialties
- Plumbing fixtures

In the plumbing equipment section, information regarding the hot water re-circulation pumps, booster skids, water storage generators and other components of the system may be found. In the plumbing specialties section, system devices such as pressure reducing valves (PRV), thermostatic mixing valves, balancing valves and water flow meters are generally described. Finally, the plumbing fixture specification section is where lavatory flow rate requirements are described.

Plan Review

The plumbing plans should be reviewed to determine the following:

- Are individual hot water return loops shown, and will they provide hot water for each desired location?
- Does each hot water return loop location have thermal mixing valves (TMV) or does one central TMV maintain the required hot water temperature to fixtures?
- Does each hot water return loop have balancing valves indicated on the plans?
- Does each balancing station have required flow rates indicated?
- Location and inclusion of pressure reducing valves if the building is multi-level.
- Location of the circulation pump and hot water heaters for the hot water return loop.
- Domestic cold water booster pumping station if applicable.

Submittal Review

The MEP submittal will include the balancing valves, pressure reducing valves, hot water generators, pumps and plumbing fixtures for the domestic system. Review of the submittal should include:

- The size/type of the balancing valve.
- The differential across the balancing valve at rated flow and is it within range of instrumentation. If not, suggestions should be made through appropriate channels.
- Lavatory flow rates and do they meet or match those in the specifications?
- Hot water heater temperature requirements and flow rates.
- Hot water circulation pump and associated pump curve.

Action Plan and Testing

Once a thorough review of the construction documents has been performed, the TAB technician can begin to assemble an action plan to test and balance the domestic water system.

The typical domestic water system begins at the booster pump skid, if applicable. If the building is designed with multiple levels or has a potential requirement for high usage of domestic water, i.e. a sports arena, then a domestic water booster skid will be part of the system.

The booster skid is designed to maintain a greater supply water pressure than the city water pressure can provide. The intent of the booster pumps is to provide domestic water to upper floor levels, or have the capacity to provide high volumes of water to meet demand. The design documents should include the set point for the domestic water booster pump, which will be set by the contractor with the assistance of the booster skid supplier.

Once this is complete, the domestic hot water heater start-up can be performed by the contractor. The typical hot water set point for the domestic hot water system in a commercial building is 140ºF. Commercial kitchens and restaurants typically will have a higher set point for sterilization purposes, but for this illustration, we will follow the commercial building application.

The hot water heater skid package should include all the components to maintain the required water temperature set point and internal water circulation. The circulation pumps located at the water heaters are for the operation of the heaters and are not the hot water return loop circulation pumps.

Once the heater start-up has been performed and a consistent supply hot water temperature is maintained, the inspection of the domestic thermal mixing valve(s), if applicable, can be performed.

"Thermal mixing valve temperature settings should be field verified once the hot water system is balanced."

Thermal Mixing and Pressure Reducing Valves

The thermal mixing valve (TMV), if applicable, can either be centrally located, or there may be individual mixing stations at different point-of-use locations. If the TMV is centrally located, it will be stationed near the hot water heaters. The function of the main TMV is to continually mix the hot water generated by the hot water heaters with the cold water makeup to provide a consistent temperature to all point-of-use stations.

This mixing temperature set point is variable, but the project documents generally will provide the required set point. The TMV will have a manual set point adjustment for "warmer/cooler," or the control will be electronic with a digital display indicating the water supply temperature.

In the case of an electronic device, it typically takes computer software and an infrared sensing device to manipulate the temperature set point. These TMV are generally tamper resistant and provide increased temperature stability.

Individual thermal mixing valves will be located at each point of use station or each return loop balancing station. The supply water from the hot water heaters will be made available at each TMV with cold water makeup providing the other source to mix the desired temperature at the point of use station. Each of the individual thermal mixing valve temperature settings are generally set by the manufacturer/supplier and should be field verified once the hot water system is balanced.

The domestic return loop circulation pump should be installed at the main TMV location, if applicable, or near the hot water generators. The circulation pump maintains the required return flow at all balancing stations. This return flow is delivered throughout the domestic system by the circulation pump.

