TAB Journal

AABC

THE MAGAZINE OF THE ASSOCIATED AIR BALANCE COUNCIL • FALL 2010

Optimizing HVAC Performance

- Troubleshooting Coils & Economizers
- Verifying TAB for Commissioning
- Specifying for Test & Balance

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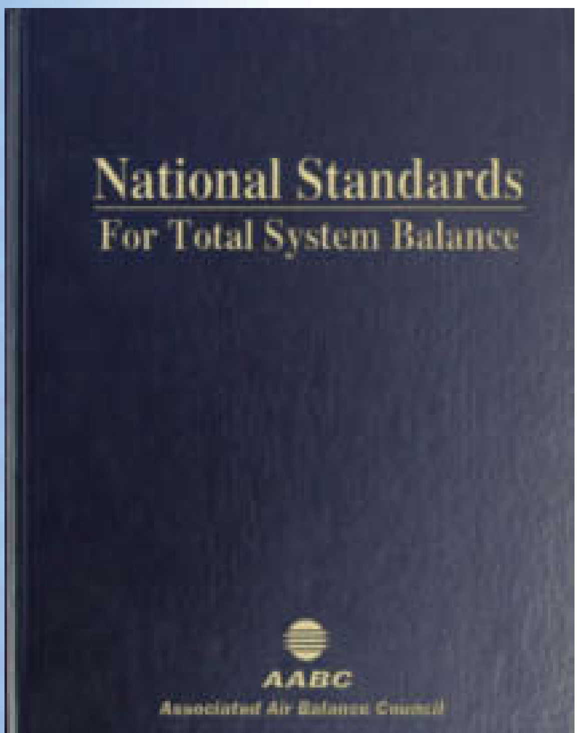

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AABC believes that by promoting the concept of Total System Balance, the industry will be encouraged to adopt more consistent practices, thus ensuring greater success for all parties involved in the design, installation, start-up, operation and testing of HVAC systems.

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Associated Air Balance Council

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From the Publisher

Focusing on various ways to optimize HVAC performance, the Fall 2010 *TAB Journal* covers several important industry topics.

In "Hydronic Balancing to Achieve Optimum Indoor Climate Control," David Hudson and Dwayne Squires of Victaulic, Inc., discuss the utility of hydronic balancing in ensuring occupant comfort, minimizing energy and costs, and determining the causes of improper heating or cooling.

Michael Carrillo from Professional Balancing Services, Inc. presents issues that can arise when testing economizers, and the steps that can be taken to mitigate them in "Solving Economizer Problems."

The Fall issue also features "Building a Better Test & Balance Specification"-—an excerpt from the specification recently developed by the AABC Specifications Committee—as well as an article that addresses TAB verification as it relates to commissioning. Authored by TAC Systems, LLC's Mark Chase and Robert Collier, "TAB Verification—Knowing What's Involved," covers several specific scenarios demonstrating the importance of diligent preparation for verification.

This issue's Tech Talk covers Air Calculations and Testing of DX Coils, and specifically addresses how those two subjects are handled by the AABC National Standards.

Other articles include "Tracking Static Helps Relieve Some Pressure" by Jeff Thompson of Systems Commissioning & Testing, Inc., which describes how static pressure readings can shed light on problems that have no other apparent cause. Alan Tew of Palmetto Air & Water Balance uses a case study to illustrate an often overlooked issue in "Purge/Leakage CFM in Energy Recovery Units" and finally, Bay to Bay Balancing, Inc.'s Jon Sissel provides troubleshooting tips in his article, "Determining Causes for Poor Coil Performance."

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*.

Hydronic Balancing to Achieve

Minor changes—such as a one-degree change in the thermostat setting—can be very costly.

The symptoms of indoor climate problems within buildings usually surface as complaints from building tenants. The living or working spaces are too cold in winter, too hot in summer—or some combination of both extremes year-round. In response to these temperature variations, building occupants often compensate by using space heaters, opening windows and adjusting thermostat settings.

There are certain adjustments that can be made to the HVAC system to correct these issues. These could include the installation of larger pumps, the resizing of components, the changing of night setback and morning start-up times, and flow adjustments in mains, branch lines, and circuits.

However, such "fixes" are costly and ineffective—and ignore the root of the problem. Resetting a workplace HVAC-system start-up time from 7:30 a.m. to 5:30 a.m. means that a plant operates at capacity for two additional hours a day. This is a 25 percent increase in energy consumption, which negates the energy and cost savings night setbacks were designed to achieve. Even minor changes—such as a one-degree change in the thermostat setting—can be very costly. Each degree Fahrenheit increase in thermostat setting can add 6 percent to a building's heating costs, while each degree Fahrenheit decrease can add 8 percent to a building's cooling costs. Additional consequences of operating system changes can include increased wear on pumps and HVAC

Optimum Indoor Climate Control

By **Dave Hudson** and **Dwayne Squires**, *Victaulic*

components, and reduced control-valve authority. Finally, the change in start-up time may cause more complaints if the problem is over-corrected, or if other tenants begin to complain about the change.

The root of most indoor temperature and climate problems can be traced to incorrect flow rates due to improper terminal-unit balancing. Therefore, the key to HVAC-system effectiveness and efficiency is properly controlled and balanced flows to terminal units. Because consulting engineers typically design HVAC systems with excess capacity, the ability to provide necessary heating or cooling energy is present. The challenge is getting that energy to terminal units and air-handling units (AHUs) in the most efficient and effective manner possible.

Hydronic Balancing for Comfort and Control

The flows in an HVAC system change over a 24-hour period. Due to heat gain from the sun and changes in building occupancy, the demand for heating and cooling in a commercial structure varies not only throughout the day, but also by building position and segment. An effective and efficient HVAC system must provide correct energy output when and where required.

