TAB Journal

AABC

THE MAGAZINE OF THE ASSOCIATED AIR BALANCE COUNCIL • SPRING 2016

Troubleshooting
for Optimum System Performance

IN THIS ISSUE:

- Balancing Out-of-Sync Cooling Towers
- HVAC and Fire & Life Safety
- Outside Air Monitors and Intakes

TAB Journal

From the Publisher

The Spring 2016 issue of *TAB Journal* looks at various approaches to troubleshooting in testing and balancing in order to obtain optimum system performance.

Robert Mugford, TBE, of Air Balance Company, Inc., looks at a case study involving out-of-sync cooling towers.

Joe Helm, TBE, of Northwest Engineering Service, Inc., addresses the interaction between HVAC and Fire & Life Safety (FLS) systems in the context of a hospital project.

Tommie R. Danley, TBE, and James Cook of Southern Balance, Inc., talk about a situation in which the supplied information was incorrect, and the difficulties that arose as a result.

Brian Kaupp, TBE, of Southern Independent Testing Agency, discusses the challenges in properly pressurizing buildings in Florida's tropical climate.

Jonathan Young, TBE, of Southern Balance Company, details a situation involving data logging at an odor treatment plant.

And finally, Richard Whitson, TBE, of American Air Balance Co., Inc., looks at advances in technology and where the responsibilities of the TAB agency fall as efficiency parameters change.

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

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WATER BALANCING OUT-OF-SYNC COOLING TOWERS

Robert Mugford, TBE
Air Balance Company, Inc.

According to manufacturer specifications, multiple cooling towers are to be installed in parallel with common supply and return piping. These cooling towers are to be set to manufacturer design setpoints to ensure synchronization and appropriate flow. Incorrect setpoints could cause one tower to overflow while air is being suctioned out of the other tower. This was the case at a site in Southern California in which the overflow of 3 cooling towers with a total of 6 cells needed to be resolved.

COOLING TOWER OVERFLOW PROBLEM

The Issue: cooling tower overflows were dumping water and makeup water was constantly running.

System: 3 cooling towers, 2 cells each, 6 cells total. 50 feet between each cooling tower with a slightly undersized equalizer line between each tower. Control valves installed on the supply line only with constant flow on the suction line.

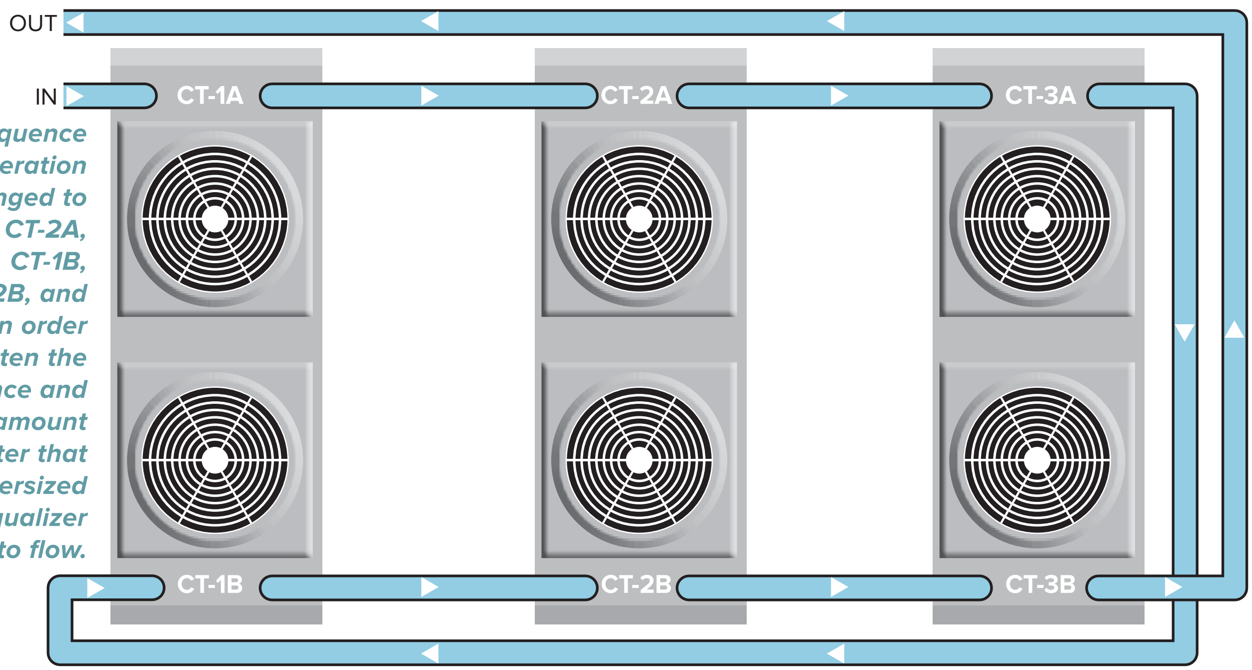
Initial Observation: Overflow levels were set correctly at 19 ¾”; however, the float for the auto fill stations was set at 18”. With CT-1A and CT-1B in operation, the basin levels would rise and overflow due to only 1/3 of the total flow supplied to the towers being directly returned to the pump. The other 2/3 of the flow traveled through the equalizer line to the other tower while CT-2A, CT-2B, CT-3A, and CT-3B basin levels would drop and the fill stations would start to introduce makeup water. This caused a constant flow of water to dump out the overflow.