Prior to any pump capacity verification, the booster skid and the hot water heaters should have been started up and fully operational. The installing contractor and the TAB technician should walk the entire domestic water system together and verify that all isolation and balancing valves in the system are open. A cursory check should be performed by touching the return loop balancing valve at each station to see if it is warm.

Domestic water systems with multiple levels may also have pressure reducing valves (PRV) on each level. These pressure reducing stations are designed to provide a consistent cold or hot water domestic supply pressure to be maintained on the individual floors. However, the hot water return loop pressures can be a function of the elevation on which they are located.

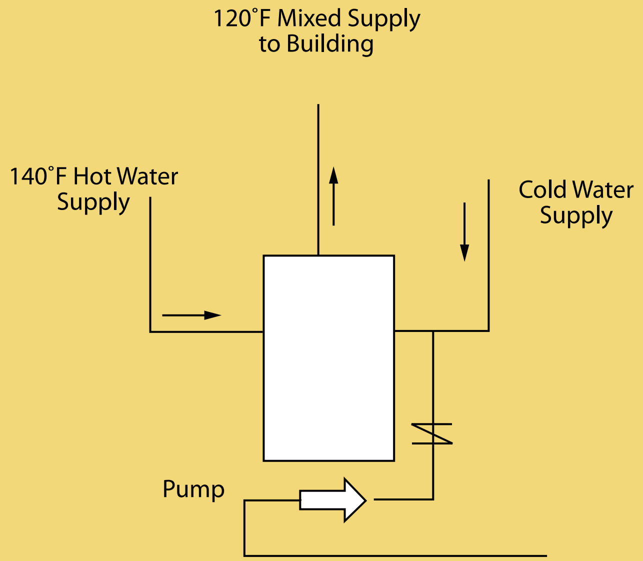
To maintain required hot water return flow, the domestic hot water and cold water supply pressure PRVs should be set slightly above the pressure of the hot water return loop. To accomplish this, additional pressure taps may be required in the domestic system for pressure verification. The testing of each PRVs and

A Note on Instrumentation and Contamination Issues

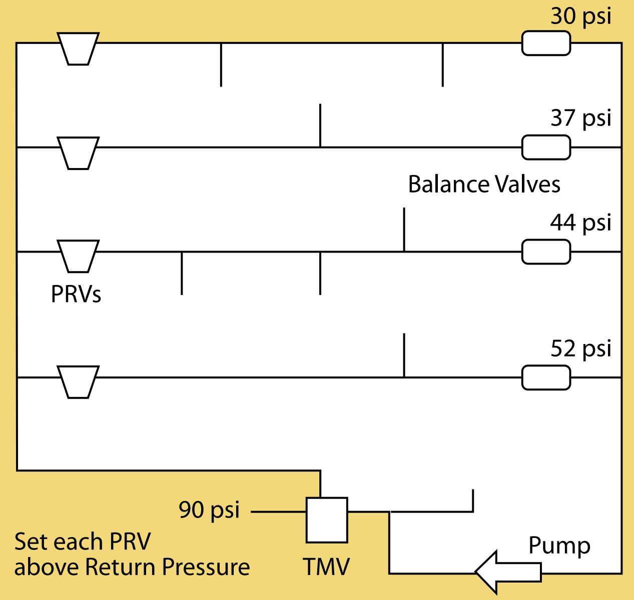
The instrumentation and components that are associated with these test procedures are very important. Tests performed on a domestic water system involve water that people will be drinking. If tests are being performed on an existing system that is already in use, some recommend purchasing specific instrumentation and components for use only on domestic water systems. The instruments and components can be sterilized before and after each use and properly stored to maintain their cleanliness. If the system being tested is a new install that has not yet been sterilized, instrumentation that has not been sterilized is acceptable for use.

Also, note the disclaimer in the user manuals for most differential pressure instruments. These disclaimers may include language that indicates the instruments are not intended for domestic water use. The intent of these disclaimers is to release the instrument manufacturer from any liability based on the use of the instrument. It is understood that additional safety precautions should be in place when testing domestic water systems.

Typical Main TMV Configuration



Typical Correct PRV Set Up



the subsequent set up of each PRV device should be performed by the mechanical contractor before any return loop balancing begins.

At this point, the discussion assumes that all isolation valves in the system are open and that all start-up activities have been completed.

