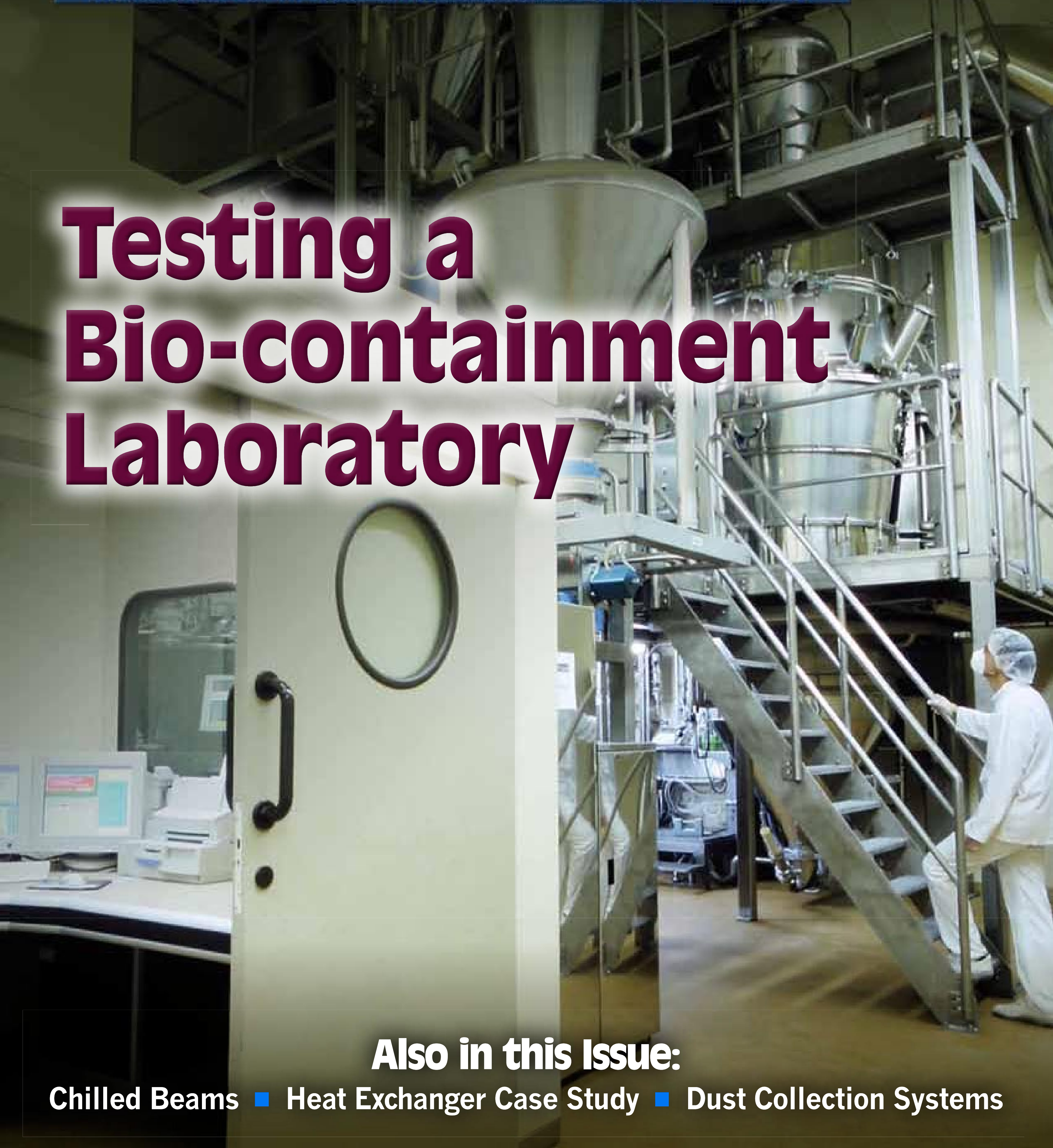
TAB Journal

AABC

THE MAGAZINE OF THE ASSOCIATED AIR BALANCE COUNCIL • WINTER 2011



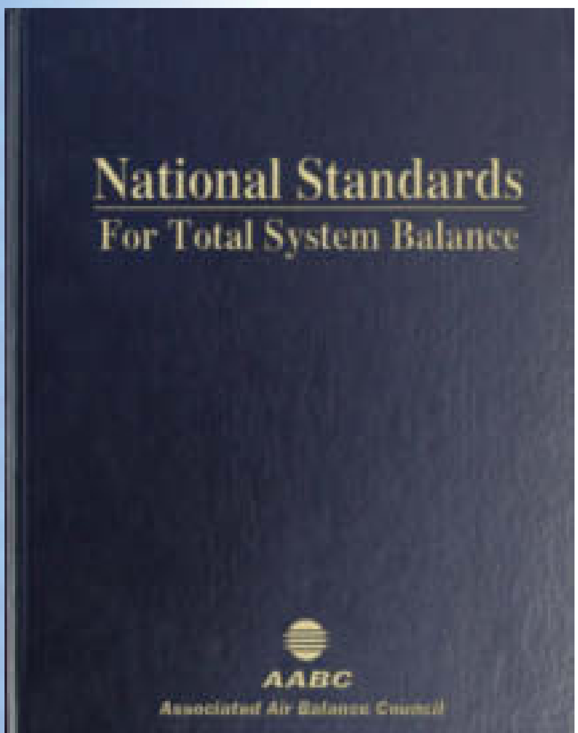
Testing a Bio-containment Laboratory

Also in this Issue:

Chilled Beams ■ Heat Exchanger Case Study ■ Dust Collection Systems

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

Encompassing a wide range of topics ranging from commissioning to system-specific case studies, the winter 2011 issue of TAB Journal provides insight and analysis valuable to anyone involved in the testing and balancing industry.

The centerpiece article, “Commissioning a Regional Bio-containment Laboratory (RBL)” by Dale Davis of Test and Balance Corporation, presents various issues that may arise in the commissioning and certification of a BSL-3 facility, and the importance of being cognizant of potential problems.

