TAB Journal

THE MAGAZINE OF THE ASSOCIATED AIR BALANCE COUNCIL • FALL 2014

AABC

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IN THIS ISSUE:

Transfer Air ■ Leak Testing and Verification ■ Indoor Air Quality

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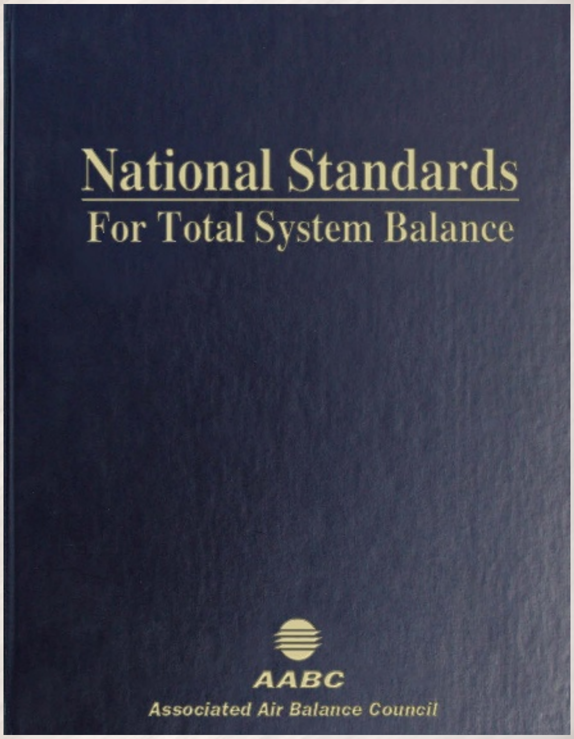

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From the Publisher

The Fall 2014 issue of *TAB Journal* examines the optimization of airflow within indoor environments. Bay to Bay Balancing, Inc.'s William Carson Judge, TBE, CxA, discusses Indoor Air Quality and what test and balance technicians should know about it.

John Bessent, TBE, of TAB Solutions, Inc. goes over transfer air and how it can be impacted by duct designs.

Craig Burrows, TBE, of National Air Balance Company LLC, looks at how smoke can be used within ducts to determine sources of leaks, and what types of smoke pose the least risk to the ductwork and indoor environments.

Brian Trogstad, TBE, of Design Control, Inc., makes the case for including duct leakage testing and verification within the initial project specifications, so potential problems can be prevented during installation.

Also in this issue, Environmental Test and Balance Company's Josh Green, TBE, talks about the proper calibration and testing of preheat coils.

Edward S. Molnar, TBS, of Dynamic Flow Balancing Ltd., presents several case studies in which the causes of system problems needed to be investigated.

And finally, Protab, Inc.'s Brian Corcoran, TBE, discusses the use of portable handheld ultrasonic flow meters and when they can be used most effectively.

We would like to thank all of the authors for their contributions to this issue of *TAB Journa*l. 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!

What TAB Technicians Should Know About Indoor Air Quality

William Carson Judge, TBE, CxA
Bay to Bay Balancing, Inc.

The Environmental Protection Agency (EPA) defines **Indoor Air Quality** (IAQ) as:

> "The temperature, humidity, ventilation and chemical or biological contaminants of the air inside a building."

This represents any condition inside the building that effects the health and comfort of the building occupants; including temperature, humidity, and the concentration of pollutants. The American Society of Heating Refrigeration and Air conditioning Engineers, (ASHRAE) defines **Acceptable Indoor Air Quality** as:

> "Air in which there are not known contaminants at harmful concentrations by cognizant authorities and with which a substantial majority (80% or more) of the people exposed do not express dissatisfaction."

Effects of Poor Indoor Air Quality

Poor indoor air quality contributes to a substantial number of health problems. Studies have linked it to poor performance in both the school and work environments. Effects can be immediate and the result of a single exposure or delayed, not showing up for years. Short term and immediate problems may manifest as allergic reactions, headaches, fatigue or asthma. At the other extreme, years of exposure to Radon may result in lung cancer. A single exposure to asbestos may cause mesothelioma, a fatal lung disease.

Different segments of the population may react differently to exposure. The very young, the elderly and those with suppressed immune systems may be much more likely to succumb to disease as a result of exposure. This increases the significance of these issues in schools, nursing homes and hospitals.

Causes of Indoor Air Problems

Pollution sources inside the building that release or off-gas pollutants can include, but are not limited to: air fresheners, smoking, perfume, cleaning products, cooking or process by-products, propane forklifts, boiler combustion by-products and off-gassing of chemicals by furniture, carpets and building materials.

Examples of outside sources of pollutants being taken in to the building through outside air intakes or infiltration into the building can include: radon, pesticides, atmospheric pollution, carbon monoxide and other combustion by-products from vehicle traffic.

The scope of indoor air quality extends to temperature, humidity and lighting within a facility.

ASHRAE Standard 55-1992, *Thermal Environmental Conditions for Human Occupancy*, addresses the most common factors related to the comfort of occupants within the space and addresses temperature, radiation, humidity, air movement, temperature stratification and drift as well as factoring in the clothing and activity level of the occupants.

The conditions outlined below are guidelines from the standard that satisfy the thermal comforts required by the standard.

VARIABLE	WINTER	SUMMER
Dry Bulb at 30% RH	68.5°F - 76.0°F	74.0°F - 80.0°F
Dry Bulb at 50% RH	68.5°F - 74.5°F	73.0°F - 79.0°F
Wet Bulb Max	64°F	68°F
Relative Humidity %RH	30% - 60%	30% - 60%

In addition to comfort issues, extremes in temperature and humidity can also exacerbate other potential sources for IAQ problems. Higher temperatures increase the reactivity of chemicals and accelerate off-gassing of compounds from building materials and interior furnishings. Increased humidity raises the risk of microbial growth and proliferation.

Beyond the physical values of temperature and humidity, many other factors can contribute to the perception of comfort. Air movement also plays a large role in thermal comfort. The lack of air movement can create a sensation of hot/stuffy air. Increased air velocity on the skin accelerates evaporation of perspiration which increases cooling. The same higher level of air movement can induce a chill in others. The goal is to find the balance of these variables that will provide the client with the highest level of satisfaction.

Increased humidity is a major cause of mold growth within the building environment. In high humidity parts of the country, it can be a considerable detriment to indoor air quality. The conditions for mold to grow require three components: mold spores, a media to feed on and moisture. Mold spores are essentially everywhere and mold is capable of using most media as food sources, including drywall, ceiling tiles, carpet and wallpaper. That leaves the control of moisture as the only practical method to control the growth and proliferation of mold.

Control of Indoor Air Quality Issues

Control of indoor air quality is typically addressed at three levels. The first step is administrative controls. Some examples of administrative controls are:

- Making decisions which would prevent the source of the pollutant in the first place.
- Having a no smoking policy or using a different process for an in-house procedure.
- Choosing low emitting products for maintenance and cleaning.
- Isolating some processes in a remote location.
- Whenever practical, administrative controls are the best solution.