Return Loop Performance

The verification of the return loop pump performance should follow the same guidelines as with all pumps. A certified pump curve is recommended because the return pumps are normally small, the capacity will be relatively low, and accuracy is very important.

Also, in many instances manufacturer-provided pressure taps have not been installed at the pump suction and discharge. This may require the assistance of the mechanical contractor to install pressure taps in the suction and discharge piping to determine pump pressures.

During pump performance testing, take particular note of the shut-off pressure on the pump discharge. The pump discharge and the domestic cold supply may share a common line into a centrally located TMV. If the cold water booster supply pressure set point is greater than the return loop circulation pump shut-off pressure, you may be required to suggest a supply PRV to be installed in the cold water supply line to make adjustments to this pressure. If another form of flow measurement is required to verify pump performance, ultra-sonic flow meters can be used to determine water flow rates.

"In a domestic system, return loop locations that are not properly balanced will not be evident if the system is under heavy usage during occupied hours."

Once the initial pumping performance has been determined, the testing of the return loop balancing stations can begin. In determining the balancing plan, a proportional balancing procedure should be incorporated.

In the design of some domestic systems, each return loop may have a specific balancing valve and the water flow measured at this station does not return through an "accumulator" or another balancing station. Other designs may have several return loop stations accumulate through one larger station. Those accumulator station flows should be set initially and then each individual flow station verified.

It is very important during balancing that the domestic system not be in use. For existing systems, that may mean that all balancing activities are performed in the evening hours when the users have left the building. For instance, each time a hot water faucet is put into use, the hot water return loop is affected and flow will cease for the period of use near that station.

Due to the limited amount of flow in a domestic system, it takes time to circulate all the hot water through all return loop stations. On initial inspection, there may have been several return stations that were cold although all isolation valves have been verified as open.

After the initial system readout and adjustment have been performed, it is important that the system be allowed to circulate for a period of time to allow circulation to all stations. During the subsequent flow verification, it is also important that the technician also "feel" each return balancing station to verify it is warm.

After the final readout of each balancing station has been performed and the technician is confident that the required hot water return flow is available at each return loop balancing valve, temperature verification at each balancing valve should be performed. The Pete's Plugs that have been incorporated into the balancing valve can be used to perform this check. A temperature immersion probe can be inserted at each balancing station and the actual hot water temperature recorded to verify flow at the return loop station.

The final test for verification of an acceptable domestic hot water loop balance is to run the hot water in selected lavatories and document the time when hot water is available at the lavatory aerator. Note: If the specified time frame for hot water availability is less than 30 seconds, the lavatory fixture flow rate should be 1.5 GPM or greater.

The forms that are required for the recording of field data should include pump data, return loop flow data, and temperature verification data forms. The pump data forms should include all typical motor and pump data that is required by the standards and procedures manual. The water balance data sheets should include the location, plan size of the return balancing station, and the design GPM. The actual water balance field data should include actual balance valve differential pressure and calculated GPM and temperature at the balancing station.

With any domestic hot water system, the lack of hot water at any lavatory sink is very obvious. However, the return loop locations in the domestic system that are not properly balanced will not be evident if the system is under heavy usage during occupied hours. The final test in the determination that the system is properly balanced is to retest after allowing the system to sit in an unused state for 12 to 24 hours. This allows return loops, in an unused system, to cool if they lack heating water return flow. Figures 1 & 2 show diagrams of typical TMV configurations and PRV settings.

Conclusion

Many of the standard practices that are used to balance chilled and heating water systems are included in this procedure. However, as noted in this article, a domestic hot water system has other dynamics that should be evaluated, documented, and followed throughout the entire process to verify the overall system is functional and operating within design intent.

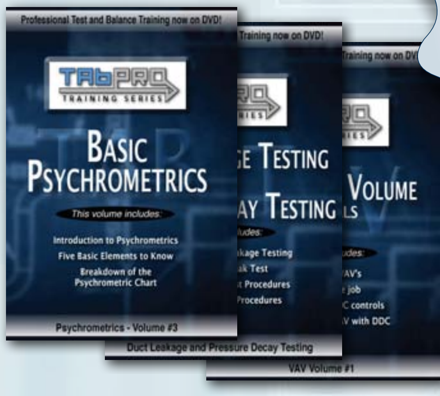
TABPRO TRAINING SERIES

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	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 ____
Company ____
Shipping Address ____________________________________
City/State/Zip _______________________________________

Phone ______________________
Fax ________________________
E-mail ______________________

Pneumatic Controls: A Blast from the Past

David Kitts, TBE
Baltimore Air Balance Co.