Hydronic balancing is essential to ensure that heating and chilled-water systems deliver correct flows to all terminal units in an HVAC circuit. When a system is unbalanced, sections of a building will have underflow or overflow conditions that impact control-valve authority and, thus, indoor climate. For instance, the terminal units closest to an energy-production and delivery source (the energy production source is the chiller or boiler and the delivery source is the pump) could receive excess flow, resulting in excessive heating or cooling. Terminal units farthest from an energy-production and delivery source could receive insufficient flow, resulting in inadequate heating or cooling.

Hydronic Balancing and Building Controls

The building controls in a large commercial structure are the thermostats or sensors in each room or space which take in and read temperature information, to then electronically trigger the mechanical systems to open/close or modulate valves which changes the flows in the cooling or heating circuit, to maintain the temperature at the specified level.

A consulting engineer will typically specify both the building controls and the hydronic controls/system, and thus would need to make sure that the two systems are integrated and compatible to achieve the desired goal of climate control.

The challenge with integrating the hydronic systems with the building controls is that the building controls are dependent on the hydronic systems in order to function correctly. The control system can only be as good as the hydronic system. If the system is not properly designed, installed or balanced correctly, the system design flows will not be achieved. Thus, it is very important that the consulting engineer's initial plans are followed, in order to achieve design flow availability.

The Keys to Hydronic Balancing

There are three important principles to address when discussing effective hydronic balancing.

Design Flow

First, the design flow must be available at all terminals. This can be compromised for a number of reasons, with the main one being that the balancing valves are not properly adjusted. If the balancing valves are not in the right places, or there are not enough valves, then ultimately the system will not perform to its specified parameters. There will be a greater cost to the owner because of under or over flow conditions.

One can ensure availability of the design flow by choosing and setting the balancing valves according to the design flow specified rather than the pipe line size. Installing a balancing valve based upon line size and not flow rate may result in the inability to obtain the correct circuit flow rate. For example, the design line size to a specific coil may be ¾" and the coil has a required flow rate of 1 gpm. Using a ¾" valve will result in a valve setting below its recommended range and hence adversely affect the valve's control accuracy. Where-as a flow rate of 1 gpm is in the recommended flow range for a ½" valve. As a best practice, it is always a good idea to consult the manufacturer or sales representative for the valves in order to ensure they are being used and installed correctly.

If the system is not properly designed, installed or balanced correctly, the system design flows will not be achieved.

STAP Differential Pressure Controller installed in a project in Calgary, Alberta. The valves work together to control the differential pressure between the supply and return to each floor. *(Photo courtesy, Victaulic)*

Differential Pressure

The second key is to make sure that the differential pressure across the control terminals doesn't vary too much. The control valve authority should be .25 minimum, with .5 or greater being optimal.

This means that within an HVAC circuit the pressure across that whole loop should be the same. This is where building controls also become an issue, because if that pressure is constant, then the controls will have an easier time doing their job of sensing and regulating the temperature. The best way to ensure this is to make sure that you have your differential pressure control valves and differential pressure sensor for variable speed pumps in the right locations from the start, so that there are no spikes at the control valves which turn it into an on/off mechanism, rather a modulating system. Differential pressure control valves are located on the branch lines to specific system modules in the area where the isolation valves would be located. The differential pressure sensor is located on the mains near the index circuit of the system.

An effective and efficient HVAC system must provide correct energy output when and where required.

Compatibility

The final key is to make sure that water flow rate and temperature from the production side is compatible with all system interfaces. If it is not for example, in the summer, you need to make sure that you have enough chillers and capacity to provide flow to cool the building. If you haven't done the first two steps, then this step is difficult, as they all tie together.

In Summary

Far too many buildings are unnecessarily plagued by temperature variations that can lead to tenant complaints and high energy and operating expenses for owners. In most cases, these issues can be easily resolved through proper balancing of the heating or cooling system to conform with original design performance specifications from the consulting engineer.

In addition to ensuring occupant comfort and minimizing energy and operating costs, effective hydronic balancing can help pinpoint the causes of improper heating and cooling. In addition to observing the three keys to hydronic balancing, above, a comprehensive hydronic balancing program should be integrated into commissioning to save time and energy and improve the long-term value of a building.

This article first appeared in the August/September 2010 issue of Canadian Consulting Engineer (www.canadianconsultingengineer.com).

Dave Hudson is a senior engineer at Victaulic, and Dwayne Squires is hydronic balancing manager for Canada. See more about Victaulic at www.victaulic.com.

Solving Economizer Problems

Michael Carrillo, TBE
Professional Balancing Services, Inc.

When a system is functioning as intended, the design, application, and functions of HVAC equipment can appear simplistic. However, when equipment is improperly selected or operating parameters are misunderstood, problem can arise that are more complex to resolve. In these situations, test and balance agencies are sometimes called upon to validate their results.

A manufacturing area of a simple manufacturing warehouse was being conditioned with 11 constant volume rooftop units with both normal and economizer capability. A variable volume system served the minimal office space contained in the warehouse. The ducting of warehouse units was minimal at both the return and supply air ends while the office area was typical of VAV-type duct design.

The facility was also equipped with various exhaust systems totaling 7505 cfm, which was minimal in comparison to the 220,000 cfm total warehouse airflow. During normal mode "minimum" outside air operating conditions, the system performed as intended. However, in the economizer mode, the space over-pressurized, and the warehouse units' mist eliminators were collapsing into the outside air damper section.

In addition, after three months of operation the owner's facility personnel had noted and were concerned about the internal insulation that was peeling back away from the units' cabinet. While the design/build team reviewed and accepted the TAB test results, the equipment manufacturer doubted the economizer performance.

The submitted TAB report included all test measurement data, and in discussion with the equipment manufacturer's engineers, retest of typical units was requested and performed using the evaporator coil pressure differential as a satisfactory indicator of airflow. The following are test results, observations, and design team resolutions.

TEST RESULTS:

Design Conditions:
20,000 cfm, 1.9" w.c. TSP, 631 FRPM, 15.1 BHP, 0.7" w.c. Coil Diff. Press.