RSAnalysis’ Derek Shupe and Engineered Air Balance Co., Inc.’s Bryan Lacy each lend their expertise in a case study. Shupe describes the troubleshooting process that was required to resolve several problems affecting a dust collection system in “Dust Collection: Maintaining Effective Capture Velocities with Changes in Product Densities,” while Lacy’s “Heat Exchanger Case Study” details the steps taken in an attempt to repair a poorly performing heat exchanger.

This issue also features “Balancing Active & Passive Beams” by Darron Rempel of Price Company, tracing the history and development of this technology and the various measurements that need to be collected. Edward Molnar of Dynamic Flow Balancing Ltd., similarly explains the history of copper pipes and the problems that can be caused by pinhole leaks.

Air Systems Engineering, Inc.’s Mike Wozniak assumes a more big picture approach in his article, “Developing a Detailed Testing & Balancing Plan,” which outlines the components of a balancing plan and its benefits in establishing a realistic schedule for projects.

This issue’s *Tech Talk* provides guidance on reconciling AABC and ASHRAE standards when conducting testing of fume hoods.

As always, we thank the contributors to this issue, and remind you to write us at info@aabc.com if you have comments, article ideas or questions to be answered in *Tech Talk*.

Commissioning a Regional Bio-containment Laboratory (RBL)

Dale Davis, *TBE*
Test and Balance Corporation

This article is a case study about some of the problems that may arise to delay the commissioning and certification of a Regional Bio-containment Laboratory (RBL).

In 2003, in response to the 9/11 terrorist attacks on the World Trade Center and Pentagon, and the anthrax attacks shortly thereafter, the National Institute of Allergy and Infectious Diseases (NIAID) approved funding for nine RBLs and two National Bio-containment Laboratories (NBL). One function of these facilities is to assist national, state, and local health organizations in the event of a biological attack or infectious disease outbreak. This article only pertains to the RBLs, which have BSL-3 (Bio-safety Level 3) and BSL-2 (Bio-safety Level 2) capability, and not the BSL-4 (Bio-safety Level 4) capable NBLs.

Though many design firms are familiar with designing and building research facilities such as a BSL-3, there are some aspects of a BSL-3 built to the Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th edition document that make certifying the facility extremely difficult if the installing contractors and/or design firm treat the facility with the "business as usual" mentality. This article will focus on the facility side of a BSL-3 building (e.g. HVAC) being certified to the BMBL 5th edition.

> "One function of these facilities is to assist national, state, and local health organizations in the event of a biological attack or infectious disease outbreak."


© 2005 Dawn Wooley

Design Phase

Trouble can present itself as early as the "Design Basis" phase, as the owner and design firm work together to create a facility that meets both the owner's requirements and the National Institutes of Health (NIH) BMBL document. Issues arise when the owner personnel who were involved in developing the design basis will not be the same individuals who occupy, maintain, and perform research in the lab.

There have been instances when the principal investigator, researcher, safety manager or facility manager needs to change the floor layout, add equipment, remove equipment, and make many other modifications during the construction phase or late in the design phase. This is not uncommon since the individuals involved in the early stages of design, in many cases, are not the ones who will occupy the lab. These changes may add days or months to the project schedule.

With an intimate working knowledge of the types of systems used in a BSL-3 facility, the experienced commissioning agency can help reduce many of these future design issues if, and only if, it is brought in during the design phase.

Commissioning Overview

In general, commissioning (Cx) activities entail the following:

1. Design Review
2. Cx Kick-off Meeting: Introduce the Cx process and the roles each entity plays in the Cx process.
3. Preliminary Cx Plan: The plan is an on-going document that is dependent upon submittals and O&M manuals. The plan is updated throughout the construction/design process.
4. Field Inspections: Performed at different phases of construction to help identify items that need to be repaired, modified, or simplified so the systems do not fail final testing.
5. Periodic Cx Meetings: After field inspections and throughout the FPT phase of the Cx process, meetings are held to keep the design and construction team informed of the commissioning status. If any deficiencies are discovered, they can be quickly addressed and resolved.
6. Functional Performance Testing (FPT): Where the Cx team led by the Cx Authority performs specific tests that are intended to show whether or not the systems are performing properly as a total unit and meet or exceed the design intent.
7. Issue the Final Cx Report.
8. Certification of an RBL: The final phase is the RBL certification, which is normally performed by a third party who specializes in BSL-3 certifications.

"If the RBL facility does not protect the researchers from the agents or biol

Potential Pitfalls

Personnel Changes

For the subcontractors and general contractor (GC), using more than one crew and rotating employees/supervisors between jobs will most likely result in inconsistent work that varies in quality and method of construction. By working in a team environment, which is strongly emphasized in the Cx process, the negative effects of personnel turnover can be greatly reduced. However, the goal is to limit personnel turnover, which takes a high level of commitment from each contractor.

Apathy

When a project drags on for long periods of time, apathy can set in, changing the focus from providing quality work to accelerating the equipment installation process. This results in numerous delays as equipment and systems fail Cx tests and must be retested.

Sequence of Operations

Whenever a specification is vague or leaves out specific information, the controls contractor may consult with the engineer-of-record or try to interpret the engineer's intentions. Two different outcomes are possible when the engineer is consulted. An engineer can simply want to provide verbal clarifications; whereas, another engineer can provide written clarification. The latter is definitely preferred and should be strongly encouraged. In any case involving vague or non-specific sequence of operations (SOO), it is prudent to inform the engineer of the situation and urge the engineer to clarify by issuing a written clarification or re-issuing the SOO. Without an accurate and detailed SOO, the project will most likely be delayed.

Adequate Workforce

As demonstrated by the two separate BSL-3 jobs below, the lack of available experienced controls personnel can significantly delay the job and hamper quality. In construction, several jobs may become ready at the same time and the contractors may not have enough manpower to cover the work at hand. Since a BSL-3 facility requires a high level of programming, the controls contractor must utilize some of their most experienced field personnel. On one project, the controls contractor stationed a full time less experienced person and sporadically brought in highly experienced people in an attempt to complete the programming in a piecemeal fashion. However, on a separate project, the owner, general contractor, and controls contractor agreed (after several months delay) that a single full time controls person with the necessary experience and skill along with the Cx agent would remain on-site until the project was finished.