"It is easier and more cost effective to an owner to only replace the controls that do not work rather than paying a control company to install new DDC controls."

Confronted by the difficulties of today's economy, building owners and building management companies are leaning towards refurbishing the existing controls already installed in their facility rather than paying for new up-to-date controls. It is easier and more cost effective to an owner to only replace the controls that do not work rather than paying a control company to install new DDC controls. This opens up many opportunities for independent test and balance companies, who have the expertise and knowledge to go through an existing building to pinpoint the control issues and rebalance the systems for proper heating and cooling CFM.

Today's test and balance professional has to know the new DDC controls as well as how to use pneumatics. A complete checkout of all pneumatic system components is very important. Using an initial checklist or readiness checklist modified for a pneumatic system, is the best method a test and balance professional has to diagnose if the systems are working properly.

The building in this example, consisted of the following equipment: variable volume air handling unit with a vortex damper that is controlled by a static pressure sensor, direct drive outdoor air fan, direct-acting and reverse-acting thermostats. Variable air volume boxes were equipped with plunger damper, direct-acting controller or reverse-acting controller, with electric reheat controlled by a pneumatic-electric relay.

Example of some readiness checks for the main equipment components are:

ITEM	N/A	YES	NO
Compressor: Operating and maintaining discharge pressure	✔		
Compressor: Oil removal filter working properly (no oil in main air line)		✔	
Floor PRV (pressure reducing valve) operating and set correctly		✔	
Main air pressure at end run VAV for each floor 18 to 20 PSI			✔
PRV (pressure relief valve) set properly		✔	
AHU - Actuator operating properly	✔		
AHU - Vortex damper or VFD is operating properly		✔	

Control Terms

1. **Direct-Acting Controller:** A direct-acting controller increases its branch-line pressure as the condition it senses increases.
2. **Reverse-acting Controller:** A reverse-acting controller increases its branch-line pressure as the condition it senses decreases.
3. **Throttling Range:** The change in the controlled condition necessary for the controller output to change over a certain range.
4. **Set Point:** the degree of temperature, relative humidity, or pressure that is to be maintained. The point at which the controller is set.
5. **Controller:** A proportioning device designed to (1) control dampers or valves to maintain temperature (thermostat), humidity (humidistat) or pressure, (2) control other controllers (master/sub master), or (3) both of the above receiver-controller and transmitter.

After an initial check of the main equipment components, the test and balance professional can then turn his or her attention to the individual variable air volume components. Verifying the functionally of the following components:

1. **Direct acting thermostat single point:** Verify the action and calibration of the thermostat (pressure to temperature). If the thermostat is not calibrated, use the following standard calibration procedure:
   A. Determine the actual room temperature at the sensing element with a calibrated temperature sensing device.
   B. Turn the set point dial to that value.
   C. Turn the output adjustment screw until the output pressure (read on the test gauge) is at the mid-spring range of the controlled device.
   D. Turn the set point dial to the desired set point.
   E. Move the adjustment knob one degree and observe the pressure change to verify sensitivity. If required, adjust the sensitivity slide.

2. **Reverse acting Thermostat single point:** Verify the action and calibration of the thermostat (pressure to temperature). If the thermostat is not calibrated, use the following standard calibration procedure:
   A. Determine the actual room temperature at the sensing element with a calibrated temperature sensing device.
   B. Turn the set point dial to that value.

Continued on next page

Continued

C. Turn the output adjustment screw until the output pressure (read on the test gauge) is at the mid-spring range of the controlled device.

D. Turn the set point dial to the desired set point.

E. Move the adjustment knob one degree and observe the pressure change to verify sensitivity. If required, adjust the sensitivity slide.

3. Pneumatic Damper Actuator: Verify the diaphragm maintains and holds pressure. Use the following procedure:

A. Disconnect the branch-line from the actuator.

B. Connect a squeeze bulb with pressure gauge to the actuator.

C. Pump up the squeeze bulb to desired pressure, preferably mid-range. Verify that the actuator holds at that pressure for 5 minutes.