There are times when because of financial cost or sheer practicality, an administrative control cannot be used; in such cases engineering controls provide the next best solution. Engineering controls utilize a line of defense to separate the sources of pollution from the occupants in the conditioned spaces. These controls may:

- Utilize pressure barriers such as those seen in fume hoods or in isolation rooms operating under a negative pressure.
- Employ physical barriers such as a glove box in a laboratory or special filtration procedures.

There are times when the contaminant in the space does not come from one point source. This can include the off-gassing of chemicals from building materials, cleaners used to clean and wax floors and body odors from building occupants. To address issues such as these, the best solution implements the third level of control, *dilution ventilation*.

- One such solution is to introduce large amounts of fresh air to dilute the concentration of the pollutant to a level where it does not pose a problem.

TAB Related Issues

It is not the TAB technician's job to design the project, but there are many aspects of the job that can ensure the design intent is fulfilled and the building occupants are provided a healthy facility for their use.

Ventilation is probably the single item over which we have the greatest influence. Most buildings are designed with criteria based on ASHRAE Standard 62, *Ventilation for Acceptable Indoor Air Quality*, which has become the generally-accepted standard for commercial buildings in the United States. This standard combines many parameters to designate the appropriate amount of fresh air for a given space, such as the number of occupants, square footage of the space, the intended use of the space, building schedules, etc. This replaces older references to a fixed CFM per occupant.

Many systems use carbon dioxide (CO_2) levels as criteria to control outside air levels. CO_2 occurs naturally in the atmosphere typically at levels around 400 parts per million (PPM). Many control systems are designed to increase the outside air when the CO_2 level reaches a set value, typically 1000 PPM. CO_2 itself is not a problem at these levels: OSHA sets their permissible exposure limit at 5000 PPM. CO_2 is used instead as an indicator of the ventilation effectiveness. If CO_2 levels are rising to the 1000 PPM level due to generation from the human occupants then it follows that other pollutant levels will rise to potentially unsafe levels.

Outside air flows should be set up so that they satisfy the requirement outlined in the project documents under all conditions. If outside air flow is set on a VAV system at 100% flow then the same system may not provide the design requirement in a minimum flow condition when all terminal unit boxes are satisfied or in a heating mode. While some control systems accommodate such conditions many do not. A failure to meet the design in all modes should be reported and corrective action should be implemented by the project team.

Intermittent Occupancy

Rooms hosting large groups such as classrooms, conference rooms or training spaces often have intermittent occupancies. ASHRAE allows the outdoor air requirement to be based on average occupancy as long as the peak occupancy is for a period of three hours or less. There should never be less than 50% of the maximum.

Many systems are wired such that the fan shuts off when the system is satisfied. Under such conditions the system is not meeting the requirements of the project documents and corrective action is required.

Sometimes the outside air itself can cause problems. In warm, humid environments a constant volume unit when satisfied may shut down the coil at the thermostat while the fan continues to bring humid unconditioned air into the space. When the air hits cool surfaces in the space the moisture in the air condenses and provides an avenue for mold propagation. Outside air can also be the source for pollutants. Outside air intakes situated over loading docks may capture truck exhaust and bring it into the space. Exhaust fans discharging polluted air, if located near outside air intakes, may result in kitchen or sewer gas odors being carried into the occupied space. In the worst case you may be exhausting air from an isolation room or chemical fume hood which can then be carried back into the space, resulting in dangerous conditions for the occupants.

Building pressure for most facilities is designed to be neutral to slightly positive. There are exceptions to this such as laboratories, restrooms, etc. which maintain negative pressures by design. In most conditions the amount of outside air will exceed the amount of exhaust air for a given space; this ensures that slight positive pressure and minimizes the chance for infiltration.

An excess of air can lead to over-pressurization of the building and result in problems with doors closing and bubbles in roofing membranes.

Building changes can result in creating IAQ problems where there weren't any previously. Often walls are moved around, creating areas with no return or poor air mixing. Problems such as these are frequently seen in tenant modifications in office buildings.

LEED IEQ Requirements

Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of buildings. It was developed by the US Green Building Council to help designers, builders and owners create and use their facilities efficiently while promoting the concepts of sustainability.

Part of the LEED scoring process involves indoor environmental quality. It has two prerequisites required to certify the facility and numerous other credits which are optional opportunities to gain points and improve the overall score of the facility. Below are listed those that pertain most to the TAB industry.

▶ ***Pre-requisite 1***

1. Minimum IAQ performance meet requirements of ASHRAE 62.1-2007

▶ ***Pre-requisite 2***

2. Control of smoking in and around the building

▶ ***Credit 1 (Outdoor air delivery monitoring)***

1. Provide monitoring of outdoor airflow or
2. Install controls based on CO_2 levels in space

▶ ***Credit 2 (Increased ventilation)***

1. Increase outside air ventilation rate by 30% over ASHRAE 62.1-2007

▶ ***Credit 3.1 (IAQ management plan during construction)***

1. Integrate IAQ requirements into specification
2. GC creates comprehensive IAQ plan
   a. Avoid use of HVAC equipment during construction
   b. If HVAC equipment used install MERV 8 filters
   c. Cap and cover ductwork, grilles, etc.
   d. Use low VOC materials
   e. Install temporary barriers to separate construction from occupied areas.
   f. Maintain housekeeping with regular sweeping and damp mopping of space.
   g. Plan schedules to limit occupant exposure to construction area.
   h. Document with photos
   i. Replace air filters used during construction

▶ ***Credit 3.2 (Construction IAQ prior to occupancy)***

1. **Option 1** – Flush out building with fresh air. **Do a. or b.**
   a. Prior to occupancy flush out building at a rate of 14,000 CFM per square foot of occupied space. Maintain at least 60˚F and do not exceed 60% relative humidity.
   b. Prior to occupancy flush out the building at a rate of 3,500 CFM per square foot of occupied space. Ventilate once occupied at a rate of .30 CFM per square foot or the design outside air flow rate whichever is greater. Begin three hours prior to occupancy and continue during occupancy. Maintain the flush out until 14,000 CFM per square foot of occupied space has been delivered to the space.
2. **Option 2** – Conduct baseline IAQ testing prior to occupancy. Use EPA protocols test for the following: Formaldehyde, Particulates, Total volatile organic compounds, Carbon monoxide and 4-Phenylcyclohexane.
   a. One test per 25,000 square feet
   b. One test per floor
   c. One test per ventilation system
   d. Collect during the occupied mode for a minimum of four hours.
   e. Take samples between 3 and 6 feet
   f. Include areas with the lowest ventilation and highest source strength.

▶ ***Credit 5 (Indoor and chemical pollutant source control)***

1. Permanent entry way walk-off system at least 10 feet long
2. MERV 13 filtration on return and outside air intakes
3. For hazardous gas and chemical use areas
   a. Exhaust with rate of .5 CFM per square foot
   b. Use self-closing doors
   c. Use deck to deck partitions or hard lid ceilings

There are additional IEQ credits related to low emitting materials, acoustics, daylighting and ergonomics that have little involvement with the TAB process.

It is not the TAB technician's job to design the project, but there are many aspects of the job that can ensure the design intent is fulfilled and the building occupants are provided a healthy facility for their use.