Initial Balance: The first step was to set the floats on the autofill stations correctly. The manufacturer data showed that the level in the basin should be set at 9”; however, with the manufacturer supplied linkage, the basin level could only be set as low as 10 to 11 inches. After multiple calls to the manufacturer, no direct response to this issue had been given. The second step was to verify the proportioning of all 6 cells on the water being supplied to the tower. This was achieved by running all 6 cells with full flow and measuring the upper basin water level depth. A small amount of proportioning was needed and completed, leaving all 6 upper basins at an equal level and therefore equal flow. With no ultrasonic water meter on hand, the lower basin suction balance was completed by shutting the equalizer line valve and checking the basin level. If the basin level drops, suction flow is high. If the level rises, suction flow is low. Although time consuming with a few passes, the proportioning was within tolerable limit of basin levels raising and lowering.

Functional Testing: The sequence of operation calls for the staging to be CT-1A, CT-1B, CT-2A, CT-2B, CT-3A, and CT-3B. As the towers were staged, the pump speeds were established to provide full flow to the tower. Once the third stage was reached, it was observed that the offset between CT-1A and CT-1B, and CT-3A and CT-3B lower basin levels was at 8”. This was due to CT-3 only having suction flow and 8” offset was needed for the equalizer to provide flow to CT-3. This left the basin levels after the system filled 18” on CT-1 (very close to overflow) and 10” on CT-3. As the 4th stage was turned on, CT-1A and CT-1B started to overflow and the basin on CT-3A and CT-3B dropped to 8”. A 12” offset in basin levels was needed for the equalizer to flow the 50ft to CT-3. A 12” offset was too much based on our fill level of 10” and overflow of 19 ¾”. It appeared that the equalizer line was too small to provide the flow to CT-3 with suction only. The mechanical contractor did not want to go the distance of installing control valves to shutoff the suction line along with the supply in order isolate the individual cells, as that would be a very costly.

Final Fix: The decision was made to change the sequence of operation in order to shorten the distance and the amount of water that the undersized equalizer needed to flow. The new staging would be CT-1A, CT-2A, CT-3A, CT-1B, CT-2B, and CT-3B. This meant that when 4 cells were in operation each tower would have 1 cell with supply flow, and this would cut the total GPM that the equalizer must flow in half. After running through all the stages the worst case scenario put the basin offset at 8”. This resolved the issue putting the fill level at 10” and the highest basin level at 18” with no overflow.

The sequence of operation was changed to CT-1A, CT-2A, CT-3A, CT-1B, CT-2B, and CT-3B, in order to shorten the distance and the amount of water that the undersized equalizer needed to flow.



MEASUREMENT AND VERIFICATION FOR HVAC & FLS IN A HOSPITAL

Joe Helm, TBE
Northwest Engineering Service, Inc.

In some applications, the interaction between HVAC and Fire & Life Safety (FLS) systems can be a complex one. Smoke management, safety and security protocols depend on demonstrated operation of many devices, controllers, programming logic schemes, communication links and interlocks. All of these elements need to function as intended for a given mode of operation. Often overlooked is the actual performance of the building during an alarm event when HVAC system response is critical.

The test and balance professional has special skills and abilities that can verify whether or not these very important systems produce acceptable results. This article will focus on Fire Smoke Dampers (FSD), exploring several opportunities to add value to a project incorporating activities beyond traditional TAB scope.

During design, anticipated static pressure losses influence duct sizing and equipment selection. Significant impacts to these assumptions may stem from the number, location, aspect ratio, fit and reproducible operation of fire smoke dampers. "Functional testing" during the (re)commissioning process might show desired equipment response but "performance verification" may need the additional support of flow and pressure data gathered in the field by qualified TAB providers.

Consider the case of a recent hospital project commissioned by the firm with TAB services provided by others under a separate contract. The authority having jurisdiction required additional FSD in order to satisfy local occupancy zoning requirements. This increased the external static pressure targets of the air handlers, complicating duct design and coordination layouts due to accessibility and clearance accommodations.

Competition for floor space always impacts the size of equipment rooms, and this project was no exception. Layouts within the mechanical space added to the increasingly unfavorable downstream conditions by adding special fittings such as multiple mitered 90's, turning vanes and various other system effects at the fans, compounding the demand for more static pressure.

Photo 1

TAB-related problem equipment, and responses that occurred during integrated testing:

- **Testing of zone alarm events did not always shut down air flow as required:**
  - **Dampers appeared to be fully closed.**

    Static pressure measurements indicated leakage. Bore scope pictures indicated improperly sized damper sections. (See photo 3).
  - **In some cases dampers remained open; In other cases the dampers only partially closed.**

    Static pressure measurements helped track down which devices were not responding and whether or not responses were consistent.
- **Sometimes an air handler would shut down when it was not required to do so. Was this a programming issue or a performance problem?**

  Fans were required to operate at higher RPM and TSP in order to satisfy unexpected downstream static pressure requirements during normal operation. In an alarm condition, activating some FSD radically changed the pressure profiles, stiffening the system curve enough to create this condition. Duct high limit safeties were tripping.
- **In cases where an alarm condition was generated, some air handlers that were supposed to shut down would not always restart as required.**