D. If test pressure does not hold, the diaphragm is faulty and the actuator needs to be replaced.

4. Controller/ Regulator: Verify the minimum and maximum diaphragm is maintaining pressure. Use the following procedure to verify the controller is operational:

A. Disconnect the B-port (actuator line) and connect a pressure gauge.

B. Adjust the thermostat so no air pressure is provided to the T-port line of the controller. 85 degrees for direct-acting and 55 degrees for reverse-acting.

C. Turn center knob until 8 psi is on the test pressure gauge.

D, Adjust the thermostat until full pressure is being sent to the T-port line of the controller, 55 degrees for direct-acting and 85 degrees for reverse-acting.

E. Adjust outer knob until 12 psi is on the test pressure gauge.

F. If all the pressures are maintained, than the diaphragms are intact.

5. Pneumatic-Electric (P-E) switch for the electric reheat coil: Verify the pressure setting for the P-E switch is correct and the switch is enabling and disabling according to the pressure received by the reversing relay. Adjust if necessary.

When all of the above inspections and tests are complete the repairs required for the system can be documented. When all repairs are completed the system will be ready to be balanced. The test and balance professional can now use the *AABC National Standards* balancing procedures to complete the project.

TROUBLESHOOTING:

Expect the Unexpected

Robert J. Wade, TBE
CFM Test & Balance Corporation

A semiconductor manufacturing company hired a test and balance agency to increase the total air flow on a small rooftop HVAC unit, which served a critical area and was required to run continuously. The owner indicated that their maintenance personnel had tried to correct the problem by replacing the motor sheave, but were unsuccessful in achieving design air flow.

The original test and balance report indicated that the system was rated for 6,000 CFM. Total air flow was measured at 3,907 CFM via duct traverse. While performing an initial inspection of the fan, the direction of rotation was confirmed to be correct.

Amperage was measured at 12.0 amps, which was full load for the 10 horsepower motor. Filters and coils were clean and the mixed air plenum pressure was not excessive, indicating no problem with the return ductwork. This system did not have a return fan.

Based on the initial testing, the system appeared to be working fine. Without shutting the system down, all the expected problem areas were checked and found to be trouble free.

However, further investigation showed that when compared to the original test and balance report for this system, RPM was now 26% lower, CFM and static pressure were both lower, and amperage was higher than that indicated in the report. If not for the motor being fully loaded, it seemed all that would be needed to achieve design air flow was an increase in fan speed.

Since the motor was fully loaded, a possible problem with the fan itself was suspected. It was decided to shut the system down and inspect the double-width, double-inlet airfoil fan.

After a quick look at the fan wheel, the problem became apparent: the fan wheel itself was installed backwards. When the owner was notified of the problem, they indicated they had recently replaced the fan bearings.

From that piece of information, it quickly became obvious what had happened. The fan wheel must have been removed to install the new bearings and was reinstalled on the shaft backwards. Through further discussion, it was also determined why the original motor sheave had been replaced with a smaller sheave. Upon starting the fan after the bearings were replaced (and the fan wheel installed backward), the motor was overloaded.

> ***"After a quick look at the fan wheel, the problem became apparent: the fan wheel itself was installed backwards."***

The client was happy that the problem was conclusively pinpointed. After the fan wheel was reinstalled properly, the test and balance agency completed the job by returning with a new motor sheave and adjusting it to achieve the required 6,000 CFM.

Tech tips

Cross Drafts and Kitchen Hoods

Jeff Wicka, TBE, San Diego Air Balance Co.

Cross drafts are a kitchen hood's enemy because they can prevent a hood from capturing smoke and heat properly even though the hood's air flow is at design.

A cross draft is an airflow, often from the make-up or air conditioning supply air diffusers, that intrudes on an area served by a hood, pushing the smoke, odors, and radiant heat from the cooking surfaces away from the hood containment area and into the kitchen. They are one of the first things to look for when investigating kitchen hood complaints, and are typically caused by supply air distribution installed too close to the hood. To avoid cross drafts, any air distribution should be a minimum of 10' away from the hood.