As a result, the latter example was completed in a timely manner and passed certification on the first attempt. When inadequate manpower was provided in the former example, the project was delayed by months to a little over a year. The reader should understand that the contractors are not being blamed for these situations but the very chaotic nature of construction. That period when several jobs are ready at the same time and the manpower to cover them all is not available is the nature of the industry.

"Using more than one crew and rotating employees/ supervisors between jobs will most likely result in inconsistent work that varies in quality and method of construction."

Time

This is probably one of the most devastating aspects to any project, but especially a BSL-3 facility where everything has to operate together in unison under very demanding situations. These include keeping the BSL-3 labs under negative pressurization during failures such as power outages and exhaust fan failures. If the schedule slips, but the general contractor and/or owner force the subcontractors to keep the original schedule, errors will be made. To use a tired expression – “haste makes waste.”

Forcing the contractor to meet schedule when it is not feasible creates even more problems. We’ve all seen the headlines where a contractor beat schedule and was under budget. This usually involves throwing more manpower and working longer shifts, which increases the chances for human error.

Value Engineering

This can occur at the request of the owner to cut costs or by the design firm’s desire to win the contract. Either way, value engineering may result in a building that operates properly for a short period of time if lesser quality materials and equipment are selected. As the owner and design firm look for ways to reduce costs, sometimes devices are deleted that the users discover they need. One example is the removal of certain pressure monitors in a BSL-3 space. During the design phase, the owners thought they could do without them but found they were needed to comply with the BMBL. This doesn’t mean value engineering is a negative endeavor. Properly applied, it is a valuable tool that benefits the owner (reduced costs) and the environment (less materials).

A Major Hurdle: Maintaining Negative Lab Pressure During a Failure

One of the largest impacts on the design firm and controls contractor of a new BSL-3 facility is the BMBL 5th Edition requirement —“The laboratory shall be designed such that under failure conditions the airflow will not be reversed.” The HVAC system must be designed and programmed so that during failures such as power outages, fan failures, etc. the lab pressurization remains negative or neutral. If the controls contractor does not take this aspect seriously, the facility will fail. Programming to prevent airflow reversal is a time consuming task that goes beyond testing one system (e.g. one lab) and then copying and pasting the program to the other systems. It has been observed this commonly used technique of copy and paste, which works well in a less demanding facility, does not in this case as the components for each system may have a slightly different response (e.g. some dampers close quicker than others; fans ramp down at different rates).

Private versus Public

For budgetary reasons or by law, many public institutions take the lowest bidder. This may be tolerable for a less sophisticated project such as an office building where inadequately performing devices can be resolved with the only risk being the comfort and inconvenience of the occupants. However, for a BSL-3 facility, which may be handling “Select Agents” or other highly contagious and deadly biological organism, this is not acceptable

Quality of installation is paramount in a BSL-3 facility because human lives may be at risk on a daily basis. This situation of taking the lowest bidder is not exclusive to public institutions as some private companies and universities fall into the same trap of selecting the low bid.

It is important to point out that taking the lowest bidder is not, in and of itself, an indicator that the final product will be poor. However, when the contractors know the client must or will most likely take the lowest bid, it opens the door to installation shortcuts as the contractor tries to squeeze out a profit or limit losses.

Supervision/Management

Oversight and conscientious on-site supervision is an absolute necessity. Without focused supervision, project delays are inevitable and usually quite costly since some deficiencies will only be discovered during the FPT phase of commissioning; unless, the contractors conduct their own FPT prior to the Cx agent’s arrival. As the general contractor pushes to meet schedule and make the substantial completion date, human error will be even more prevalent as personnel work longer shifts and weekends to meet sometimes unrealistic deadlines.

“Programming to prevent airflow reversal is a time consuming task that goes beyond testing one system (i.e. one lab) and then copying and pasting the program to the other systems.”

Testing in a Piecemeal Fashion

During testing of a BSL-3, the general contractors can push to have portions of the HVAC systems tested and balanced instead of having whole complete systems tested. Early in the job, it is recommended that the TAB contractor is not involved until complete systems are ready and that the test and balance agency not be brought in until the facility as a whole is ready for FPT. However, as the schedule slips, the general contractor may discuss alternative testing methods that mean bringing in the TAB contractor early. With multiple trades on-site during TAB activities, TAB progress will most likely suffer as the TAB contractor tries to work around the other contractors. It has been observed that in instances where the HVAC system was not set up to its most efficient operating point was because the systems were not fully complete and/or by the actions of other contractors (e.g. opening access doors to cool off, etc.).

Conclusion

By their nature, BSL-3 facilities deal with extremely hazardous (and sometimes deadly) infectious microorganisms (agents) and biological materials. The researchers rely on a facility that operates flawlessly from a pressurization standpoint, or at the very least, in a failsafe manner since the agent or material may have the potential for respiratory transmission.

In addition, if the facility can not accurately control temperature and humidity, months or years worth of research can be lost along with the large monetary value associated with the research. Without a focused and professional work ethic during construction and testing, the ultimate goal of BSL-3 certification will take much longer as the schedule slips along with commissioning activities.

These delays can be several months to over a year in duration. And during this time, the owners incur overhead costs including power bills (>$20,000/month) and staff payroll (researchers and support personnel) who sit essentially idle waiting for the building certification. Not to mention the revenue opportunities that may be lost as grant moneys expire.

As a final word, if the RBL facility does not protect the researchers from the biological materials they are testing such as an antidote to an agent/material released in a bioterrorist attack, the public could ultimately pay the price with extreme illness or loss of life.

“Without a focused and professional work ethic during construction and testing, the ultimate goal of BSL-3 certification will take much longer as the schedule slips along with commissioning activities.”