Observational Analysis

A certified TAB technician should be aware of conditions which can contribute to IAQ problems. Below is a list of items which should be verified to minimize the chance of IAQ problems related to the HVAC system and its balance.

Coils

1. Are coils clean?
2. Are face velocities low enough to prevent water from being carried off of the coil?
3. Are there any leaks in the valving assembly?

Drain pans

1. Are there any leaks?
2. Is the pan installed so that it slopes to allow all water to drain from the pan?
3. Is there any sign of standing water in the pan?
4. Is there any evidence of biological growth in the pan?
5. Is the drain properly sized and installed?
6. Is the drain clogged?

Filters

1. Are filters clean?
2. Are filters properly sized?
3. Are filters tight fitting?
4. Does filter efficiency meet design requirements?
5. Air distribution & louvers
6. Do supply grills show signs of smudging or dirt patterns?
7. Are return air grills dirty?
8. Is the location of supply and return grills such that the air is not short cycling?
9. Does the throw of the air create drafts or interfere with the collection of air by hoods such as those used in laboratories or kitchens?
10. Does the location and throw of the grills in the room allow good air mixing in the space and minimize stratification of temperatures?
11. Are outside air louvers located in close proximity to exhaust discharge louvers?
12. Is the outside air intake in a location away from environmental pollution sources such as traffic, loading docks, dryer vents, downwind from stacks, etc.?
13. Is the outside air intake located near stagnate water sources?
14. Does the outside air intake have a fine mesh insect screen that can become easily clogged?

Ductwork

1. During construction is duct work protected from dust and debris?
2. Is duct wet inside?
3. Is duct work properly sealed? This is especially critical for return ducts which can draw in contaminants from the attic, basements, etc.
4. Are duct linings dry?

Exhaust Systems

1. Is discharge louver location far enough away from outdoor air intakes?
2. If this is local exhaust does it capture the source pollutant?
3. Is a source for makeup air provided such as undercut doors, transfer grills, etc.?
4. Does the space pressure meet the design requirements?

Economizers

1. Are the controls operating properly?
2. Can the system handle the latent load while in economizer mode?
3. Economizers are not typically used in hot & humid environments?

Cooling Towers

1. Is drift being minimized?
2. Is a water treatment program in place?
3. Is the proximity of the cooling tower to the outside air intake to close?

Humidifiers and de-humidifiers

1. Is there any indication of microbial growth?
2. Does the duct or liner near the equipment get wet?
3. Are drains functioning as designed?
4. Is potable water used in the humidifier?

Return air plenums

1. Are there any chemicals being stored in the mechanical room?
2. Is the plenum clean?
3. Are there exhaust ducts in the plenum which could be leaking contaminated air into the air stream?
4. Are there any water sources in the plenum that could contribute to microbial growth such as condensation on ducts and pipes, or leaky valves?

Boilers

1. Verify boiler room is under a positive pressure adequate enough to prevent siphoning of combustion gases from the flue.
2. Gaskets should be in good condition
3. No water leaks or drips
4. Verify location and height of exhaust stack will prevent the flue gases from being drawn into the outside air intakes.

While this outline is not all-inclusive, it provides a basis for understanding indoor air quality and the technician's role in the success of maintaining a healthy work space for customers.

If the tenant complains about temperature within a space, whether the door is open or closed may be a key factor. If the door is closed and room temperature is an issue, transfer air may be compromising the supply airflow.

Transfer AIR

John Bessent, TBE
TAB Solutions, Inc.

There have been many debates between the mechanical engineer community and the test and balance community on one particular topic, transfer air. Engineers are still trying to design better HVAC duct designs to adequately transfer the air, to include return and exhaust air systems.

The most common method used is the return air plenum method. This includes a large ducted return air plenum opening above the drop ceiling. The theory is to have the HVAC unit draw return air from each individual office space through a return air grille, then back to the plenum and eventually back to the suction side of the fan. For this to work effectively there need to be transfer air openings cut in the drywall separating the rooms above the ceiling.

Unfortunately, often during the construction process the transfers get missed. There have also been cases where openings were not cut large enough per specifications, or construction plastic did not get pulled from the transfer air ducts.

This can pose problems for the test and balance contractor. The TAB contractor needs to be aware of the design so they know how to properly balance the system. There are many times though, that due to time constraints this can get overlooked by the test and balance company. When dealing with plenum return systems it is always best to perform the test and balance with the doors closed, this way you can tell whether or not there is enough transfer path above the ceiling to the room, to properly transfer air out of the room and return back to the unit. If the room is balanced without a door there is still a good possibility that the supply airflow was not affected by a lack of transfer air and the space can properly maintain temperatures. However, in this case above ceiling inspection needs to be made to verify the presence of the transfers. If the tenant complains about temperature within a space, whether the door is open or closed may be a key factor. If the door is closed and room temperature is an issue, transfer air may be compromising the supply airflow.

If a TAB contractor is ever in this situation, the best way to handle it would be to insist that the test and balance be performed with the doors installed. If not, once the doors have been installed, the supply diffusers would have to be rechecked with the doors closed to ensure that the final airflow quantities are valid. There have been situations where the supply airflow had dropped by 10-15% when the doors were closed and the supply diffuser re-tested.

In a perfect test and balance world, the TAB contractor would not have to worry about this particular situation. As mentioned before though, time seems to be so limited when the balance company comes to the job and time does not allow waiting for everything to be ready, like it should be. So if doors are not installed at the time of test and balance, then the TAB contractor should count on another trip to the project in order to test once the doors are installed.

Commercial duct testing

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In the past, technicians would light a smoke bomb inside the duct and add pressure with a blower to find the leaks visually — however, many smoke bombs are toxic and leave residue in the ductwork.

Leak Testing with SMOKE

Craig Burrows, TBE, *National Air Balance Company LLC*

Many projects require the test and balance firm to perform pressure or leak testing of the ductwork. This is also a requirement in residential ductwork that is run in unconditioned spaces such as attics and unfinished basements or crawl spaces as part of the energy code.

One common problem has been found in many types of duct installations. The installer faces a challenge in determining the source of leaks. Even if the blower is left for the sheet metal contractor to use while attempting to seal the leaks, when technicians return to test the duct it still does not pass.

In the past technicians would light a smoke bomb inside the duct and add pressure with a blower to find the leaks visually. The problem today is that many smoke bombs are toxic and leave a residue in the ductwork.