Test 1 Condition Normal (O/A) Damper Position A:
21,000 cfm, 2.4" w.c. TSP, 701 FRPM, 16.0 BHP, 0.69" w.c. Coil Diff Press.

Test 2 Condition Normal (O/A) Damper Position B:
21,000 cfm, 2.35" w.c. TSP, 701 FRPM, 16.0 BHP, 0.70" w.c. Coil Diff. Press.

Test 3 Condition Economizer (O/A) Damper Position A:
22,000 cfm, 2.25" w.c. TSP, 701 FRPM, 16.5 BHP, 0.67" w.c. Coil Diff. Press.

Test 4 Condition Economizer (O/A) Damper Position B:
18,700 cfm, 2.55" w.c. TSP, 701 FRPM, 15.0 BHP, 0.65" w.c. Coil Diff. Press.

Notes:

1) The manufacturer was accepting the coil pressure drop method for their conclusions, while the airflow test data above reflects actual traverse measurements which were also plotted on the manufacturer's curve. (This explains why Test 3 has higher cfm at a lower delta p than Tests 1 and 2.) Normally, the coil air pressure differential is used only as an indicator of proper performance and not a true measurement of airflow—primarily due to the possibility of the moisture content on the coil varying, which would in turn change the pressure difference.

2) Damper positions A and B noted above are economizer damper positions.

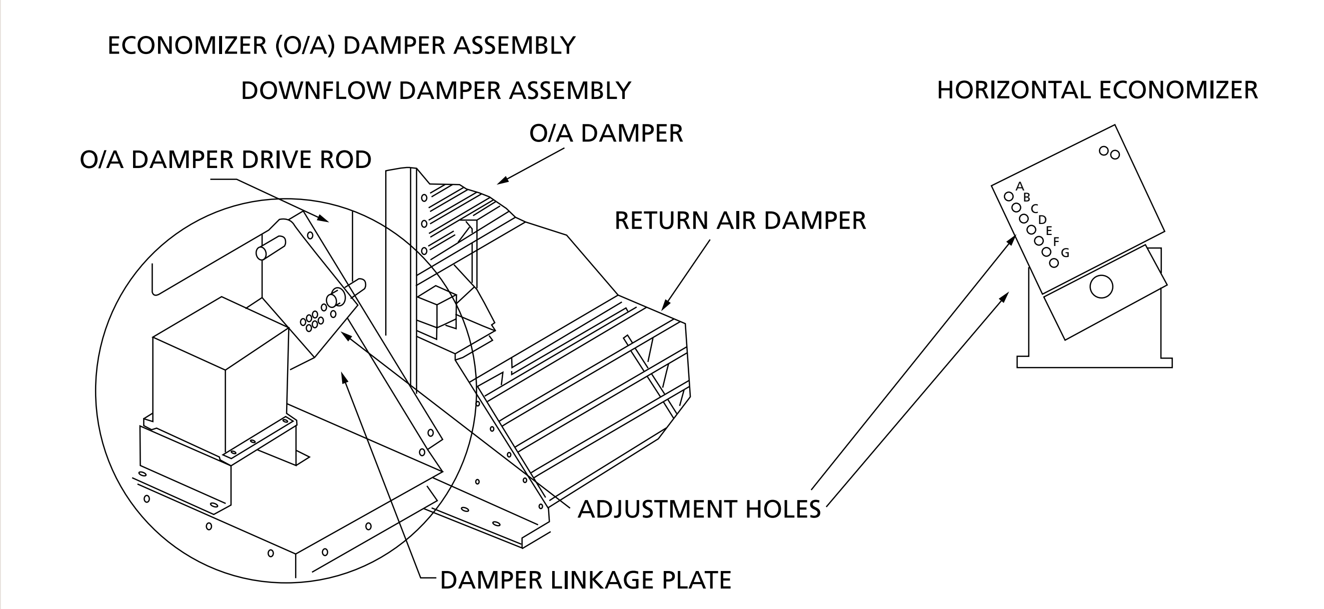
OBSERVATIONS

- Changing the economizer damper position from A to B had minimal effect on airflow. In regards to damper movement, the slack in the damper linkage was similar to the change in damper position.
- Unit was equipped with non-adjustable sheaves. Recommendation to provide sheave which met the manufacturer's specified RPM was deemed unnecessary by design build team and the manufacturer's representatives due to performance allowances within 10% of design.
- The unit discharge opening was oversized in comparison to the return air opening and outside air opening resulting in the majority of the system static pressure occurring on the suction side of the fan. The manufacturer specified a maximum of 1.4" w.c. in the mixed air plenum to keep the cabinet vapor barrier from peeling off. Note: In all test conditions, the fan discharge static pressure did not exceed +0.35" w.c. and the fan suction section static pressure exceeded 1.4" w.c. There was no apparent difference between the mixed air plenum and fan suction cabinet vapor barrier installation methods, allowing for the vapor barrier to peel off at both mixed air and fan suction panels.
- Mist eliminator area allowed for excessive velocities and static pressure differences. The mist eliminators would bend in the center and eventually completely fail.
- The relief air was not powered by relief fans allowing for an average of 40% relief and the previously mentioned over-pressurization of the facility. The design build team was under the assumption that a unit equipped with full economizer would also be manufactured with matching relief capability.
- Equipment manufacturer doubted test results which validated their published performance data.
- The design build team waited for the manufacturer to propose solutions to the mist eliminator failure and the vapor barrier peel-back problems due to warranty issues. A period of eight months lapsed between publishing of the TAB Report and retest with the manufacturer's representative witnessing testing, and another three months to agree on solutions.

SOLUTIONS

- Redesign of additional warehouse relief using barometric wall relief dampers to achieve acceptable pressurization conditions during economizer.
- Reinforce outside air mist eliminator brackets to prevent the collapse of the mist eliminators.
- Repair vapor barrier and reinforce edges of panels to deter the onset of the peeling effect. This action also resolved the insulation issues from the high suction static, and satisfied the concerns of the engineer and owner.