TABPRO

TRAINING SERIES

Bundle (VAV, Duct Leakage & Psychrometrics)

3 DVDs

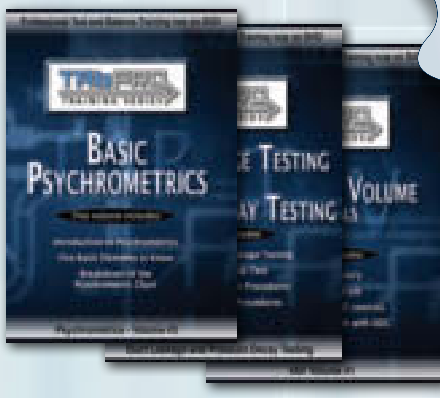
Total run time 106 minutes

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.

		Price	
Quantity	**Title**	**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 ____________________


Photo courtesy of Imperial Systems, Inc.

DUST C

Maintaining Ef
with Changes i

Derek R. Shupe, *TBE*
RSAnalysis, Inc.

On a recent project, an existing dust collection system housed in a plant had two primary problems that needed to be resolved. First the exhaust pick up points were becoming clogged with product and second, the bag house was getting full of dust and debris.

Obtaining some history on the project as to how the system was currently being used from the maintenance personnel proved to be valuable information.

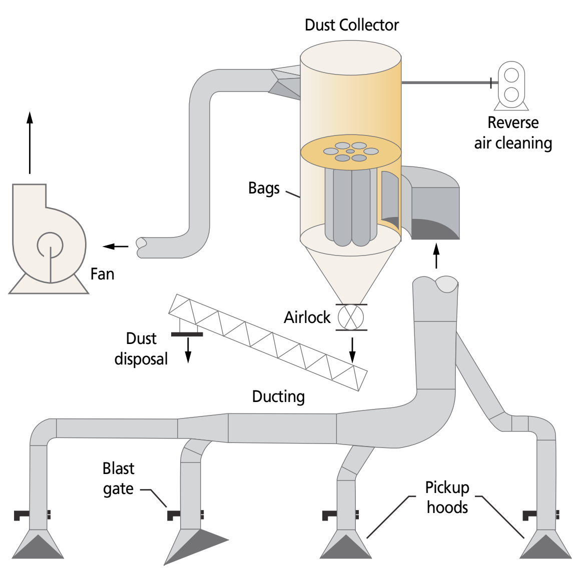
This plant produces powdered and liquid detergents and absorbing agents such as cat litter. The process is completely automated. At each point that the detergent or product is handled there is an exhaust port located to effectively contain the dust particles that will be generated during the mixing and packaging process.

The dust collection system for this particular line of powdered detergent was designed several years prior to the problem arising of the plugged up inlets and wasted product ending up in the bag house. The original formula for the detergent was quite granular and heavy. Consequently the original design capture velocities were calculated at a much higher velocity.

OLLECTION:

fective Capture Velocities n Product Densities

Typical Dust Collection System Process



The product mixture that is now being formulated has additives that are much lighter and more of a powder consistency similar to flour or chalk. Since the current product is a mixture of several different sized and weighted products, there was no one particle size or density that could be identified.

Without much design criteria for the original system or information regarding the new product mean size and density, the original design capture velocity at the various pick up points throughout the system had not been revised. In most all cases the average velocities were 3500 to 4000 FPM. There were some locations in the system where the pick up points were located at the top of an enclosure and due to the distance of the pick up point from the product, these locations were not a significant problem and needed the higher velocities to capture the dust.

Since it was then established that there was a lighter product to deal with and the system was designed around heavier particles, it was a matter of finding a velocity that would indeed pick up only the dust and let the main product fall during the mixing and packaging process.

During a shut down day, experiments were conducted testing several different velocity settings at process point locations. It was noted that generally, a velocity of 2700 FPM would pick up just the dust particles for most of the points that were having problems plugging up.

Utilizing the existing blast gates, the system was proportionally balanced as operating. The blast gates also presented another challenge. At some locations with the blast gate inserted partially into the duct, the velocity would dynamically entrain product and pack it on the negative portion of the intake. Needless to say, that to avoid this situation, the distance the blast gate was inserted into the duct needed to be minimized as much as possible.

Once the system was proportionally balanced, a main damper was installed at the discharge of the bag house exhaust fan to regulate the total flow, which in turn reduced the pickup point velocity proportionally.

Note: The damper was used in lieu of changing sheaves until it was determined if in fact the proportion would hold, and if any further adjustments needed to be made to the capture velocities.

The overall air flow handled by the system was reduced by 31%, which proved to still capture the dust and allow the main product to continue through the process of mixing and packaging.

In the last meeting with the plant personnel, the option was presented to change the sheaves on the fan and open the balance damper to allow the system to now function properly. But the plant personnel then explained that there may be another mixture of product soon to be introduced to this system that will have completely different properties.

The final recommendation was to equip the fan motor with a variable frequency drive (VFD) which may prove to be the best alternative to the sheaves and the damper. With the VFD, the operators will be able to set the air flow to allow for differing product entering the same system.

Heat Exchanger Case Study

Bryan Lacy, *TBE*
Engineered Air Balance Co., Inc.

A lab facility project in Houston, Texas was designed to exchange heat via a coil in the AHU and a coil in the exhaust duct with refrigerant piping connecting the two coils. In reviewing the installation, this was found to be typical for five (5) air handling units each with a coil located downstream of the suction side filters. The piping from these air handling units coils traveled up to a section of exhaust ductwork (on top of each AHU) where a similar coil was located in the exhaust section of each duct. So each of the five AHU's had an independent, self-contained set of coils that were piped as a closed loop system with a refrigerant pump installed. This was used to assist in moving the liquid refrigerant due to the elevation difference in installation of the two coils only during the winter months.

At that point, the technician decided to peruse his submittals to try to become more familiar with this equipment. The first thing discovered was that the "working liquid" in the coils and piping was R-134A (Freon). It was then noticed that there was no device to make the liquid flow from one coil to the other. At that point, there were still many unanswered questions so the technician referred to the manufacturer's website to better understand this equipment.