  Timing issues with AHU isolation dampers, motor controls, and downstream FSD created unfavorable conditions in the system under test. Depending on the static pressure profile in the discharge duct work at the time the alarm was generated, high pressure safeties would trip requiring manual reset.
- **Repeated alarm generation with pressure testing at the same location indicated problems were not reproducible.**

  After sorting out explainable pressure related effects on performance, we discovered that the Fire Alarm & Building Automation Systems had mismatched baud rates. Depending on the level of network traffic, communication devices did not always broadcast or receive complete instruction sets in the data packets. Resolution of this condition led to repeatable test conditions reproducible results.
- **Required air delivery rates for some TU's did not match the values indicated in the TAB report.**

  Static pressure measurements indicated high drops across coils which did not correspond with calculated values using engineering data from the submittals. Device information stickers that had been attached to assemblies (See photo 4) were found on the inlet side of several reheat coils, reducing flow and increasing the differential pressures.

Photo 2

The balancing contractor was able to produce a report documenting full flow through all terminal units on a zone by zone basis. Operating data on the fans characterized irreproducible test conditions, demonstrating design CFM delivery but providing no information regarding distribution effectiveness. The balancers considered their work complete. During normal operation however, various branches on several different air handlers were starved for airflow. As might be expected, these conditions were worse during full cooling. The TAB contractor failed to identify critical issues regarding intended operation. A performance problem was beginning to surface.

Meanwhile, functional testing of the FLS system ultimately verified operation of components at the zone level. This included pull stations, lights and horns, fire and smoke detectors, FSD response, magnetic door holders, door access control and alarm panel annunciation. Pressure relationships among different occupancies needed to be verified for compliance and documented for both normal and alarm conditions. When the FLS system was tested on a larger scale, by floor and by system, results were not reproducible, and equipment response appeared to be random. Reliance on control system graphics certainly was not likely to produce an understanding of what was wrong.

TAB technicians from the company were brought in to work with commissioning personnel in order to characterize the problems. Although capacity testing is still done as a matter of course, this type of testing is not generally done by other balancing firms. TAB data gathered for these conditions is invaluable to the commissioning process. On problem fan systems, operating data is needed for the system during 100% Heating at minimum outside air (MOSA), 100% Cooling at MOSA, 100% OSA. In hospital occupancies, documenting relative room pressures are also important under these conditions.

It was necessary to know what static pressure was required to maintain terminal unit controllability, even if it turned out to be unachievable in the 100% cooling condition (Control schemes that poll TU damper positions to reset fan speeds do not provide this crucial information). Static pressure profiles were needed for some branches to identify unreasonable duct and fitting losses. In some cases, suspect locations were examined in greater detail to explain anomalies.

Testing protocols may not always produce the desired component response, but in any case repeatable results should be achieved every time a sequence of operation is tested. If this is not the case, it is an indication that more needs to be understood about the engineer's design, equipment selection, sequences of operation, acceptance criteria, control programming and component configuration. This is as true for testing and balancing as it is for commissioning activities. By their very nature, these professional services are complimentary to one another.

There is more for a commissioning provider to consider when reviewing a TAB report than just looking at balanced zone distributions or fan operating data that support design flow rates. As this example demonstrates, successful integrated operation of the HVAC and FLS systems is dependent on establishing confidence in both equipment function and system performance. TAB techniques are extremely useful in troubleshooting, problem resolution and documenting important elements in an operating facility. Acceptable performance of critical systems cannot be assured by functional testing alone.

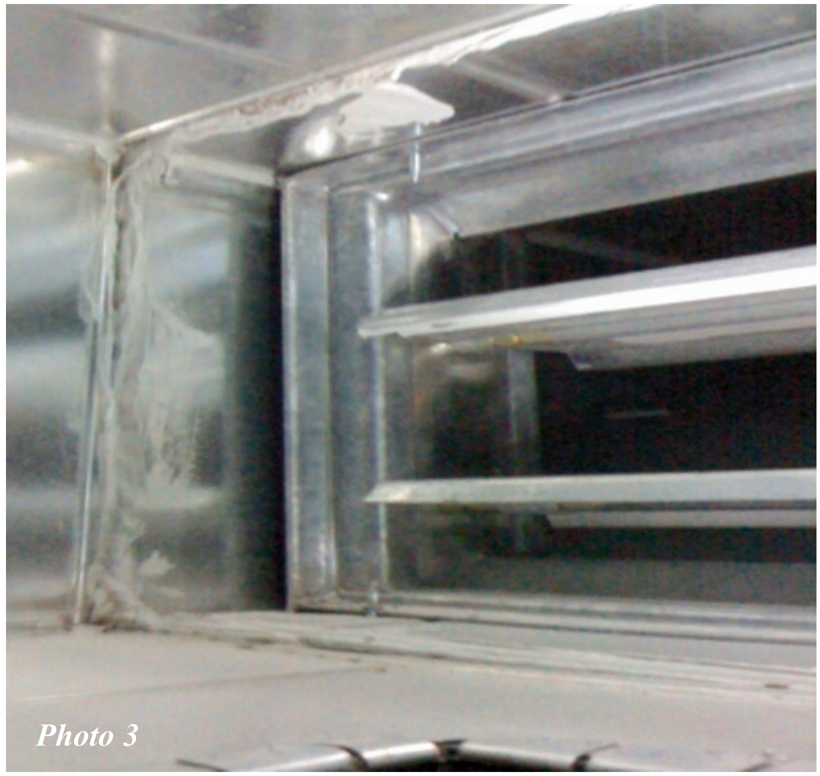


Photo 3

Photo 4

SOMETIMES THE INFORMATION IS WRONG

By Tommie R. Danley, TBE, and James Cook
Southern Balance, Inc.