In conclusion, what at first may seem to be a simple project may be much more complicated. In this case, a "simple" project required the initial dissatisfaction of the owner; numerous meetings involving engineers of the design/build team, owner's representatives, and manufacturers; and TAB retest services before it was completed.



Building a Better
TEST & BALANCE SPECIFICATION

Jon Ziegler, TBE - *AABC Specifications Committee Chairman*
General Air Control Inc.
AABC Specifications Committee Members
Eddie Alejandre, P.E., TBE - Los Angeles Air Balance Co.
Brian Corcoran, TBE - Protab, Inc.
Joe Baumgartner, P.E., TBE - Baumgartner, Inc.

A detailed, well-constructed specification is invaluable in helping test and balance work and project closeout go smoothly. Because the specification is under the control of the engineer, it is one of the most important tools he or she has to ensure that the test and balance work results in a building that functions properly and as designed.

Due to the increasing demands placed upon the design team, reviewing or revising the test and balance specification becomes increasingly difficult. In response, AABC is developing a new spec—following AIA's "short form" format—for engineers to use as a guide if they choose.

Highlights of some of the areas that are being addressed are excerpted below. These include a more detailed description of the contractor's responsibilities in preparing for test and balance, recommended tolerances, and greater clarity in some procedural aspects of the specification.

While this specification is obviously a very helpful resource for the test and balance agency, everyone from the engineer to the owner to the general and mechanical contractors also benefit greatly from TAB proceeding in an orderly fashion.

To download the present, editable version of the specification, see https://www.aabc.com/resources/downloads.aspx, or email headquarters@aabc.com to request a copy. We welcome any comments as the final version is being reconciled with the new version of the AABC National Standards, which are expected to be published in 2011.

1.4 QUALITY ASSURANCE

A. Agency Qualifications: Engage an independent T&B agency certified by AABC

Engineers may specify whichever certifying bodies that they wish. However, it is worth noting that only AABC requires that its members be 100% independent of any affiliations with general or installing contractors, manufacturers, or design engineers.

1.5 CONTRACTOR RESPONSIBILITIES

A. Provide T&B agency one complete set of contract documents, change orders, and approved submittals in digital and hard copy formats

B. Controls contractor shall provide required BAS hardware, software, personnel and assistance to T&B agency as required to balance the systems. Controls contractor shall also provide trending report to demonstrate that systems are complete.

C. Coordinate meetings and assistance from suppliers and contractors as required by T&B agency.

D. Provide additional valves, dampers, sheaves and belts as required by T&B agency.

E. Flag all manual volume dampers with fluorescent or other high-visibility tape.

F. Provide access to all dampers, valves, test ports, nameplates and other appurtenances as required by T&B agency.

G. Replace or repair insulation as required by T&B agency.

H. Have the HVAC systems at complete operational readiness for T&B to begin. As a minimum verify the following:

1. Airside:
   a. All ductwork is complete with all terminals installed.
   b. All volume, smoke and fire dampers are open and functional.
   c. Clean filters are installed.
   d. All fans are operating, free of vibration, and rotating in correct direction.
   e. VFD start-up is complete and all safeties are verified.
   f. System readiness checklists are completed and returned to T&B agency.

2. Hydronics:
   a. Piping is complete with all terminals installed.
   b. Water treatment is complete.
   c. Systems are flushed, filled and air purged.
   d. Strainers are pulled and cleaned.
   e. Control valves are functioning per the sequence of operation.
   f. All shutoff and balance valves have been verified to be 100% open.
   g. Pumps are started, and proper rotation is verified.
   h. Pump gauge connections are installed directly at the pump inlet and outlet flange or in discharge and suction pipe prior to any valves or strainers.
   i. VFD start-up is complete and all safeties have been verified.
   j. System readiness checklists are completed and returned to T&B agency.

I. Promptly correct deficiencies identified during T&B.

J. Maintain a construction schedule that allows the T&B agency to complete work prior to occupancy.

Providing complete documentation to the test and balance agency, and verifying system readiness for T&B, allows the test and balance agency to focus on its primary job: testing that systems achieve all required flows, temperatures and pressures.

3.9 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential pressure (DP) sensor is located per the contract documents.

2. Determine if there is diversity in the system.

B. For systems with no diversity:

3. Follow procedures outlined in section 3.8 for constant-flow hydronic systems.

4. Prior to verifying final system conditions, determine the system DP setpoint.

5. If the pump discharge valve was used to set total system flow with VFD at 60 Hz, at completion open discharge valve 100% and allow VFD to control system DP setpoint. Record pump data under both conditions.

6. Mark all final settings and verify that all memory stops have been set.

K. For systems with diversity:

1. Determine diversity factor.

2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.

3. Follow procedures outlined in section 3.8 for constant flow hydronic systems.

4. Open control valves that were shut. Close a sufficient number of control valves that were previously open to maintain diversity, and balance the terminals that were just opened.

5. Prior to verifying final system conditions, determine the system DP setpoint.

6. If the pump discharge valve was used to set total system flow with VFD at 60 Hz, at completion open discharge valve 100% and allow VFD to control system DP setpoint. Record pump data under both conditions.

7. Mark all final settings and verify that all memory stops have been set.

It is important to determine whether or not the system has diversity, and balance accordingly.

3.10 TOLERANCES

A. Set HVAC system's air flow rates and water flow rates within the following tolerances:

8. Supply, Return, and Exhaust Fans: Plus or minus 10 percent.

9. Air Outlets and Inlets: Plus or minus 10 percent.

10. Minimum Outside Air: Zero to plus 10 percent.

11. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

12. Heating-Water Flow Rate: Plus or minus 10 percent.

13. Cooling-Water Flow Rate: Plus or minus 10 percent.

Note that the tolerances above are for standard projects, for which tighter tolerances are often not obtainable, cost-effective or necessary. For specialized applications such as some health care facilities, laboratories, etc., tighter tolerances will be called for. Tolerances presently are being reviewed by the AABC standards committee and will be included with the AABC long-form specification that is in development.