In the investigation, it was found that the heat exchanger transferred heat by using the refrigerant mechanism in which a liquid at the hot side of a conductive surface turns into a vapor by absorbing the heat. The vapor then flows to the cold side while condensing back to a liquid when it comes into contact with the cold side surface, thus releasing the heat. The liquid then returns back to the hot side by means of gravity and repeats the cycle.

In the testing procedures, the exhaust and supply airflows were set up as noted in the contract documents. Recorded temperatures during the summer conditions only indicated an 8 degree F delta as opposed to the 17 degree F temperature differentials noted in the manufacturer's submittal data. After rechecking the sensor calibration, it was revealed that the averaging sensors were mounted directly (resulting in metal to metal contact) to the stainless steel cabinet frames and that sensors with the wrong temperature ranges were installed. After these issues were corrected, the sensor verification was rechecked and determined to be within acceptable tolerances.

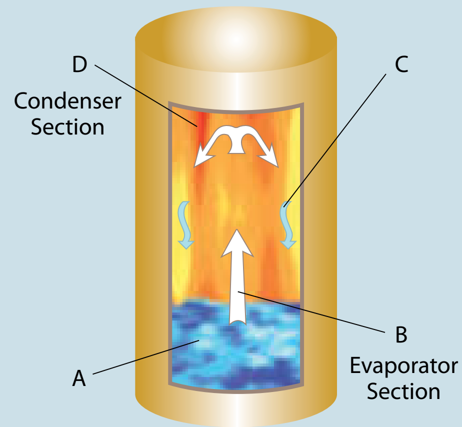
Pumps that assist in moving the liquid refrigerant up to the upper coil.

Refrigerant piping penetrating the AHU upstream of the pre-cooling coil.

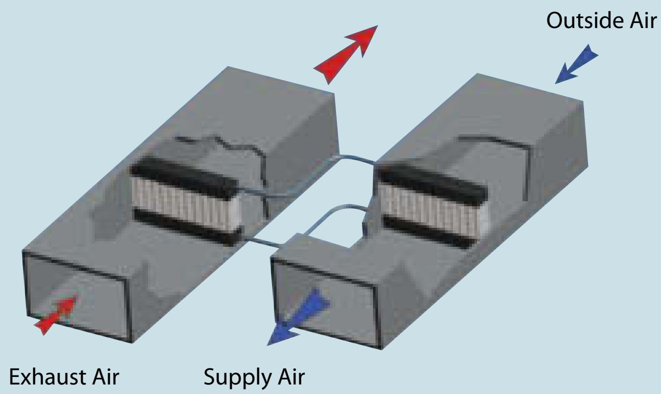
The second attempt to verify a temperature difference across the coils again failed to meet the manufacturer's submitted temperature differentials. The manufacturer was then called out to assist in the efforts in order to determine the cause of the lack of differential temperatures. The manufacturer's representative determined that the volume of refrigerant in the system had exceeded what was necessary. The excess was removed, but the temperature differential still failed to increase to the submitted conditions.

After an extensive investigation by the manufacturer's expert and representative, several issues were found that still caused a lack of performance.

1. During the summer months when the "working liquid" was injected from the side of the coil, it had to travel 12' in length to the other side before being vaporized and sent to the cold side. The result was that the heat transfer was good on the first half of the coil, but the other half saw very little work. The piping configuration was modified to inject the "working liquid" from both sides of the coil to allow good heat transfer from either side.
2. During the winter months when this process was operating in reverse, the lower section (supply air) was causing the vapor to condense into liquid. The liquid level was unable to be pumped to the upper section with the present pump controls, thus plugging the system. The fluid pumps had to be modified with level controls and VFD's on the pumps to allow the liquid to flow to the upper section (exhaust air).
3. Finally, during the design of the project, the engineer sent the manufacturer data that would allow him to properly size the system. Unfortunately, although the data that the engineer sent indicated that the supply and exhaust airflows across the coils on each of the five (5) self contained systems were equal, the supply and exhaust airflows were not equal in actuality. The unequal airflow resulted in the systems having a much smaller coil on the exhaust side than was needed to accommodate the temperature differentials submitted. Instead of having 17 degree F temperature differential, the system could only produce 12-14 degree F temperature differentials.



Heat Pipe Process



Heat Pipe Structure

Darron Rempel, *P.Eng*
Price Company

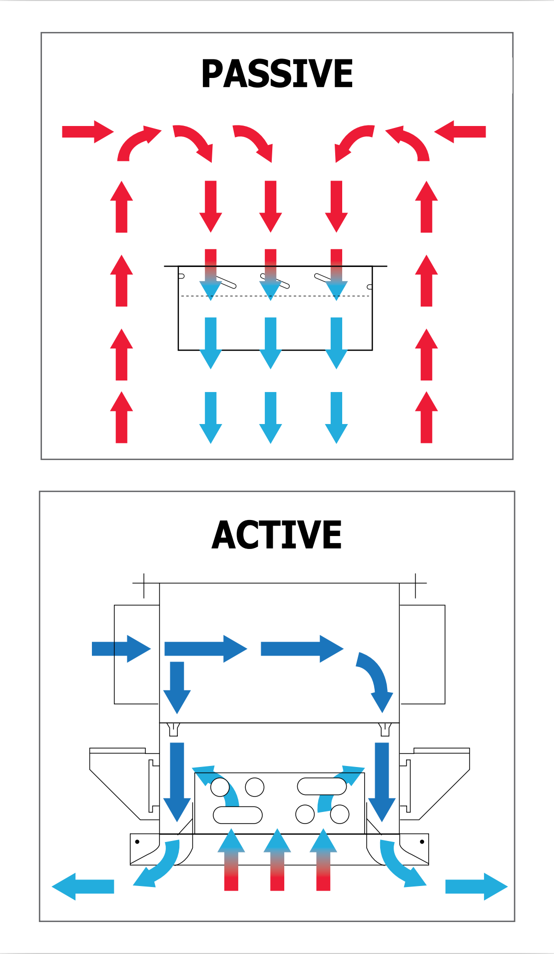
Balancing Active & Passive Beams

In recent years the technology of active and passive beams in North America has undergone a dramatic change from little known only a few years ago to an increasingly requested HVAC design system. Evolving in Europe from the need for additional cooling in a zone without also requiring additional air supply, this system first came to be known as a chilled beam because the natural convection only worked when operating in cooling mode. Moving energy with water instead of air allowed for reductions in equipment and duct sizing in favor of much smaller pipe sizes and lower energy consumption.