A local utility administration office required balancing services. It was a medium size project: Two McQuay air handlers, (12,000 and 17,000 CFM), 42 pressure independent VAV boxes with hot water reheat, ±200 grilles and associated exhaust fans and three water cooled chillers and three pumps. The air side, hot water and condenser water balancing went well, and commissioning was no problem. But the chilled water system presented difficulties.

The chilled water system was constant flow, with a three way valve being controlled by a flow station with a digital readout, which maintained constant flow through the three chillers. The system also had a flow monitoring station for total flow before the coils. The two AHU's had two-way valves. The system had automatic flow balance valves. The whole piping system was only 80 to 90 feet from one end to another. This should have been a very simple and self-balancing system.

AHU-1 design coil DP was 10.2' at 114 GPM. The measured DP was 14.0' at 133.0 GPM.

AHU-2 design coil DP was 9.9'; at 152.0 GPM. The measured DP was 13.0' at 174.0 GPM.

The three chillers were design for 3' at 110 GPM. The measured DP at each chiller was 5.5' at 149 GPM each for a total of 447.0 GPM.

It should be noted the chiller total (330.0) and AHU (266.0) and pump total (320.0) were different by 67.0 GPM. The difference from the AHU and chiller flow was diverted through the three way valve to keep the chiller flows at design.

The system also had a flow monitoring station for total flow before the coils. The two AHU's had two-way valves. The system had automatic flow balance valves. The whole piping system was only 80 to 90 feet from one end to another. This should have been a very simple and self-balancing system.

The pump was set for the design GPM of 320. Differential pressure (DP) was read on the auto flows and the DP was 3 to 4 PSI. Both flow readout stations were calibrated and reading 318 and 321 GPM. But when DP was read on the coils to the AHUs and the chillers, none of them came close to what the auto flows said the flow rate was.

The pump was set up for 320 GPM.

Surveying the test results of total pump flow of 320.0 GPM, coil total of 307.0 GPM and chiller coil flow of 447.0 GPM, something appeared to be wrong.

It was verified that the water system was clean. The contractor was directed to take one of the auto flows apart just to ensure that was clean and check the strainers. Testing was conducted again with another meter and hoses to rule out equipment error.

Once it was determined that it was not equipment or human error, another TAB company was called in to make sure. Their readings were very similar to readings originally conducted. The conclusion was drawn that some of the information given at the start had to be wrong. The mechanical contractor was asked to verify the equipment submittals were correct for the equipment installed, as there had been some equipment changes early on in the project.

The mechanical contractor came back with revised submittals for the air handler coils, but said the chiller data was correct. Flows were recalculated:

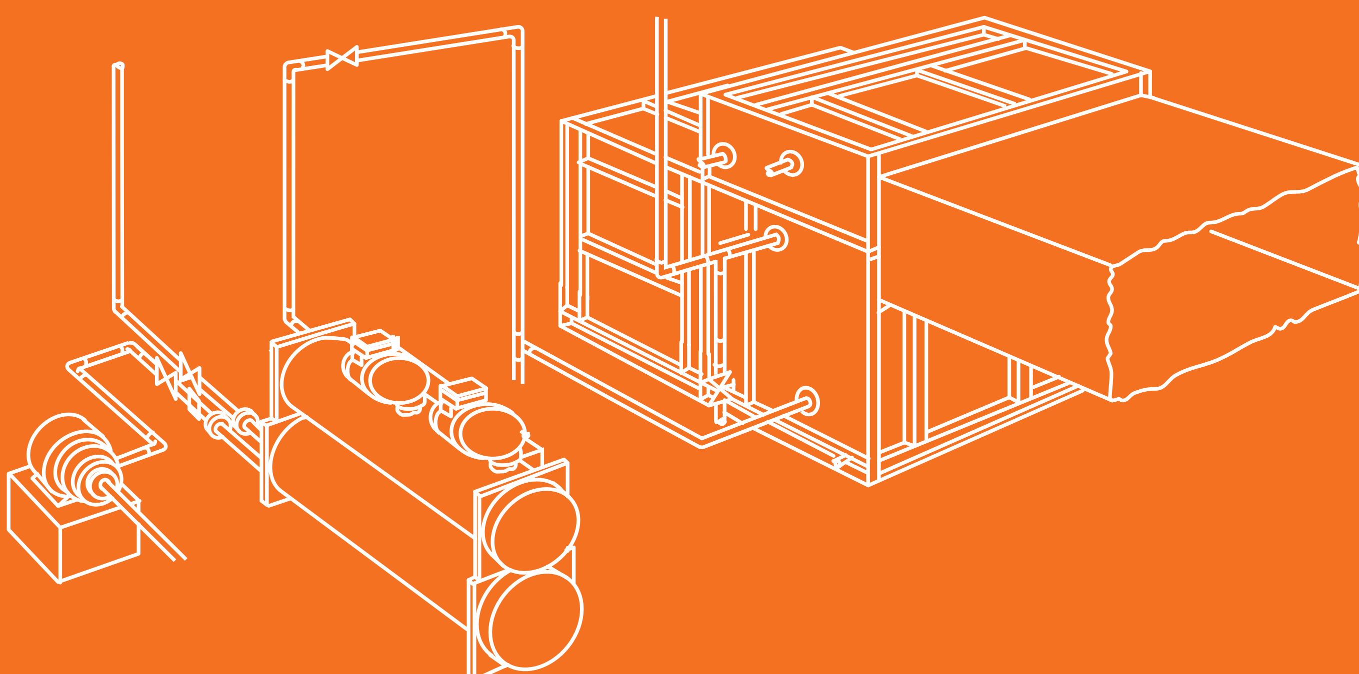
AHU-1 design coil DP now was 16.2' at 114 GPM. The recalculated GPM at 14' was 106.0 GPM