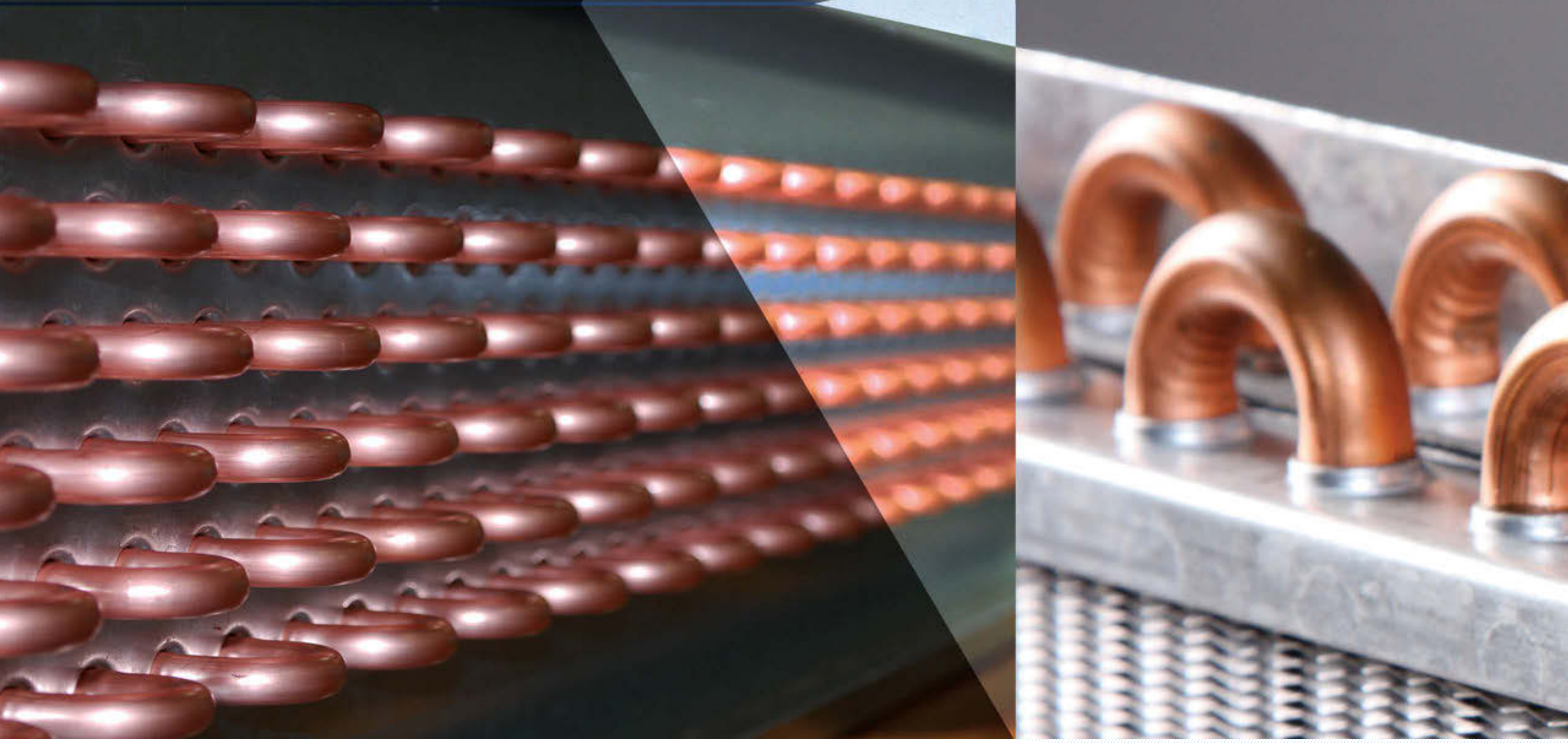
To solve this problem and still be able to visually identify the leakage a water-based fog machine can be utilized. The water-based solution leaves little to no residue. The smoke that is generated is the same that is utilized in theatrical performances and is nontoxic. Technicians have even utilized this smoke in ductwork that has the duct detectors installed without setting off the alarm, although doing this is not recommended without taking the fire alarm system off line.

There are two methods that can be used while performing the test with smoke. One is to fill the ductwork or "charge" the duct full with smoke. This can be accomplished by having an opening at the beginning and the end of the duct. Set up the fog machine and pump fog into the duct until it comes out the far end. At this point one opening is sealed, and a blower is attached. Note where the smoke emits from the duct. This method is best when there is sufficient manpower to watch for leaks on the entire duct run at the same time. This is because time is limited to determine the source of the leak, before the duct would have to be re-charged with smoke.

The other method is to introduce the smoke at the intake of the blower, using caution to adjust the smoke output to match the amount of air being moved by the blower. This method will locate the leaks closest to the blower first and may take multiple attempts to find the leaks at the further ends of the system.

Either method will help locate the areas that need to be addressed while leaving the duct clean from residue.

Whichever system is utilized there should be some advanced planning on how to remove the smoke from the area tested if the building is enclosed.



PREHEAT COILS

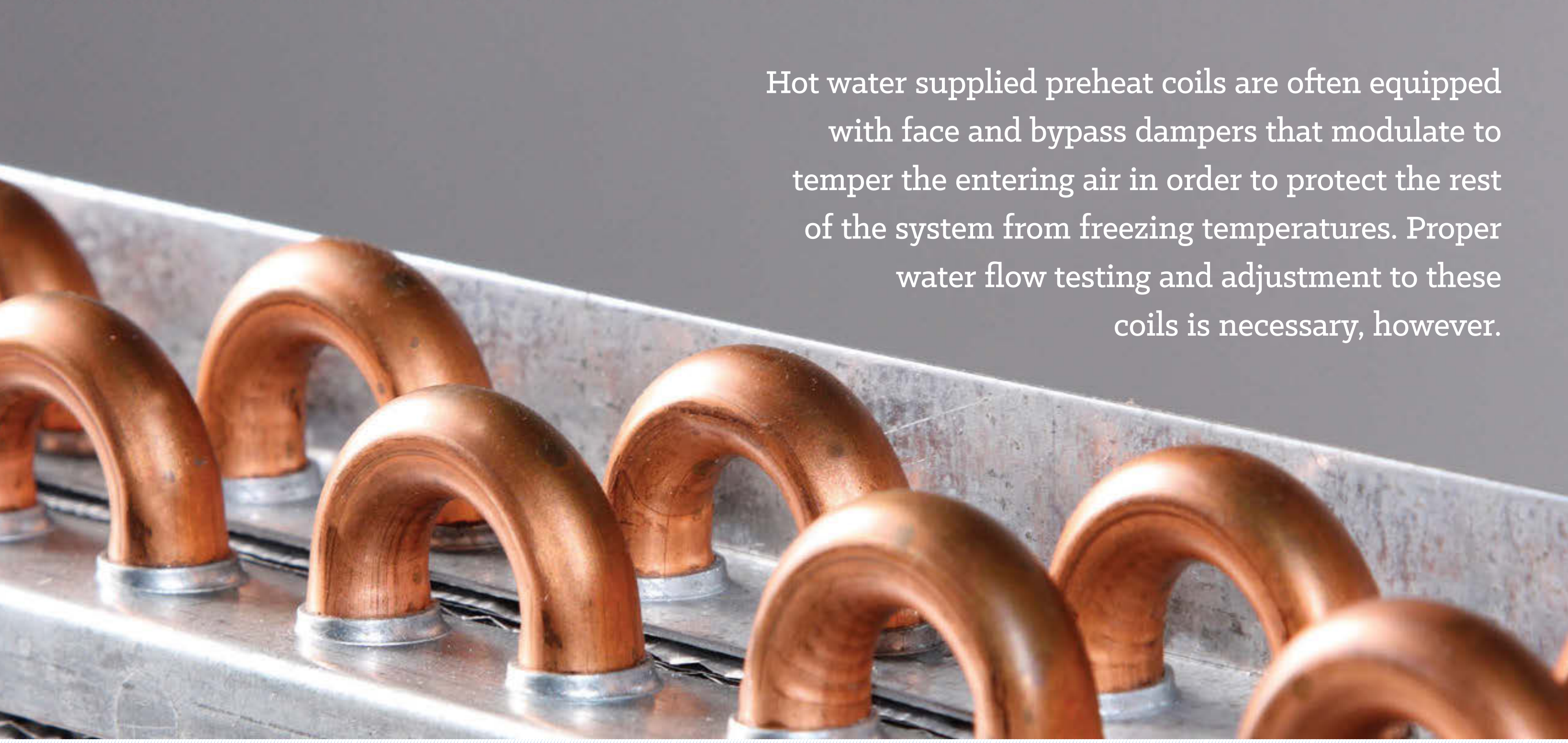
Josh Green, TBE
Environmental Test and Balance Company