The conception of the original passive beam then prompted the development of the active beam. This new tool combined the benefits of a hydronic energy transport system with the operation of an overhead cooling and heating unit using minimal ventilation air as the driving force in the system.

The passive beam works on natural convection to move the air, relying on warm air surrounding the unit to cool as it passes through the chilled heat exchanger and falls into the room. The performance of the system is very simple; modifying the water supply temperature or the water flow rate changes the performance. For this reason, verification of the supply water temperature and flow rate based on the design specifications is key for the effective operation of the passive beam.

The active beam is based on the primary air inducing secondary air through the heat exchanger to provide cooling or heating to the space. The majority of the cooling or heating occurring with an active beam comes from the heat exchanger which can provide 50 – 100% of the cooling or heating from the unit. The concept is to provide primary air in minimal quantities to the beam plenum at a static pressure typically between 0.3 – 0.5” wg. The primary air is forced through the nozzles creating a low pressure region above the heat exchanger. This draws secondary room air through the heat exchanger at a rate of 2 to 6 times the primary air flow rate.



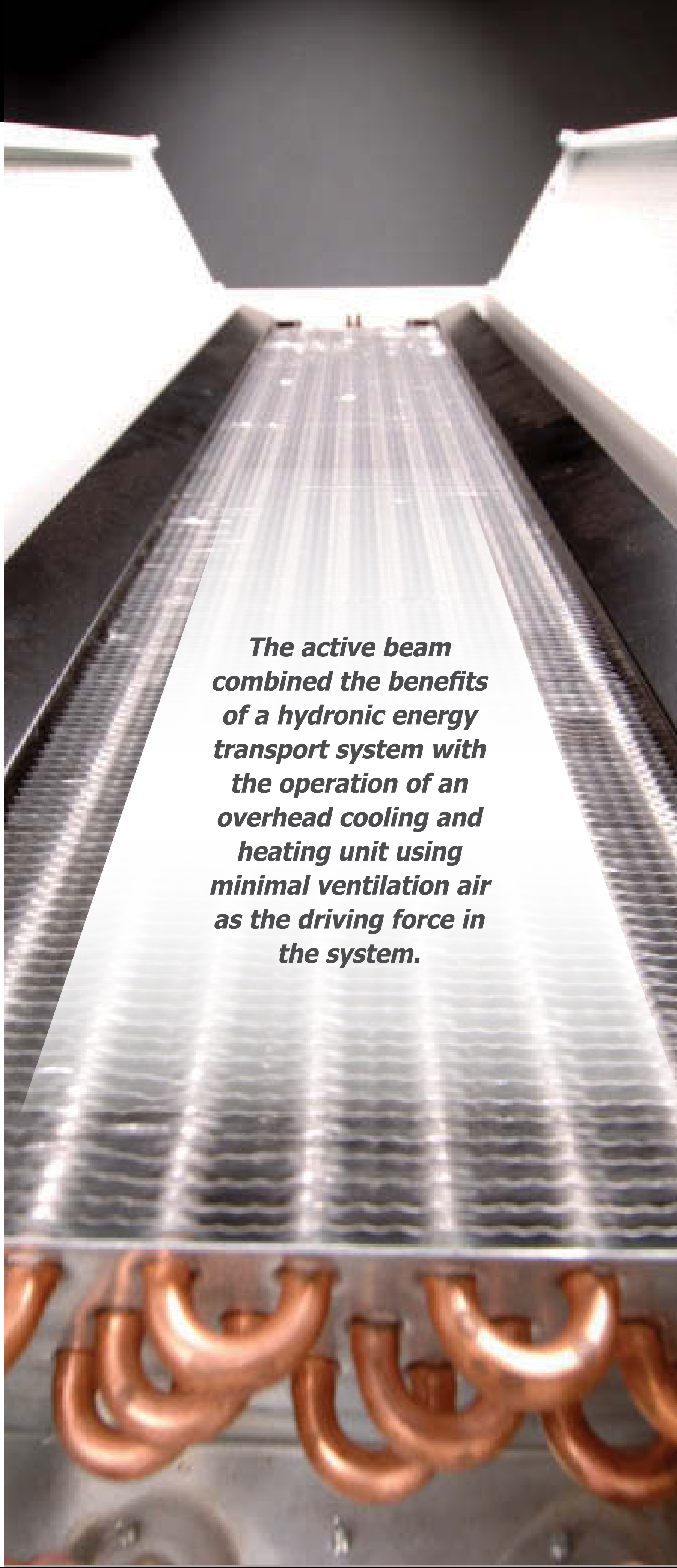
Measurements

The standard duct flow rate measurement method can be used to measure air flow rate. However, air flow rates can be very small as an active beam air flow rate typically operates between 10 to 200 cfm, often averaging 20-80 cfm, which may make standard measurements more difficult.

More commonly, the plenum static pressure is measured either with a probe stuck through the nozzles into the beam plenum or by using a manufacturer provided pressure port connected into the plenum. The nozzles in the plenum act as an orifice plate. Thus, the static pressure within the active beam plenum can be directly related to air flow rate; however the relation is manufacturer specific, depending on unit length and nozzle configuration. With static pressures typically around 0.5”, beams along a branch line typically will see the same static pressure and airflow.

The second important measurement is the water conditions. The active beam requires verification of entering water temperature and water flow rate to operate to the design conditions. Just like passive beams, performance is based on the difference between the average water temperature in the beam and the room temperature.