AHU-2 design coil DP now was 12.9' at 152.0 GPM. The recalculated GPM at 13' was 152.0 GPM

This put the Pump total at 320 GPM, the AHU coil total at 268 GPM, the flow stations at 318 at 321 GPM, but the chiller coils still tested at 447.0 GPM. All five of the auto flow still had a DP of 3-4 PSI.

The chiller data was still believed to be wrong. A chiller with this high of flow would not function for long without some kind of problem. How to prove it was another challenge.

...it was decided to isolate one chiller and one coil so water flow could be verified through the air handler coil and the chiller coil.



The ambient temperature was in the low 30s to 40s so the chillers could not be loaded to test by the temperature methods. A quick temperature test was conducted and it showed the flows were around 100 GPM on the chillers. This lent further credence to the theory that the chiller submittal data was wrong, though it remained unproven.

Because the pump flows, flow stations and coil drops for the air handlers could all be proven, it was decided to isolate one chiller and one coil so water flow could be verified through the air handler coil and the chiller coil. AHU-1 was used at 114 GPM and Chiller 1 at 110 GPM. The control contractor was directed to lock all of the two way valves to 100% flow and the three way to 100% through the chillers. AHU-2 and Chillers 2 and 3 were manually locked out of the system flow. This left only AHU-1 and Chiller 1 with water flowing. Auto flows were tested on both coils; both were operating at 20-21 PSI. The flow station read outs were 112 and 110 GPM. The pump tested at 116.0 GPM. The air handler coil DP tested at 17' for 115 GPM, but the chiller coil DP tested at 6' for 155.5 GPM. With this it could be determined the chiller coil data was wrong. The test procedure could be verified by opening any configuration of AHU and Chiller flows and accurately predicting what the flow stations would read by picking the design flow of the auto flows selected.

With this information a call was placed to the contractor and commissioning agent to meet on site. The testing procedure was followed with them before the retest began. Again the pump and flow station flows could be predicted.

The mechanical contractor went back and contact the chiller manufacture and again requested that the submittals be verified. It was later determined the coils on these chillers were different than what that standard model chiller should have had. The new design DP was 6.0' for 110 GPM. This put the pump at 320 GPM, the AHU coil total flows at 268 GPM, the flow station at 317 @320 GPM and the chillers at 315.0 GPM total.

In conclusion, sometimes experience indicates that the information given is just not right. This was the first time encountering a situation where the submittal data and what was actually there were so drastically different. It just goes to show, new is not always good, and the supplied information can be wrong.

FLORIDA TESTING AND BALANCING OUTSIDE AIR MONITORS AND INTAKES

Brian C. Kaupp, TBE
Southern Independent Testing Agency

> “Most manufacturers have installation guidelines to ensure minimum duct diameters are met on the front and back side of the monitor for proper operation.”

A properly pressurized building is very important in Florida; especially with its tropical environment which can play havoc with the indoor environment of the building. One way to ensure the quality of the building environment and pressurization is to directly monitor the outside air flow rate.

The outside air monitor can be a big part of how a building performs; but installation issues along with location issues plague not only the test and balance firms, but the performance of the building. Although pressurization is not the sole source of moisture issues or indoor air quality issues, it is a major cause of the "M" word—mold.

Most manufacturers have installation guidelines to ensure minimum duct diameters are met on the front and back side of the monitor for proper operation. When these guidelines are followed, not only does the monitor function properly, but they can be calibrated and validated.

It is important to not forget rooftop units with outside air intakes. Location and accessibility is just as important in order to test and set. Included here are pictures of a recent project showing issues TAB firms have with accurately setting the outside air. Problems for the TAB firm service personnel include:

- Accessibility to test outside air
- No access to the motorized damper to adjust settings.
- Roof line and gutter route rain water to the top of intake.

Properly placed and installed monitors and intakes allow accurate testing and balancing which lowers your start-up, maintenance cost, reduce energy consumption and improve control of the HVAC system.

Poor location/placement of a roof top unit (RTU), indicates the potential roof rain water being directed towards the outside air intake along with access issues for service.