Pre-heat coils that are installed in 100% outdoor air units and other systems that require a large percentage of outside air may use hot water, steam, electricity or natural gas as an energy source. Hot water supplied preheat coils are often equipped with face and bypass dampers that modulate to temper the entering air in order to protect the rest of the system from freezing temperatures. Proper water flow testing and adjustment to these coils is necessary, however. To verify the coil's performance, temperature testing should be performed during the heating season when the outdoor air temperature is optimum. The proper location of temperature and pressure ports (P/T ports), calibrated balancing valves (CBV) or circuit setters is necessary to verify the water flow quantity. The current equipment submittal data is also needed to compare the measured field data to the design specifications. Measuring flow by comparing the coil pressure drop to the design or measuring the circuit setter flow rate will confirm the coil temperature data, and provide a secondary means of flow measurement.

Conflicting temperature data on hot water coils that were balanced during the cooling season have been encountered on a number of occasions. One particular preheat coil that was balanced during the summer months was reported not to be heating properly when the cooler temperatures arrived. A calibrated balance valve was initially used to balance the water flow to the coil. At that time temperature testing was not performed due to the outdoor air conditions. A retest of the system was requested and the testing and balancing agency met with the controls contractor and the owner's representative to investigate further. Repeated freeze stat trips when the outdoor air temperature dropped below approximately 20 degrees F prompted the retest. The coil was designed to preheat the air to 55-degrees with a 0 degrees F entering air temperature.

During the test the pressure drop across the calibrated balancing valve was measured, which confirmed the correct water flow to the coil. Coil pressure drop was not used initially to confirm the calibrated balance valve reading due to the low rated pressure drop (0.17 PSID design). During temperature testing, however, the heat transfer capacity of the coil was not meeting the manufacturer's design performance data. The design entering water temperature and airflow were verified, as well as the face and by-pass control signal. A 100% output signal was being sent to the actuators which should have opened the dampers to allow full flow across the coils. Based on the measured GPM quantity at the calibrated balancing valve, and the entering air and water temperature, the specified capacity should have been available at the actual airflow.

Further investigation suggested that the dampers designed to bypass air around the coils were not closing fully. This would result in a larger percentage of air bypassing the coils than required. The apparatus was configured with vertical coils and dampers and designed to bypass some airflow around the coils but the submittals did not specify the actual bypass airflow quantity. According to the controls contractor, the bypass



Hot water supplied preheat coils are often equipped with face and bypass dampers that modulate to temper the entering air in order to protect the rest of the system from freezing temperatures. Proper water flow testing and adjustment to these coils is necessary, however.

dampers were fully closed yet low discharge air temperature continued to be a problem, so the actual water flow quantity was again in question.

A recheck of the water flow via the CBV and a secondary means of coil pressure drop verified correct water flow. Subsequently, the contractor was persuaded to adjust the bypass linkage. The coil capacity was re-measured and the final data revealed that the coil was operating much closer to design and the problem was resolved. The secondary means of measuring flow provided some assurance that the correct water flow was present and also directed attention to the problem with bypass dampers.

Circuit setters and calibrated balancing valves should be utilized to measure and adjust the actual water flow quantity based on the valve's pressure drop referenced to a chart or wheel. These devices should be installed to serve each coil. Limitations with these devices include:

- Often the manufacturer's upstream and downstream pipe diameter requirements are not met due to space restrictions.
- Pressure drops charts are not readily available or the valve model/reference tag has been removed (both are encountered frequently on existing devices)
- The required pressure drop at the design GPM quantity is less than 1.0 FT w.g. which often results in inaccurate or non-repeatable readings based on the chart or wheel GPM increments.
- Proprietary, expensive or impossible-to-find fittings are needed to access the pressure taps.
- Clearance issues with adjacent piping and obstructions prevent accessing the P/T ports.
- The final balanced position of the valve is almost closed making it a very effective strainer (this is most common on terminal unit re-heat coils).

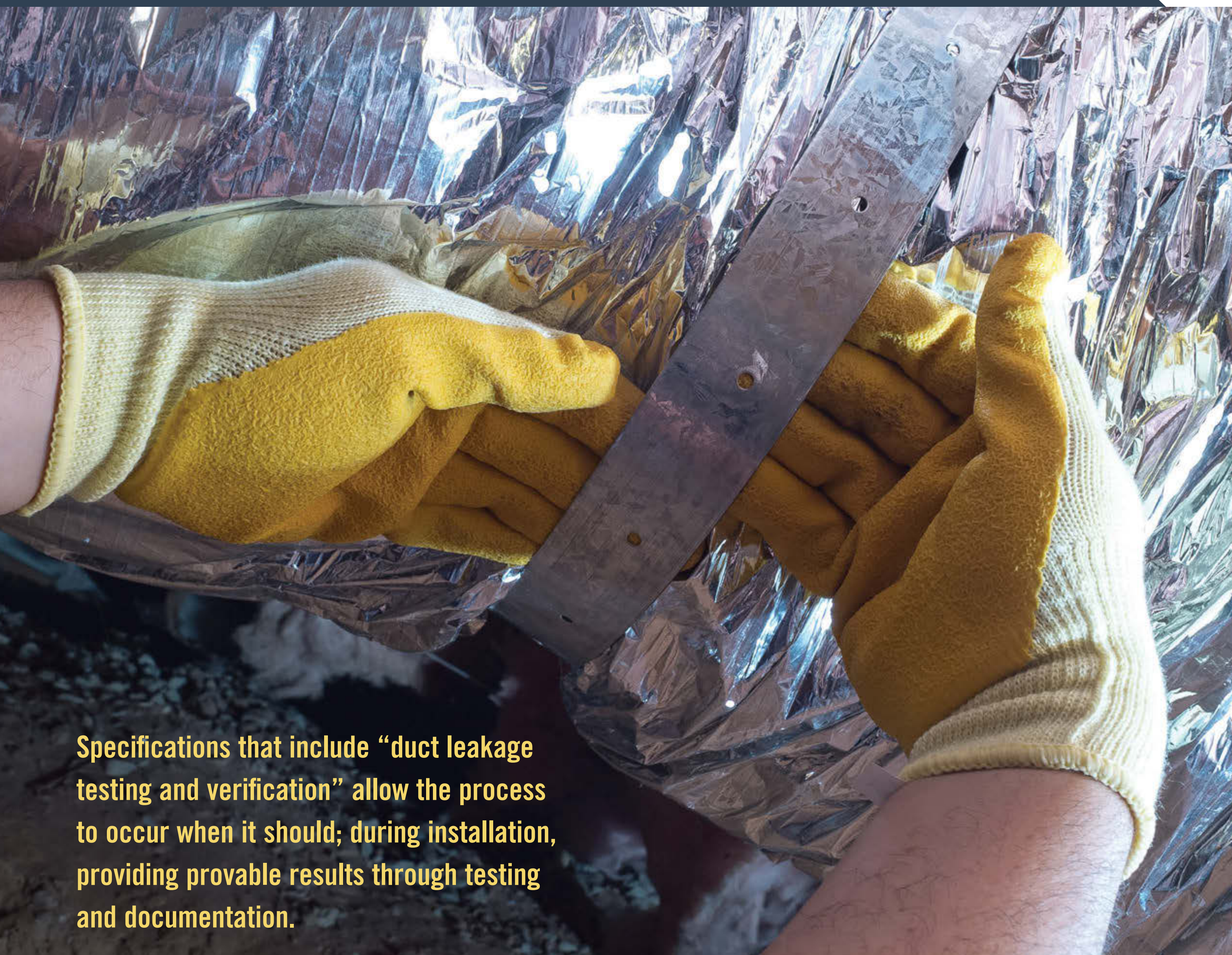
P/T ports should also be properly located so that the coil pressure and temperature drops can be measured accurately. Problems often encountered with these devices include:

- Location of the P/T ports results in more than the coil pressure drop being measured (strainers, valves and fittings become included in the measured pressure drop). P/T ports should be located as close to the coil as possible so that only the coil drop is measured.
- Excessive stand-off lengths prevent temperature probes to come in contact with the medium. Pipe stand-off lengths should not be excessive so that the probe can come in contact with the water.
- P/T ports are installed on the bottom side of the piping, which allows debris to clog the port.
- Clearance issues that prevent accessing the P/T ports.

Why Specify for

Duct Leakage Testing & Verification?

Brian Trogstad, TBE
Design Control, Inc.



Mechanical specifications are often very detailed but unless someone is there to enforce or prove the specified activity occurred, many items are not done proficiently or often go overlooked.

HVAC duct sealing is one area where various levels of quality will be achieved depending on what is specified. Not all projects or engineers specify duct leakage testing. This results in the quality of the workmanship often showing up during testing and balancing. Many times the quality of work is less than expected, resulting in excessive duct leakage. The results are often unacceptable to the mechanical engineer and out of the range for project specifications.

All mechanical specifications call for duct sealing but at times are vague and do not require testing and verification during the installation process to prove the quality of workmanship. For example:

- Seal ducts for duct static pressure and seal levels specified.
- Seal to eliminate duct leakage.
- Seal duct seams and joints according to SMACNA's HVAC Duct Construction Standards and as per pressure class.

These specifications expect a good sealing job, but do not go the extra step to require proper testing and verification. Vague specifications often result in mechanical contractors providing little or no duct sealing except in mechanical rooms or visible locations to satisfy "mechanical engineering walk through" requirements. Most projects could be sealed better without much more effort or cost.

When testing and balancing results show excessive leakage, contractors are often called back in to duct seal to improve results. This leads to duct sealing with ductwork that is either insulated, up against walls or ceilings, or completely inaccessible due to sheet rocked ceilings, chases or concrete. Even after many hours of time and effort, the results in most cases will fall far short of a properly sealed and tested system completed at initial installation.

On a recent law enforcement center project, the specifications did not require duct leakage testing and verification. The project consisted of two Air Handling Units which provided supply air to security cells. The units were fed fresh air from two Energy Recovery Units which then exhausted from the same security cells. Preliminary testing showed low exhaust air at the registers in the security cells and near design airflow quantities on the pitot tube traverse performed in the mechanical room. Duct leakage was approximately 30%-35% on each of the exhaust systems. The contractor was called back in to duct seal. The duct was sealed well on their return trip, however less than half the duct was accessible, as the other portion of the duct was located above the cells surrounded by concrete. Units were sped up slightly to achieve design airflow at the fan and registers were balanced proportionately. Duct leakage improved by approximately 9%, but remained well above a reasonable leakage rate.

Obviously the mechanical engineer was involved in the process, and there were some improvements in leakage results, but to a large extent there were limited options to resolve the problem. Because the system was not properly sealed, tested and verified during installation, permanent problems remained that could not be feasibly corrected. By the time testing and balancing occurs in the project, and all the other trades (electrical, piping, ceiling, insulation, etc.) are nearing completion, there is little chance 100% of the ductwork will be accessible for sealing.

Specifications that include "duct leakage testing and verification" allow the process to occur when it should; during installation, providing provable results through testing and documentation. Including this process during construction should provide reassurance to the owner, architect, engineer and mechanical contractor that time-consuming problems will not be occurring as the project is coming to a close, where timelines for project close out are always challenging.

Balancing RESCUE

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

Dynamic Flow Balancing is often called in by building owners and by mechanical engineers to investigate mechanical system concerns in buildings. This process involves testing and evaluating to determine root causes of problems, and then assisting the engineers in deriving solutions by providing them pertinent information. The end goal is to bring the building into proper balance, and achieve building environmental control as per the design intent. These are called Balancing Rescue Projects. **Here are some recent episodes:**

EPISODE 1 - The Imposter

In this case, the balancing report was rejected by the mechanical consultant, as it was not from a certified company. The mechanical subtrade contracted Dynamic Flow Balancing, informing us that all the balancing was completed, and that it would be a simple process of just measuring and reporting. They expected technicians would only be required for a few hours. In reality, it was more than three days.

Once on site, the measurements began. Pulley changes were required to bring some fan performance levels within the design parameters. Systems were found to be lacking sufficient balancing dampers, and these had to be installed before the systems could be properly balanced. Some systems were revealed to have sufficient dampers, but had not been balanced within the design parameters. Outlets that were shown on the drawings, were found to not have been installed. Some areas were revealed to have airflow levels 50 to 60 percent below the design requirements.

It was apparent why the initial balancing report had been rejected.

THE BOTTOM LINE: Specify a certified balancing company, and then enforce the requirement.

Ideally, the owner should hire a competent, certified company, early in the construction phase, and have them involved in the drawing and shop drawing reviews.

EPISODE 2 - The Impossible Measurements

An investigation was requested on a domestic hot water system, which could not provide properly tempered water throughout the building. A number of risers distributed the hot water throughout the multi-unit residential building, to provide hot water to each suite. Each riser had a circuit balance valve (CBV) to allow for measurement of the water flow to that riser.

A balancing report existed, and indicated that the design flows had been achieved on all the risers. As there were flow problems evident, the engineer questioned whether the flows to each riser were actually being achieved. Dynamic Flow Balancing was brought in to investigate.

The first step was to measure the pump flow, and it was determined the pump was achieving the design flow rate.