An additional safety measure may be included in the design to prevent condensation from occurring. Should the room dew point temperature rise above the entering water temperature, condensation sensors or humidity sensors may be installed to modify the entering water temperature or shut off the water flow. Refer to the sensor manufacturer’s verification instructions to verify operation. In the event there are no instructions, breathing directly on the sensor should be sufficient to activate the sensor.



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).**

Fume Hood Testing

Q

QUESTION: ***We have a project requiring ASHRAE 110 fume hood testing and certification. We have a Supervisor who has taken classes to perform the ASHRAE 110 tests. Our TBE is going to certify the hoods to AABC standards. Is there a problem stating that the hoods have been AABC certified and that we have also performed the ASHRAE 110 tests?***

A

AABC: ASHRAE 110 is a method of test for fume hoods covering the purpose, scope, definitions, instrumentation and equipment, test conditions, flow visualization and velocity procedure, tracer gas test procedure, and references.

According to Section 5.1 in the chapter on test conditions, "Airflow systems in the laboratory shall be properly commissioned prior to this test. This includes calibration of airflow controls, calibration of automatic temperature controls, balance of supply air, conduct of a duct traverse on the exhaust duct and, if used, on the auxiliary air duct, and balance the total exhaust flow."

Anyone testing fume hoods can follow that procedure and claim the hood is tested to that standard. Both AABC (in chapter 16.3 of the *AABC National Standards*) and ASHRAE allow smoke visualization; ASHRAE 110 has a procedure for tracer gas and also a test for variable volume hoods. Whoever is approving this test should verify the testing procedures used. AABC requires a Pitot tube traverse to establish airflow, while ASHRAE 110 states that the hood airflow is set in the commissioning process.

In general, I have always felt the best way to overcome the comments that something is tested to certain standard is to quote the specific standard test line by line and show the test results next to the quoted text. So in this case, the lab's airflow (supply and exhaust), temperature and airflow controls have been tested and balanced within the tolerances of the specification and AABC Standard. The test procedure for the fume hood followed chapter 7 of the ASHRAE 110 Standard.

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

Copper Pipe Leakage

Edward S Molnar, *TBS*
Dynamic Flow Balancing Ltd.

During projects in recent years, technicians have encountered a number of buildings where pinhole leaks have sprouted in the copper piping. Internal pitting of pipes is a rare occurrence; however, it is a very serious problem when it happens. Water damage can occur, and this can lead to mold concerns. Also, the expense of repairs can be considerable.

In some projects, the problem occurred in condominium developments. In one case, the copper tubing risers from top to bottom of a multiple floor high-rise building had to be replaced after repeated pinhole leaks, which was very costly.

Pictured above is the section of pipe that was leaking inside the wall of a building.

History of Copper Tube Usage

Copper piping is widely used in domestic hot water supply systems. Copper is easy to use and is resistant to corrosion. Since the early 1960's, copper has been installed in approximately 80% of all buildings.

Copper Corrosion (Known as Pitting)

Pitting corrosion is the most likely cause of pinhole leaks in copper pipe. Pitting is the non-uniform decaying of a copper pipe. Pitting is initiated by unknown factors, and then certain combinations of water chemistry allow pitting to continue, while other combinations do not. There are three classifications of pitting corrosion.

Type I Pitting

This is associated with moderately hard waters with a pH below 7.2. It is most likely to occur in cold water, and the pitting is deep and narrow, resulting in pipe failure.

Type II Pitting

This pitting occurs in certain soft waters, with a pH below 7.2. It is most likely to occur in water temperatures above 140 degrees F, and the pitting is narrower than type I, but however, still leads to pipe failure.

Type III Pitting

This pitting occurs in cold soft waters, with a pH above 8.0. This is a more generalized type of pitting, which tends to be wide and shallow.

Causes of Pinhole Leaks

Water velocity is one factor. Water velocity should be approximately 4 feet per second.

Excessive water velocity can erode the pipes' protective coating, creating areas of unprotected pipe. This proliferates a rapid rate of corrosion. The biggest impact of water velocity on the pipe occurs at locations where there is a change of flow direction.

Poor pipe installation can cause problems. Excessive use of fluxes is not recommended, as fluxes are corrosive by nature.

Soft waters with low pH, high suspended solids, assimilable organic carbon content (organic carbon in the water that can be used for microbial growth), water stagnation, low or non existent chlorine levels, maintaining water at temperatures that promote rapid growth of naturally occurring bacteria can all cause pinhole leaks.

Aggressive water (water containing high levels of acidity or chlorine) can promote pipe wear and subsequent failure.

Preventing Pinhole Leaks

Pinhole leaks can very expensive to repair when they occur in a building. The following steps can reduce the likelihood of this problem occurring in your building:

- Test water regularly to ensure proper pH levels and proper chemistry is maintained.
- Ensure the water velocity in the pipe is in the proper range.
- Ensure good workmanship in the soldering of the pipes occurs.

Proper design, installation, balancing (to ensure proper water velocities), and proper monitoring of water chemistry will go a long way in preventing the occurrence of copper pipe pitting. It is considerably cheaper, and less disruptive to prevent this problem than it is to deal with it once pinhole leaks begin.

DEVELOPING A DETAILED Testing & Balancing Plan

Mike Wozniak, *TBE*
Air Systems Engineering, Inc

The demand from building owners for contractors to maintain a construction schedule is growing every year. Building owners require a substantial construction completion date to be established and expect the construction team to meet this date to occupy the building on time.

Most of these construction schedules incorporate the testing and balancing at the end of the project, usually to receive a certificate of occupancy. Though it is all too often that adequate time is not provided for the testing and balancing contractor to complete the total system balancing prior to the completion date of the construction schedule. Failure to complete the balancing within the scheduled time can result in the general contractor, and more importantly, the building owner, being displeased with the testing and balancing company regardless of the quality of the final balanced systems.

A detailed balancing plan can help prevent conflicts with the construction schedule, and give the testing and balancing contractor adequate time and resources to complete the total system balance on schedule for the building owner.