If you have any questions or comments about specification issues, please contact AABC headquarters or a local AABC member agency.

Tracking Static Helps Relieve Some Pressure

Jeff Thompson
Systems Commissioning & Testing, Inc

A recent project called for the balancing of a four-story office building with a system consisting of two 120-ton DX roof-mounted air handlers and approximately 85 pressure-independent VAV boxes. The total airflow at the supply fans was about 47,000 cfm per air handler.

To begin testing, the air handlers were inspected to verify proper fan rotation, outside air damper positioning, belt tension, etc. The units had been running for a few days with no problems and the initial inspection did not reveal any issues either.

Few problems were encountered in the first few days, during which the first floor and part of the second floor were successfully balanced. But halfway through balancing the second floor, it was noticed that the boxes would not satisfy to their full cooling airflow set point.

The computer program that was used only displayed a small portion of the system at any given time. So without being able to see if boxes throughout the building were not being satisfied, it was assumed that this was a localized problem.

The branch duct serving the VAVs that were not attaining maximum airflow were examined first. No dampers or other obstructions were discovered, so a static pressure reading was then taken in the branch duct. The reading was about 0.25” W.C., which was considerably lower than the operating static pressure or the pressure that was verified the day before on the first floor, of 1.40” W.C.

After this observation was made, the air handler on the roof was rechecked. The VFD was running at about 50Hz, which was comparable to what was noted earlier when everything seemed to be fine. There were no closed dampers, and everything appeared to be in working order.

The next step was then to take pressure readings on each duct, moving back through the system towards the air handler. Low readings were noted all the way back to the main chase coming through from the roof. Again, readings were taken right at the roof’s fan outlet just above the roof penetration. It was still only about 0.7”.

> *When a reading right at the fan outlet measured at 3.5" WC, the problem became immediately clear.*

Finally, when a reading right at the fan outlet measured at 3.5”W.C., the problem became immediately clear: there was obviously some obstruction in the duct work somewhere on the roof. After readings taken before and after a turning vane indicated an almost 3.0” pressure drop across it, the mechanical contractor was notified of the situation.

The next day, the contractor found that a large piece of duct lining had broken free and was stuck in the turning vane, blocking most of the path of flow.

This problem would have eventually been found, but tracking the static pressure made it considerably easier and less time consuming to discover. This could have been accomplished even faster if the readings were taken on the roof instead of at the branch duct that was being initially worked on. That’s another lesson learned.

Test and Balance Verification – Knowing What's Involved

Mark S. Chase, TBE
Robert R. Coallier, TBE
TAC Systems, LLC

Commissioning starts with the planning of the new building and is carried through design, construction, acceptance, and occupancy. An integral part of the commissioning process is TAB verification. Verification and documentation of the TAB process are prerequisites to initiating commissioning functional performance testing.

Frequently, TAB verifications are being completed by third party commissioning authorities contracted directly to the owner. These third party commissioning providers review and complete verifications on the TAB report prior to moving into functional testing. If, during the course of TAB verifications, the data demonstrates a deviation of 10% or more from what was recorded in the TAB report, the report would be automatically rejected.

It would then be readjusted and tested with new data recorded. A new certified test report would be submitted and new inspections would be completed, all at no additional cost to the owner. That being said, the TAB firm would be responsible for all additional associated costs. This could prove financially unfortunate for the TAB firm. Therefore, it is incumbent upon the TAB firm to understand and be very familiar with the requirements and the expectations of the TAB verification process. Advanced preparation and completeness of the final TAB report are critical to ensure compliance and TAB report acceptance.