The second step was to measure the flow being supplied by each riser. The riser flows could not be measured, as the flow rates were much too low to provide a measureable pressure drop across the installed circuit balance valves' orifice. The circuit balance valves that the contractor had installed were oversized for the required flow rates.

The next step was to replace the oversized circuit balance valves with properly sized ones. The balancing was then properly performed and the system operated as designed.

Ideally, the balancing company is brought into the project early, and can review the circuit balance valves sizing before installation, ideally at the shop drawing stage. If such errors are caught at this stage, the solution is not costly. Unfortunately, if the problem is revealed after the warranty period, the contractor may not be willing to replace the valves with the correct ones, and it can become an owner's expense.

THE BOTTOM LINE: The balancing contractor should be brought into the project early enough to review the CBV sizing. If the incorrect sizing is caught prior to installation, it is an easy fix. Ideally, the owner should hire a competent, certified company, early in the construction phase, and have them involved in the drawing and shop drawing reviews.

EPISODE 3 - Under Pressure

Dynamic Flow Balancing was called in to investigate a building that was under a considerable amount of negative pressure. The building had been previously balanced, but the negative pressure was clearly a problem and the building owner decided to have this investigated.

The building had a very basic mechanical design. Heat pumps throughout the building handled the environmental control, while one heat recovery unit supplied outside air to the building. The exhaust air was comprised of the exhaust through the heat recovery unit, along with two kitchen exhaust fans, and two miscellaneous fans.

The testing revealed the heat recovery unit supply quantity was below design, while the exhaust was above design. This created an immediate negative pressure situation.

The kitchen exhaust fans were operating well above their design quantities, creating additional negative pressure and increasing the total level of negative pressure.

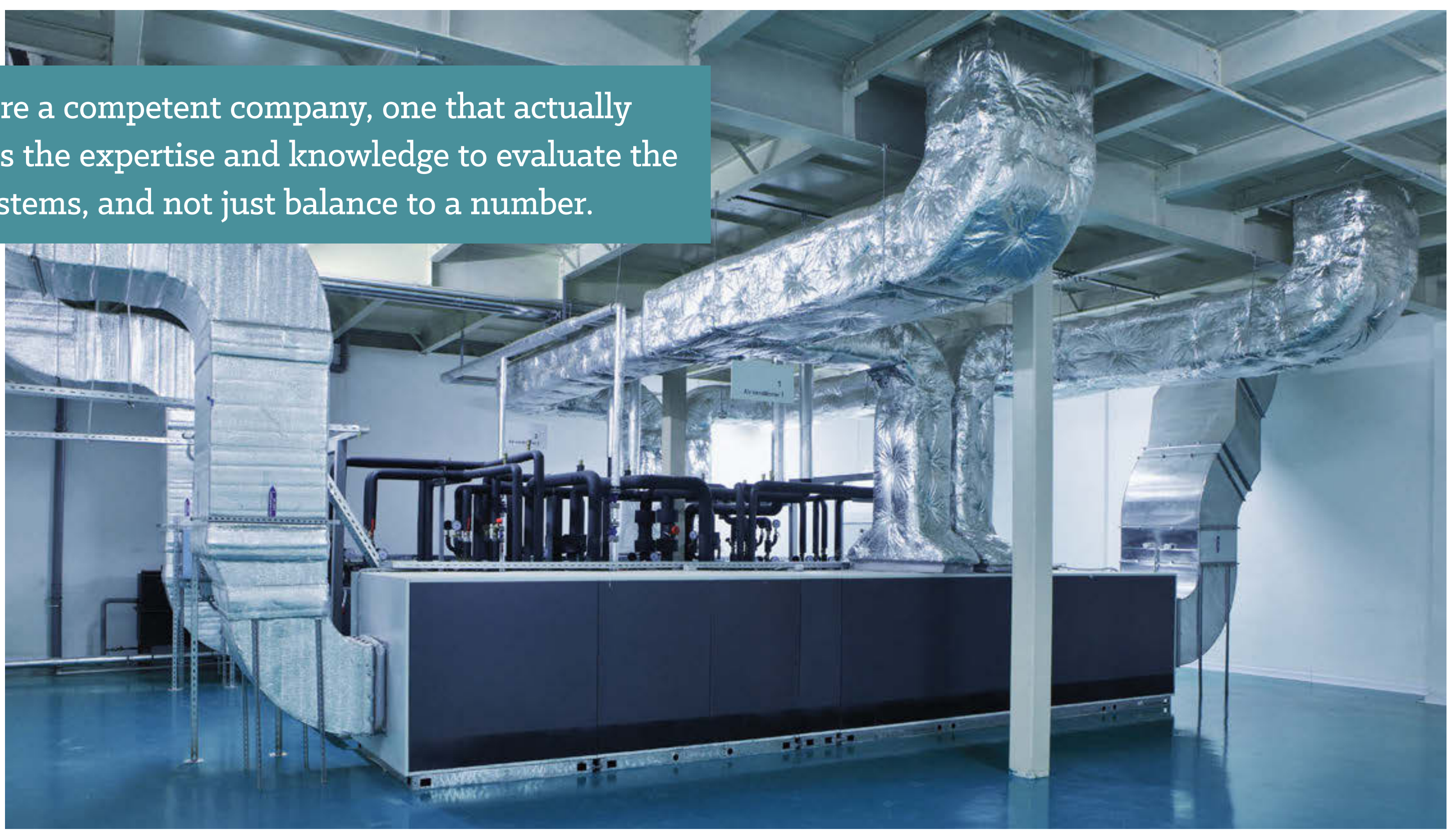
In essence, the initial building design placed the building in a negative pressure condition. The initial balancing report did not identify this. Then, by not balancing the fans to the proper design values, and leaving the exhaust fans above their design quantities, the balancer actually compounded the negative pressure problem.

Why is this building pressurization level important? Negative pressure means that the building is trying to draw in air from outdoors, through any opening it can. This results in unconditioned air being brought in, cold air in the winter, and warm air in the summer. Building occupants, in locations near where this infiltration occurs, may feel temperature fluctuations, and be uncomfortable. A very serious consideration is the drawing of moisture into the building envelope. This can result in mold growth.

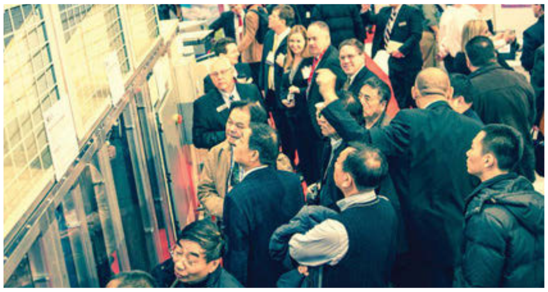
THE BOTTOM LINE: Hire a competent company, one that actually has the expertise and knowledge to evaluate the systems, and not just balance to a number. In reality, balancing can be performed within the 5 or 10% tolerances specified, however, if not reviewed thoughtfully can result in less than desirable results. For example: A supply and return fan combination, both rated for 20,000 CFM. The supply is balanced to 19,000 CFM and the return to 21,000 CFM. Both are within the design tolerance of plus or minus 5 percent, however this is an undesirable balance as the exhaust can actually be going out the outside air intake. The net effect is also a negative pressure of 2000 CFM, from this one system alone. Systems need to be looked at and evaluated as a whole. Balancing individual terminals, without looking at the overall system operation is simply insufficient.