Most project specifications for testing and balancing require a balancing plan; however, the specified requirements usually cover only the balancing techniques and/or testing procedures for individual systems and equipment. This information is helpful for the design engineer, but does little to assist the general contractor and building owner in developing a realistic construction schedule. A detailed balancing plan should also contain the required construction completeness prior to starting balancing, the estimated time required to complete the balancing process, and the building accessibility requirements to properly balance the systems.

Required Construction Completeness Prior to Start of System Balancing

Many of the construction completeness requirements prior to the start of balancing are not considered by the general contractor or building owner when developing a construction schedule. The portion of the balancing plan outlining the required construction completeness prior to starting the balancing should include the following:

1. All duct work and associated grilles/registers/diffusers installed and completed.
2. Piping systems completed, flushed and filled.
3. Equipment properly started by qualified personnel or start-up technicians.
4. Ceiling tiles installed.
5. Automation system (temperature controls) installed and completed for both air and water systems.
6. All equipment controlled in automatic ("Auto") mode.
7. Access granted to the balancing contractor to the automation/controls system provided.

The best time to submit a balancing plan is at the same time as the required mechanical submittal data.

Estimated Time Required for System Balancing

The balancing plan needs to describe in detail the required time to complete a total system balance. General contractors and building owners typically assume that the balancing process is something that happens all at one time, and if a schedule needs to be shortened then the balancing company can simply put more technicians on the project to complete the process faster. This is rarely the case. Many automation/control systems only allow communication with a few systems/equipment (sometimes only one) at a time. This makes it inefficient to have too many balancing technicians on a single project. It is also the balancing contactor's responsibility to address any issues, whether that is design or installation, which prevent a system from operating at design performance. The resolution of these issues by the responsible party may take several days, possibly weeks. The general contractor and building owner need to be notified of these possibilities when outlining a detailed time estimate for the balancing process.

Building Accessibility During the Balancing Process

The building accessibility during the balancing process is another matter that is usually overlooked during the development of a construction schedule. General contractors and building owners will typically overlap some of the finishing processes of the building construction such as laying carpet and tile flooring, waxing floors, and fire alarm testing.

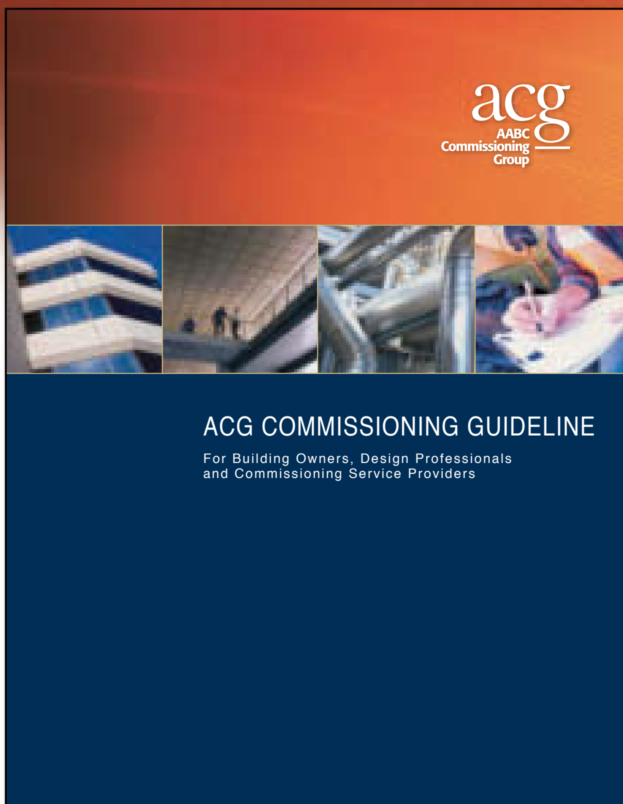
These are just a few of the construction processes that may interfere with the balancing process. Other issues such as lift work on finished floors and access above sheet rocked ceilings can also be obstacles for proper system balancing and should all be addressed in the balancing plan.

A detailed balancing plan should be submitted for most substantial size projects whether it is required or not. The best time to submit a balancing plan is at the same time as the required mechanical submittal data. A balancing contractor should also follow up with the general contractor and/or building owner to ensure that the balancing plan has been properly reviewed and incorporated within the construction schedule. Most of the details within a balancing plan are common to almost all projects. A well written balancing plan can be reused for future projects with little modifications.

Submitting a detailed balancing plan allows the general contractor and the building owner to develop a construction schedule that will incorporate a much more realistic balancing schedule, resulting in less scheduling conflict and a better reputation for the balancing contractor.

"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
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

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) 861-1458

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

(ABCO) 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

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.
San Francisco, California
(650) 583-9400

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

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

COLORADO

AirDronics, Inc.
Parker, Colorado
(720) 220-1062

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

Penn Air Control, Inc.
Kapolei, Hawaii
(808) 485-8880

Test and Balance Corporation of the Pacific
Honolulu, Hawaii
(808) 593-1924

ILLINOIS

United Test and Balance 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 Corp.
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 Corp.
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

Environmental Testing and Balancing of Nevada, Inc.
Las Vegas, Nevada
(702) 227-6950

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

National Air Balance Company, Inc.
(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., Inc.
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.
Bronx, 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, NC
(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
Cincinatti/Dayton, Ohio
(513) 248-4141

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

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

Precision Air Balance
Company, Inc.
Cleveland, OH
(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 & Sterling
New Cumberland,
Pennsylvania
(717) 232-0529

Kahoe Air Balance
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
Wes Laco, 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.
Addison, 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, TX
(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, TX
(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

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

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

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

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

Airwaso Canada, Inc.
London, Ontario
(519) 652-4040

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

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

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

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

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

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

Groupe Danco Televac, Inc.
Sherbrooke, Quebec
(819) 823-2092

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

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

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

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

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

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

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

INTERNATIONAL MEMBERS

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

Penn Air Control, Inc.
Kangbuk-gu, Seoul
South Korea
82-2-982-0431

Studio S.C.S.
Ingegneri
Scarbaci-Cuomo
Pordenone, Italy
39-043429661

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