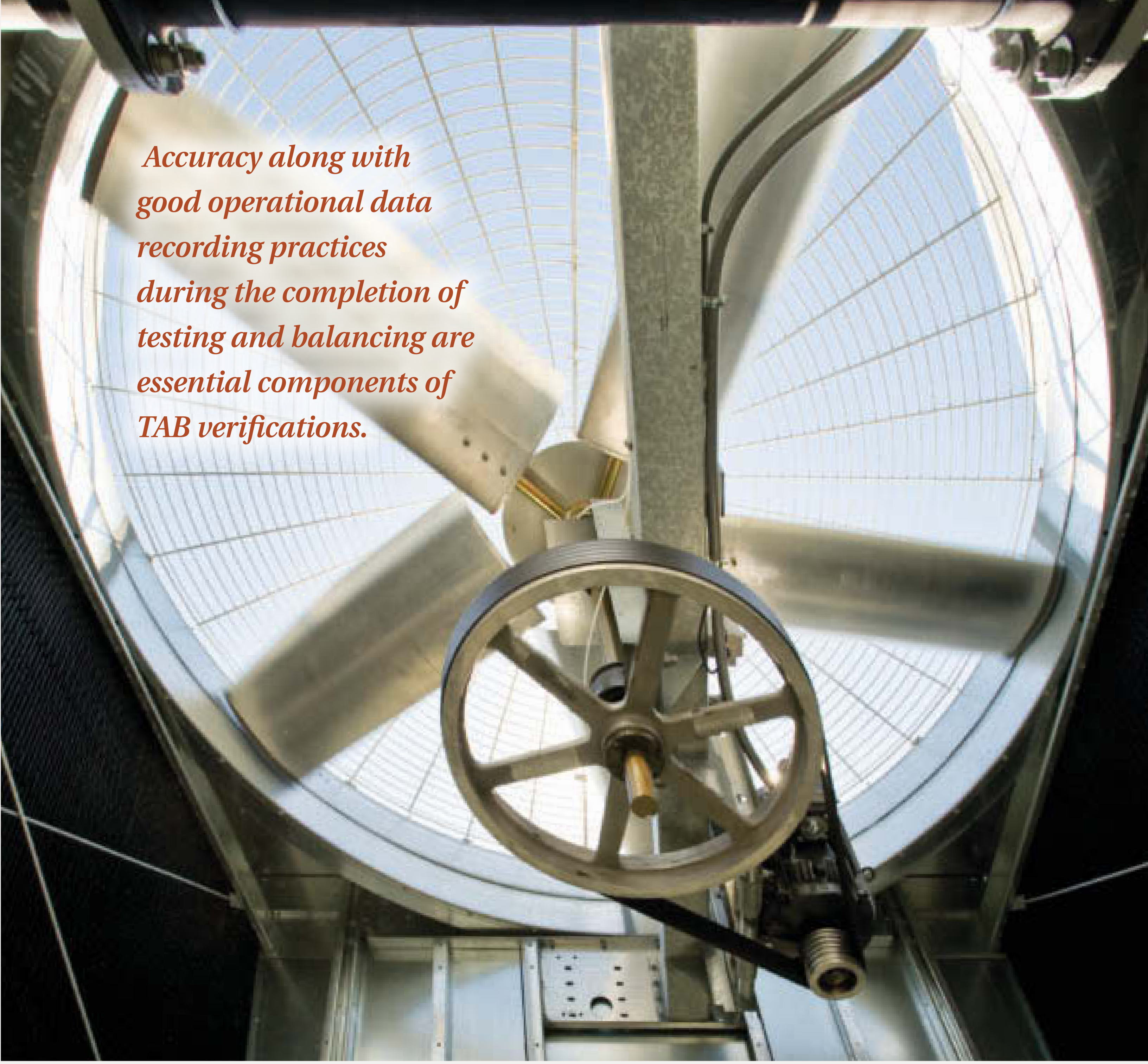
The construction phase of a project typically takes place when the details of the commissioning procedures are finalized. During this phase the thoroughness of the expected TAB verifications should be carefully reviewed by the TAB firm in concert with the commissioning authority. Although the specification will delineate in terms of percentages of failures or out of tolerance that would be acceptable on data such as CFM, GPM, pressures, and fan speed and so on, agreement should be made regarding what constitutes a failure on all tabulated test data.

It is incumbent upon the TAB firm to understand and be very familiar with the requirements and the expectations of the TAB verification process.

The following example from a real scenario illustrates this concept. Assume a duct traverse is being performed and there are 64 individual velocity readings required. Is a duct traverse single point velocity reading in one plane considered a failure if the initial reading was 2100 FPM vs. 2312 FPM as determined during TAB verification? Or, is the average of the tested velocities used to calculate the final flow the critical parameter?

In this example it was agreed that as the final velocity is averaged then this would be allowable or, a non-failure. However, the opposite approach could have been taken; that of the 64 test readings, 6-7 readings would be verified and if those were not within ±10% limit, then these could potentially count as failures and could lead to the entire TAB report being rejected. Therefore, it is in the TAB firm's best interest to establish the parameters of what constitutes a pass or a fail with the commissioning authority at the onset.

While good practice is critical for an accurate and repeatable duct traverse, it is often difficult to repeat the exact velocity number consistently at a single point. Therefore, if a traverse is to be included as part of verification, then the complete traverse should be examined, not just a single point. This once again highlights the importance of discussing with the commissioning authority at the onset of the commissioning procedures development process what types of data will be tested and what would constitute a failure.



Accuracy along with good operational data recording practices during the completion of testing and balancing are essential components of TAB verifications.

Another critical aspect to TAB verification testing is setting all systems to the same operational mode as when the systems were originally tested and balanced. Inaccurate systems settings could potentially lead to failures and again, lead to TAB report rejection. Accuracy along with good operational data recording practices during the completion of testing and balancing are essential components of TAB verifications.

Any and all deviations or alterations to the systems or operational modes should be accurately recorded and included within the final TAB report. Conditions may arise during testing and balancing that will require the firm to proceed with the work although all systems may not be in their final configuration.

For example, initial sound level testing completed prior to the placement of furniture, computers, and window treatments may show different readings than the subsequent noise testing completed again as part of TAB verification. The addition of these items will have an impact to the noise background tests and can potentially cause a deviation greater than the allowable 3 dB limit taken at baseline.

On a VAV system, where the commissioning authority selects a single outlet on a 10 outlet system, one reading may demonstrate whether or not the outlet is within tolerance. However, it certainly doesn't indicate whether the system is proportionally balanced, nor does it indicate what the cause of the deficiency is. Therefore, it is prudent to measure all outlets served by a single VAV terminal box and have all of them contribute to the overall verification percentage as opposed to only measuring one. Then, if during the verification testing there is a problem such as a control set point error, filter fouling, etc, it will be easier to identify the cause and determine the solution. Once the issue is corrected, retesting should demonstrate compliance with the TAB report.

It is essential to also remember that there will be projects where the TAB verifications will not be conducted immediately upon completion of the TAB work. It is a real possibility that 6 months or a year can pass until these verifications are performed due to project phasing. Consequently, it will be necessary to address any issues that may impact the performance and demonstration of the testing and balancing potentially caused by these normal 'wear and tear' effects.

It is a real possibility that 6 months or a year can pass until TAB verifications are performed due to project phasing.

In preparation for TAB verification, the TAB agency should ensure that all instrumentation is the same as the equipment employed during the original test and balance. All instrument calibration certificates for equipment employed on the project should be current and available for verification by the commissioning authority. There have been many instances where the commissioning authority possess their own balometer and subsequently use this to complete TAB verifications. This generally is appropriate for checking proportionality, however, for the purposes of TAB verification testing, the use of the same instrumentation is recommended.