Any air distribution installed near the hood should be adjusted to deflect the airflow away from the hood. This may involve changing the type of diffuser from a 4-way to a 2-way to direct the air sufficiently away from the hood.

Do you have a "Tech Tip" that you would like to share with our readers? If so, please contact AABC at:

Associated Air Balance Council
1518 K Street NW, Ste 503
Washington, DC 20005
Fax 202.638.4833
E-mail: info@aabc.com
www.aabc.com

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).**

Static/Dynamic Flushing & Strainers

Q

QUESTION: ***I have several questions: 1) During static flushing of a chilled water system, is it required to clean the strainers or not?***

2) In the cases where strainers were not cleaned during static flushing, is it right to connect the CHW pipes to CHW pumps to do dynamic flushing?

3) Finally, is it required to use temporary startup strainers during dynamic flushing?

I am the manager assigned to witness the TAB & commissioning of a project, and the TAB contractor argued that these items are not required per AABC Standards (per the specifications the TAB agency shall follow AABC procedure). Please clarify.

A

AABC: The mechanical contractor should be responsible for cleaning and removing strainers, while the TAB agent is to verify the strainers are clean. 1) Yes, it is best to clean strainers at each fill-flush cycle. 2) We have used the CHW pumps for the flushing. 3) Yes, temporary or construction startup strainers are needed until fine debris is removed.

Section 6.7.2 of the AABC Standards requires the use of the Hydronic Systems Checklist, table 6.3. In this checklist, the TAB agent verifies a number of hydronic items including piping free of debris, systems cleaned and flushed, and construction strainers (fine mesh) replaced.

— Steve Young, TBE, The Phoenix Agency, Inc.

A

AABC: 1) The amount of suspended solids must be identified by the specifications of the plant operator. A screen that is 200 mesh, equivalent to .003 inches, is called a strainer. Anything finer than 200 mesh is called a filter. As long as the filter or strainer is collecting suspended solids, cleaning is required.

2) I do not understand the reference to static cleaning versus dynamic cleaning. Before any heat exchangers are connected, the piping system must be cleaned and flushed. *The 2011 ASHRAE Handbook – HVAC Applications*, Chapter 49, titled Water Treatment states: "Before new systems are treated, they must be cleaned and flushed. Grease, oil, construction dust, dirt, and mill scale are always present in varying degrees and must be removed from the metallic surfaces to ensure adequate heat transfer and to reduce the opportunity for localized corrosion. Detergent cleaners with organic dispersants are available for proper cleaning and preparation of new closed systems." AABC considers static testing to be done with the pumping system off and all high points are free of air, with approximately 5 PSI measured at the top of the system. The flushing is accomplished by circulating water with detergent cleaners through the piping system until the system meets the specified cleanliness, which is done by the mechanical contractor.

3) The use of temporary and/or startup strainers would be dependent on the specification requirements.

As a final note, the AABC Standards and/or Procedures do not cover flushing the piping systems, because this is a requirement of the mechanical contractor who installs the piping system.

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

2- and 3-Way Automatic Control Valves, Revisited

[Ed. Note: the following response to a previous Tech Talk item was received from a TAB Journal reader, a consulting engineer in Toronto, Canada.]

QUESTION: ***An item regarding 2-way control valves appeared in Tech Talk in the Summer edition of TAB Journal. The question was: Should the control valve be in the supply or the return?***

AABC:

It is usually preferable to have 2-way control valves in the return piping. For chilled water systems, having the control valve in the return reduces valve and actuator sweating. For heating systems, the lower return water temperature helps to prevent actuator overheating.

There are some cases in hot water systems where the control valve may be located in the supply. On closed piping systems, when the heating pumps are located in the basement or ground floor of the building, the control valves located near the top of the building tend to cause problems as there may not be a lot of outlet pressure at this point on the valves and cavitation may occur. The formula for determining the cavitation point can be expressed (approximated for HVAC applications) as:

Maximum allowable pressure drop allowed through the valve = 0.5 (the typical valve recovery coefficient for HVAC valves) x [Inlet pressure - Vapor pressure]; Inlet pressure = outlet pressure + differential pressure.