DATA LOGGING AND INNOVATIVE AIRFLOW TESTING

Jonathan Young, TBE
Southern Balance Company

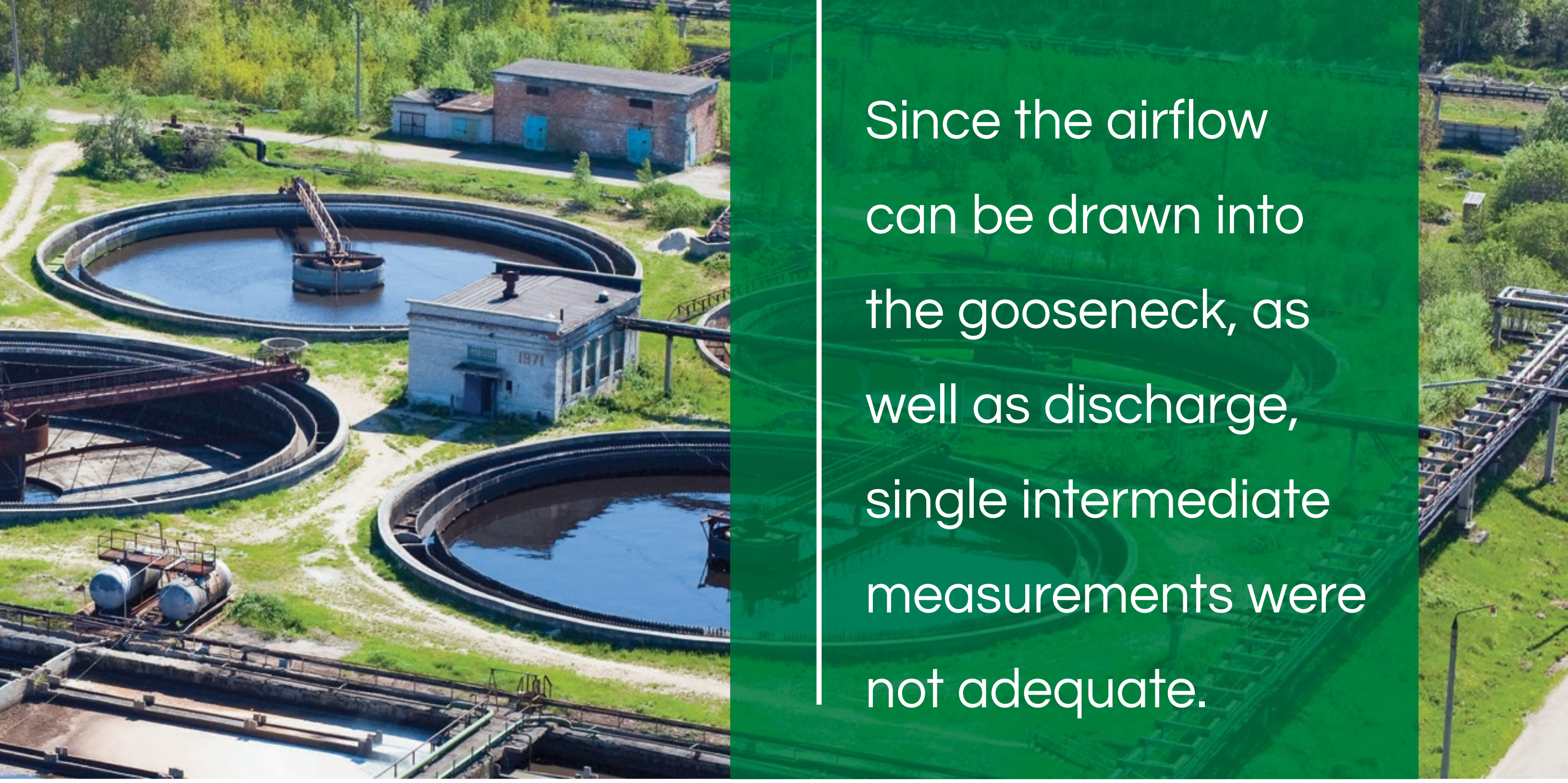
Odd circumstances can sometimes create the need for creativity to assess and resolve many airflow problems. One such problem occurred recently, during an inspection to assist with a solution of outdoor odor problems near a public stadium.

A local county water authority had been receiving complaints about excessive sewer odors near an interstate frontage road. This particular road was experiencing a boon of new construction on a previously unused stretch of road, with new apartments and potential new parking lot and walking bridge near the facility. The culprit was an old sewer pipe, approximately 15' tall, with a 14" round gooseneck exhaust opening. The sewer pipe opening was at the top of an approximately 100' deep fifty-foot wide tunnel, leading to the county main water collection system. The bottom of the tunnel led to the main odor treatment plant several miles away, which handled odor scrubbing duties through a series of fans at the water treatment plant.

Frequently, with heavy rains and other conditions at the treatment facility, the bottom of the water collection system would fill entirely. This occasionally blocks the flow of airflow through the huge underground tunnel system, and results in odors being discharged through the top of the gooseneck vent pipe into the air.

The question of the study was to determine how much air was being relieved through the vent pipe during all conditions, and potentially what size air scrubber would need to be installed to clean up the odors. The site was located in a small field, essentially, with no power available. Individual measurements of the exhaust airflow can provide one-time conditions, but trending the conditions over time was the best method to assess changing airflow conditions. Having a technician continuously at the site was also not a practical solution. Additionally, since the airflow can be drawn into the gooseneck, as well as discharge out of it, single intermediate measurements were not adequate to assess the conditions.