Verification procedures can vary from one commissioning provider to the next. In some instances it can be as minimal as the confirmation of the outside air quantities. In other instances, it may be a complete verification of up to 10% of the total number of items tabulated in the report. This could include but not be limited to each single point in a duct traverse velocity profile, a single amperage or voltage measurement on a three phase motor, a single static pressure measurement from an air handling static profile, model and serial number, area factor, belt size, center to center distances, noise level at a single octave band, etc.

There also can be cases where both projects have the same commissioning specification yet two different commissioning providers working for the same firm have completely different approaches to TAB verifications. However, you must assume the specification is impervious. If sufficient costing is not considered in the TAB proposal, then it is entirely possible that the TAB firm would likely be in the red in their completion of the TAB commissioning verification phase.

In one example, the commissioning authority determined that on a particular TAB data sheet there were 144 fields recorded. This commissioning authority included every 10th item as an eligible data record to be validated. Therefore, each data sheet had 14 items to verify. Typically, a commissioning authority would have tested 10% of the final volumes, static's, etc. or as described in the *AABC National Standards* paragraph 23.5.2.2: "Report data" is defined as one tabulated item on a report form, such as the air flow at a specific outlet, air or water flow quantity, differential pressure reading, or electrical or sound measurement," which would normally have amounted to approximately 1-5 items per page. Once again, it is prudent to determine what parameters will be tested during development of the commissioning planning procedures.

Chapter 23 of the *AABC National Standards'* Report Analysis and Verification is an invaluable preparation tool to use in advance of TAB verification. Familiarization of this chapter in the *Standards* is essential to TAB verification process as the *Standards* describes in detail the critical parameters for successful performance of the verification process. AABC TAB firms should understand their responsibilities based on both the requirements of the specification and per *AABC National Standards*.

References
(1) ASHRAE, 1999 ASHRAE Handbook, HVAC Applications, Chapter 41.
(2) ASHRAE, 1999 ASHRAE Handbook, HVAC Applications, Testing, Adjusting And Balancing, Chapter 36.
(3) Associated Air Balance Council, National Standards, Chapter 23.

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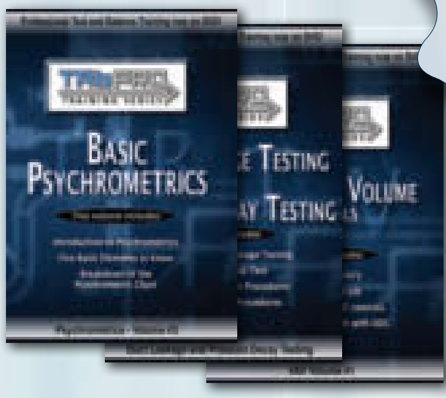

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DVD format
Run time 19 minutes
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Member price: $90.00

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
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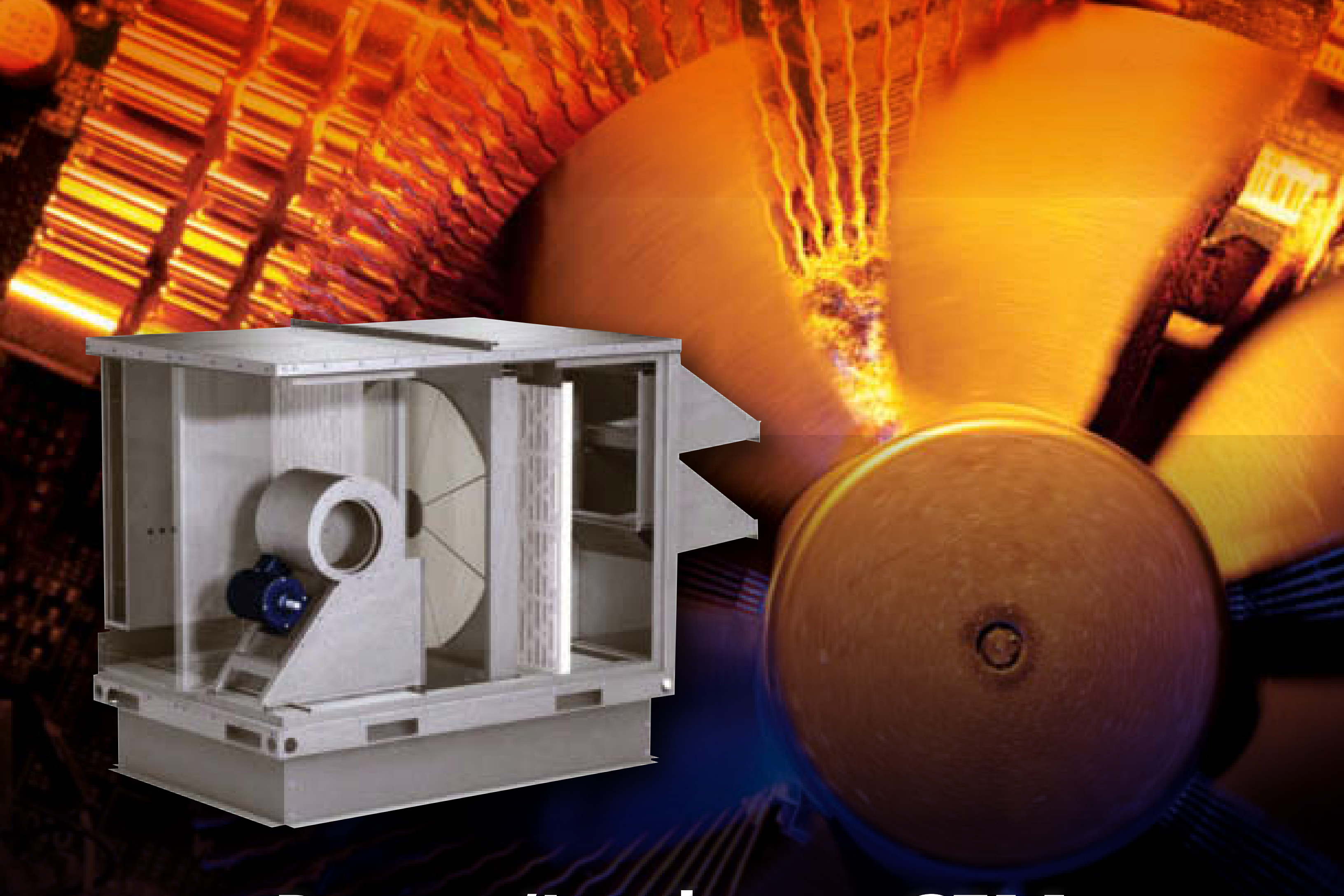