The higher the water temperature system, the higher the vapor pressure. For example, the vapor pressure at 60˚F is 0.256 psi, vapor pressure at 150˚F is 3.71 psi and vapor pressure at 180˚F is 7.51 psi.

Therefore, on heating systems with lengthy piping runs, it would be acceptable to locate the control valves (located towards the end of the piping system) on the higher pressure side (the supply side) of the heating coil. However, it is preferable to locate the valves in the return and to raise the expansion tank fill pressure in the system. This raises the valve outlet pressure above the cavitation point. Another way is to lower the heating supply water temperature, possibly by scheduling or testing how low the water temperature can be lowered before one valve is 90 percent open on a design day. This lowers the water vapor pressure, which increases the allowable differential pressure. This is not a concern on chilled water systems as the vapor pressure is much lower.

Pressure independent damper control on duct systems is similar to valves in open piping systems. Balancing issues from too much system pressure arise when a few constant volume terminal boxes with HEPA filters are supplied from in a large pressure independent system. This occurs mainly in hospitals or lab duct systems.

These boxes may require 3 in. wg. inlet pressure to provide enough pressure to offset filter loading. If there are other boxes served by the same duct system which do not have HEPA filters downstream, those boxes may only require 0.3 in. wg. inlet pressure. This means the dampers on these boxes will be closing off against 3 in. wg. pressure, putting the damper in a 98% closed position. In this position, it is difficult to control (causing damper hunting) and will generate higher noise.

In situations like this, double manual dampers can be installed in the inlet duct of the branches (or boxes) supplying the boxes with the low pressure requirement. Each damper can be balanced to drop approximately 1.25 in. wg. of pressure (2.5 total) leaving 0.5 in. wg. pressure available for the boxes with the low pressure requirement. This allows the low pressure box dampers to operate in a much better position for control and generates much less noise.

In conclusion, locate control valves in the return. Cavitation in heating systems can be prevented by increasing system fill pressure, reducing supply water temperature (where possible) and by using suitable valve designs.

— Mark Baniuk, CET, H.H. Angus & Associates Limited, Consulting Engineers

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. (ABCO)
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

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.
Sunnyvale, 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
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
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

Test & Balance Corporation of Orlando
Orlando, Florida
(407) 894-8181

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.
Atlanta, 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 Corporation of the Pacific
Honolulu, Hawaii
(808) 593-1924

ILLINOIS

United Test and Balance Service, Inc.
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
(800) 535-5594

Baltimore Air Balance Company
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 Company
Dearborn, Michigan
(313) 584-7450

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

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
Center City, 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 & 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 Co., 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

Air Balance Corporation
Greensboro, North Carolina
(336) 275-6678

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

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

Palmetto Air and Water Balance
Asheville, North Carolina
(828) 277-2256

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

Palmetto Air and Water Balance
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 Company)
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 Balance Co.
Newberg, Oregon
(503) 537-0826

PENNSYLVANIA

Butler Balancing Company
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
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 Company
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, Inc.
Spring, Texas
(281) 651-1844

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

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

UTAH

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

VIRGINIA

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

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

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

WASHINGTON

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

Penn Air Control, Inc.
Vancouver, Washington
(253) 472-6804

TAC Systems, LLC
Blaine, Washington
(360) 332-4789

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) 652-4040

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

**An interesting case study?
A new method? Tell us about it.**

TAB Journal welcomes submissions for publication. TAB Journal is published quarterly by the Associated Air Balance Council. Send letters or articles to:

*Editor • TAB Journal
1518 K Street, NW, Suite 503
Washington, DC 20005 • info@aabc.com*

ALNOR IS EXCITED TO ANNOUNCE THE NEXT GENERATION OF

Analog Balometer® Capture Hoods!

Since 1919, Alnor has provided rugged and reliable analog instrumentation to HVAC technicians, and the tradition continues with the new Analog Balancing Tool (ABT) Balometer.

The ABT series Balometer utilizes a low current analog meter with a large, easy to read scale. Fast meter response combined with smooth needle movement allows for quick and accurate flow measurements from supply diffusers and return grilles. For more information visit www.alnor.com/tab

TSI | ALNOR®

PHONE: 800 874 2811 E-MAIL: CUSTOMERSERVICE@ALNOR.COM