In conclusion, hire a balancing company that is AABC certified, and that has the knowledge and understanding to provide great results. This will ensure a properly operating building for years to come, and can prevent the need for Balancing Rescue.

Hire a competent company, one that actually has the expertise and knowledge to evaluate the systems, and not just balance to a number.




GAS FURNACES



Although not cost-effective for everyday test and balancing, a hand-held portable unit can be carried and used to check unlimited measuring points throughout a complex hydronic system.

PORTABLE HANDHELD ULTRASONIC FLOW METERS

A Useful Troubleshooting Tool for Today's Test and Balancing Requirements

Brian Corcoran, TBE
Protab, Inc

Innovations in portable ultrasonic flow meter designs allow for much greater accuracy than older technology and, at a reasonable cost, have become a very useful tool in the diagnostic and troubleshooting portion of today's modern testing and balancing work. Although not cost-effective for everyday test and balancing, a hand-held portable unit can be carried and used to check unlimited measuring points throughout a complex hydronic system. With the proper transducers, a handheld unit can handle a wide range of pipe materials, pipe sizes and pipe schedules. As compared to measuring flow through field-installed fixed flow devices, which generally consist of measuring a pressure drop against a known pressure drop, the portable ultrasonic flow meter is continuously reading and displaying a direct flow reading.

Portable ultrasonic flow meters are especially useful for diagnosing issues with control valves that have a suspected issue concerning flow control. Many projects have been encountered with suspected control valve issues; notably, fully opening or fully closing due to field installed linkage issues. By monitoring flow during the full stroke of control valves, the portable ultrasonic flow meter can provide a flow profile within seconds, and linkage or valve seating problems can be quickly diagnosed and corrected. On one project, there was suspicion that one port of the control valve had a blockage and, by using the portable ultrasonic flow meter, the installing contractor could be shown the flow reduction as the valve modulated toward the suspected port. Since removing a large control valve in a filled hydronic system is somewhat labor intensive, the contractor finally agreed to remove the valve and it was discovered that the suspected port, which had a flow restricting wafer installed, had additional debris clogging that port.

Portable ultrasonic flow meters were successfully used in diagnosing suspected flow issues with an older chiller that did not have any field installed flow measuring devices. Verifying flow via the chiller pressure drop, which is normally very accurate on new equipment, was suspect on this chiller due to its age. The portable ultrasonic flow meter correctly and accurately showed that the flow was on design for this chiller and, after further inspection by the service company, it was discovered that the internal chiller baffles had deteriorated and were no longer intact, causing an inaccurate low pressure drop and also premature compressor failure.

Portable ultrasonic flow meters are especially useful in determining suspected leakage in underground piping systems. They have also been used for verification that manual shutoff valves are actually shutting off the flow 100% if required for any type of field service.

Portable ultrasonic flow meters are a valuable tool for use in modern day testing and balancing. They are most useful in situations where continuous flow readings are beneficial or in situations where no other accurate flow readings can be obtained. The portable ultrasonic flow meter is useful to measure flow in older systems where the installed gauge cocks and field installed flow measuring devices have corroded or deteriorated to the point that they cannot be used for any type of accurate field measurement without risk of damage due to breakage or leakage. Though not practical for everyday use, the portability, flexibility and accuracy of portable ultrasonic flow meters makes them a necessary tool for any test and balancing professional for hydronic system troubleshooting or problem solving.

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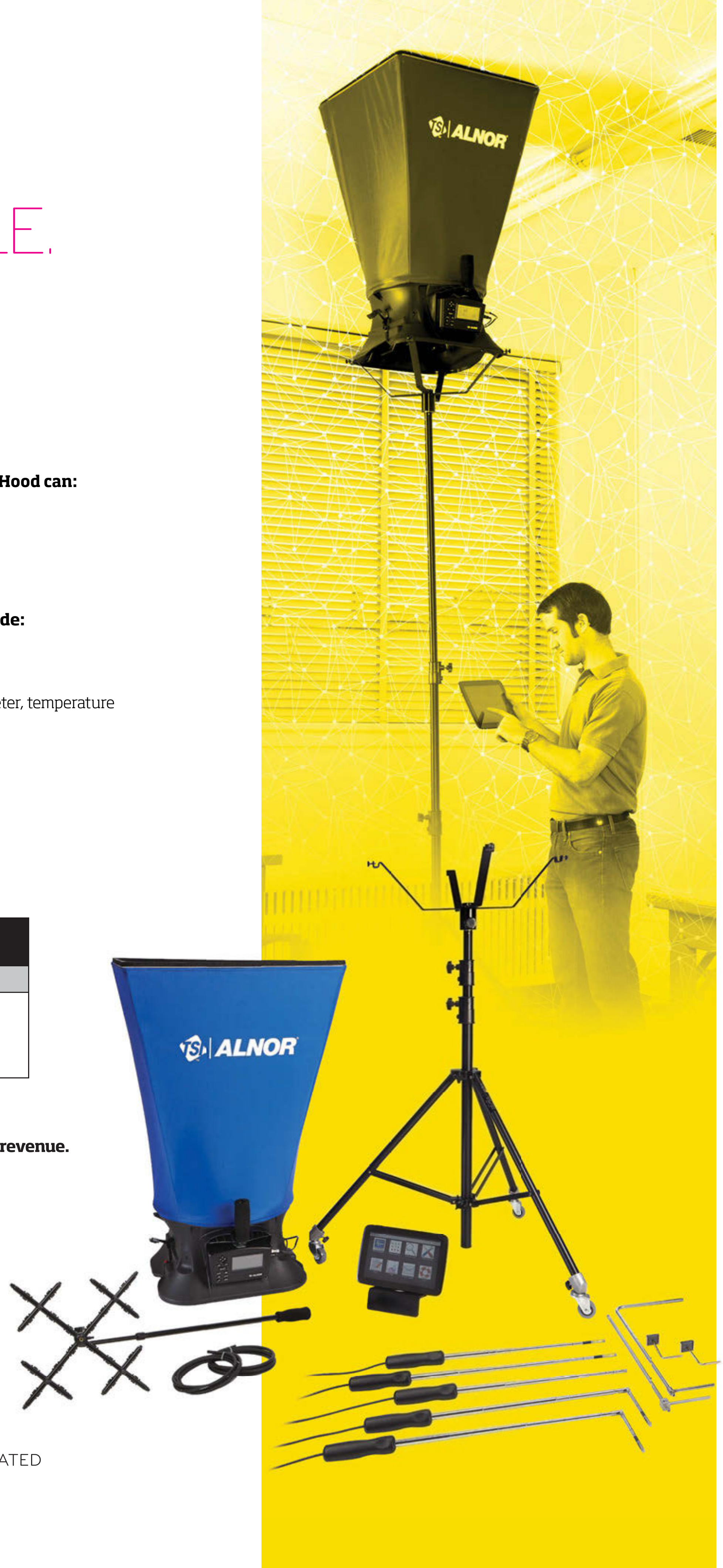

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