A Shortridge velgrid was attached to the discharge of the gooseneck vent pipe. For power, a standard truck battery was used, with an added 12 volt inverter to keep a laptop powered for continuous usage. Coupled with the wireless wrist reporter and pressure modules from Evergreen Telemetry, this set-up was ideal to trend the conditions. The Evergreen Telemetry software can provide continuous measurements of any conditions, and the system was used to measure the differential pressure at the grid, logging a measurement every 10 seconds with a time-stamp. The Evergreen Telemetry software is highly useful for configuring the measurement increments, and battery life of the wrist reporter and pressure modules is quite long. The measurements were converted to velocity pressure, and automatically logged into an Excel spreadsheet to convert the data to CFM. The truck battery would last approximately 3 days under this condition, with the laptop under full power. The battery could be recharged while



Since the airflow can be drawn into the gooseneck, as well as discharge, single intermediate measurements were not adequate.

the laptop ran on its own power, and then replaced, resulting in un-interrupted trending.

The benefit of using the velgrid, with both positive and negative airflows through the gooseneck vent pipe, was that the volume of air both entering and leaving the pipe could accurately be trended without the necessity of modifying the equipment set-up. Then, converting the spreadsheet to a linear graph, the end user could see how the airflow changes, as well as the volume of airflow leaving the gooseneck vent pipe. The time-stamp overlay allows for analyzing what happens during changing conditions of water volume in the tunnel well below ground.

This data logging procedure is not unique, but it demonstrated to our firm how useful data-logging can be, even beyond this particular application. The wireless technology from Evergreen Telemetry, and others, as well as the data-logging and trending features of the measurement equipment will be tools we employ moving forward.

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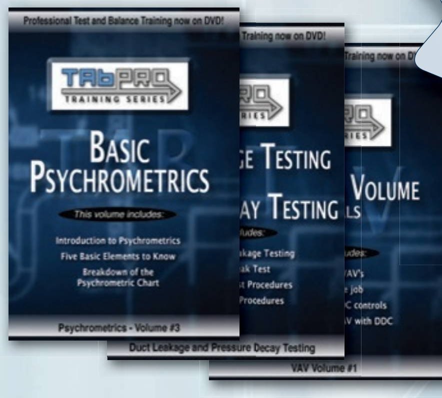

Basic Psychrometrics

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
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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.

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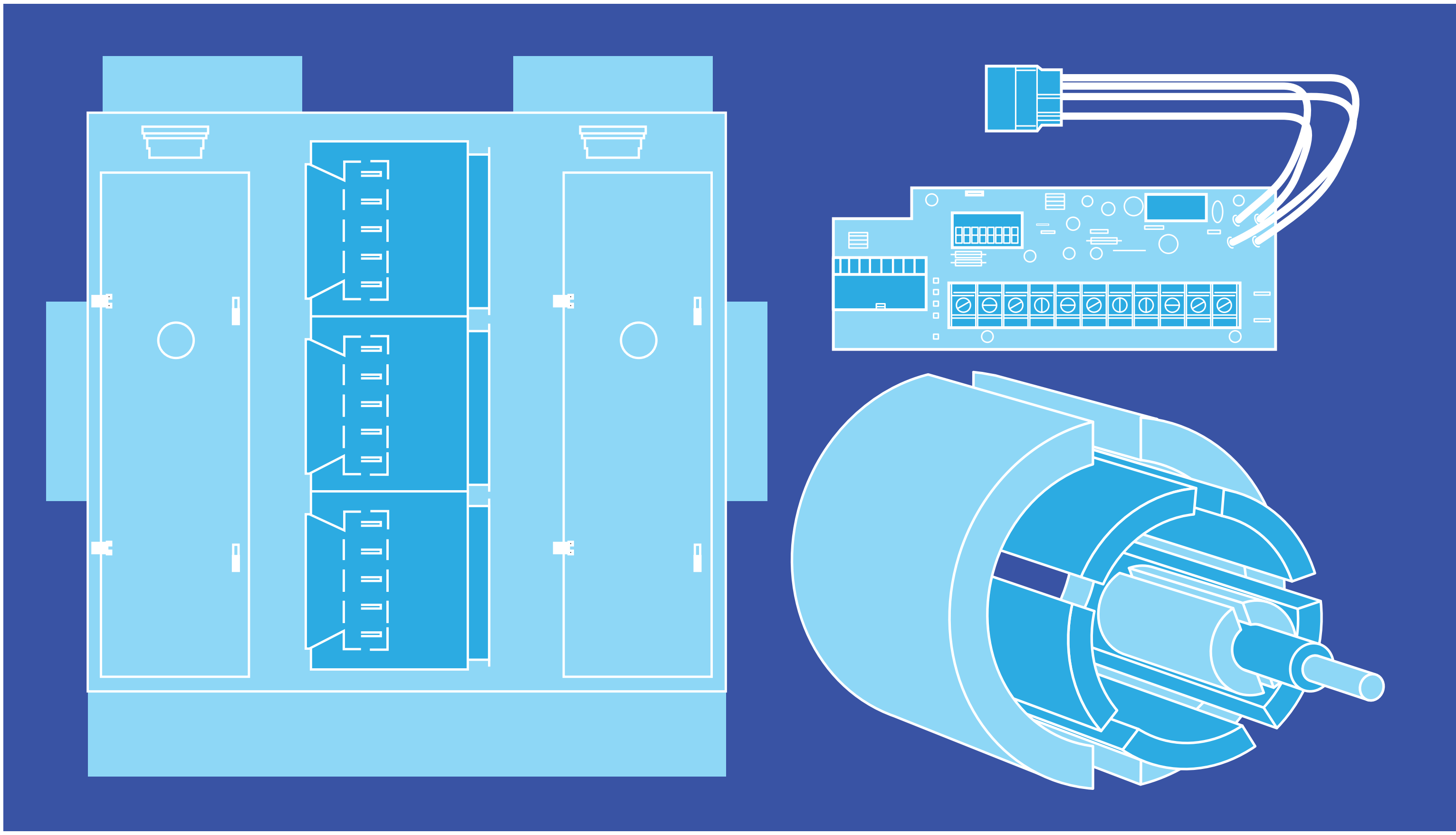
Advances in Technology
Whose Job Is It?

Richard Whitson, TBE
American Air Balance Co., Inc.



An air handler is a fairly simple machine – in theory. Its job is to move air from one part of an environment, heat or cool it and put it back into the environment. That is a very simple explanation, but that is basically what an air handler does. In the old days, if you needed more or less air than you had, you would change the speed of the fan by adjusting or changing the sheaves on the fan. This was fairly simple. There were only a couple types of adjustable sheaves to learn how to adjust and all sheaves were held onto the shafts in pretty much the same way.

Technology moves forward. Building owners and government regulations are continuingly calling for more and more efficient air handlers to lower building owners' operating costs and to satisfy ever more stringent government energy efficiency regulations. This means more and more electronics to control the air handlers.

Fan wall air handlers, which have one or more direct drive fans controlled by a single variable frequency drive (VFD), or smaller air handlers with electronically commutated motors (ECM), which vary the speed of the motor based on air flow, are examples of these new high efficiency air handlers.

Once an actual air flow has been verified, calculating a new fan RPM to satisfy the air flow requirement is a simple task that can be easily accomplished. Adjusting the VFD or ECM motor to obtain the correct fan RPM and air flow is not a

Building owners and government regulations are continuingly calling for more and more efficient air handlers to lower building owners' operating costs and to satisfy ever more stringent government energy efficiency regulations.

simple task. How the new fan RPM is set is specific to each VFD and ECM manufacturer. Learning how to adjust the VFD or ECM takes time, and that process has to be repeated each time a new piece of equipment is encountered. That translates into lost time on the job. But is it really our job?

Section 2.04 (1) of the AABC General Specifications states, "Test and adjust fan RPM to achieve design CFM requirements." That statement seems to make us responsible for all fan RPM adjustments. With belts and sheaves it is a fairly simple process and once learned varies very little from one manufacturer to another. With VFDs and ECM could take an hour or two to learn and that time would be repeated each time a new piece of equipment is encountered.

Another point to consider is liability. Could the balancing agency be liable for damage to the VFD or ECM if it is damaged during the adjustment?

As time moves on, new technologies will be encountered as they develop. Now is the time to start the conversation. Should the balancing agency be responsible for changing software parameters inside a VFD or ECM and whatever comes next or should this be the responsibility of the fan manufacturer's start up technician?

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

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

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

CALIFORNIA

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

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

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

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

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

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

Pacific Test and Balance, Inc.
Fairfield, CA
(707) 696-2444

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

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

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

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

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

COLORADO

Proficient Balancing Company, LLC
Arvada, Colorado
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CONNECTICUT

CFM Test & Balance Corporation
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James E. Brennan Company, Inc.
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Air Proserv, Inc.
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ecoTAB, LLC
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Perfect Balance Inc.
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Precision Balance, Inc.
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Professional Air Balancing, Inc.
Clearwater, Florida
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Southern Balance, Inc.
Milton, Florida
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Southern Independent Testing Agency, Inc.
Lutz, Florida
(813) 949-1999

Test and Balance Corporation
Lutz, Florida
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The Phoenix Agency, Inc.
Lutz, Florida
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Thermocline Corp.
Merritt Island, Florida
(321) 453-3499

GEORGIA

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Toccoa, Georgia
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Augusta Air Balance Company, LLC
Martinez, Georgia
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Southern Balance Company
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TAB Services, Inc.
Norcross, Georgia
(404) 329-1001

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

GUAM

Penn Air Control, Inc.
Tamuning, Guam
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HAWAII

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Test and Balance Corp. of the Pacific
Honolulu, Hawaii
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ILLINOIS

United Building & Energy Services, LLC
Wheaton, Illinois
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INDIANA

Fluid Dynamics, Inc.
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Synergy Test & Balance, Inc.
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IOWA

Systems Management & Balancing, Inc.
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Nicholasville, Kentucky
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Thermal Balance, Inc.
Paducah, Kentucky
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Environmental Balancing Corporation
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Performance Test and Balance, LLC
Bowie, Maryland
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Protab, Inc.
Hampstead, Maryland
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Test & Balancing, Inc.
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MASSACHUSETTS

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MICHIGAN

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

Air Solutions Inc.
Lapeer, Michigan
(810) 358-8644

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Mechanical Test and Balance Corporation
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SMB of Minnesota
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Capital Air Balance, Inc.
Terry, Mississippi
(601) 878-6701

Coastal Air Balance Corp.
Terry, Mississippi
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MISSOURI

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

Precisionaire of the Midwest, Inc.
Grain Valley, Missouri
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Senco Services Corporation
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NEVADA

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Raglen System Balance, Inc.
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RSAnalysis, Inc.
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NEW JERSEY

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