Purge/Leakage CFM in Energy Recovery Units

Alan Tew, TBE
Palmetto Air & Water Balance

In our industry today, energy recovery units have become common on new construction projects. Partially owing their popularity to increased overall awareness of energy conservation, energy recovery units come in a variety of configurations and are usually selected based on location and application of use.

This article focuses on a simple energy recovery unit setup with enthalpy wheel, and discusses some testing procedures that should be considered when this type of setup is encountered. The enthalpy wheel in this example is constructed from corrugated aluminum and coated with silica gel desiccant to enhance the transfer of latent heat from the exhaust air stream. The seal is a full-contact, low-bleed type constructed of a high molecular weight polyethylene.

Two common conditions that exist and are commonly overlooked when conducting test and balance on an ERU with an enthalpy wheel installation are purge and leakage CFM. Purge CFM is defined as simply the carryover cross leakage from the supply air stream to the exhaust air stream through the enthalpy wheel media itself. The point at which the purge happens is confined to directly on either side of the seal that separates the two airstreams. Leakage CFM is defined as the air volume that is inadvertently transferred from the supply air stream to the exhaust air stream simply because the seal is not air tight which allows an air path between the two air streams.

CASE STUDY:

Design Conditions (Summer):

OUTSIDE AIR

Outside Air Volume: 11406 CFM

EXHAUST AIR

Exhaust Air Volume: 9326 CFM

Exhaust Fan Design CFM = 9326

Supply Fan Design CFM = 10790

SUPPLY AIR

Supply Air Volume: 10790 CFM

RETURN AIR

Return Air Volume: 8710 CFM

With the design conditions listed above found in equipment submittals, the design purge and leakage CFM for this unit = 616.

When performing test and balance for the unit in this example, it is important to measure and record the following data so that actual purge/leakage rates can be obtained (Refer to Figure 1):

DT-1: Duct traverse of Exhaust Fan CFM

DT-2: Duct traverse of Outside Air CFM

DT-3: Duct traverse of Return Air CFM

DT-4: Duct traverse of Supply Air CFM

Measured conditions:

DT-1: Exhaust Fan CFM = 9399

DT-2: Outside Air CFM = 11713

DT-3: Return Air CFM = 7819

DT-4: Supply Fan CFM = 10193

From this data, the purge/leakage CFM can be calculated to be between 1520 and 1580 CFM (DT-2 minus DT-4 = 1520, DT-1 minus DT-3 = 1580). It is evident that the actual purge/leakage CFM is much greater than the design purge/leakage CFM of 616 CFM.

Based on past experience with this condition, the cause of the excess leakage is most likely the seal itself. The unit manufacturer in some cases should be contacted to evaluate the installation of the seal. In this example, the manufacturer found that the seal was incorrectly installed from the factory, which allowed a much greater leakage CFM than designed. Corrective action was taken and test results were recorded to be within design conditions.

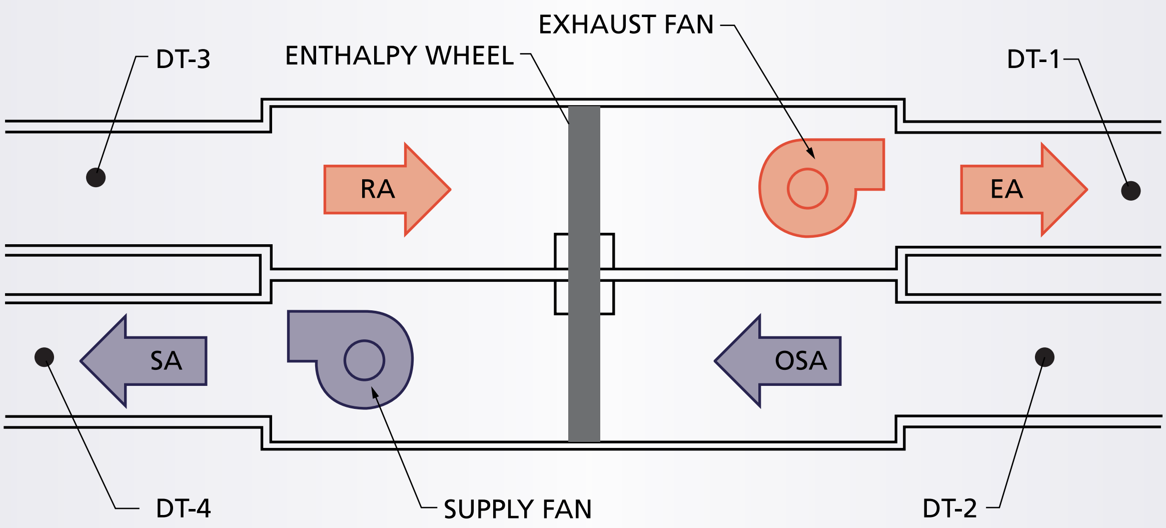

FIGURE 1.

Determining Causes for Poor Coil Performance

Jon Sissel, TBE
Bay to Bay Balancing, Inc.

While performing air and water balance at a recent project in Orlando, Florida, a cooling coil performance issue was discovered that required more testing than usual to determine the cause.

This project was a middle school that consisted of four classroom buildings, one administration building, and one multi-purpose/cafeteria building. The school has two air-cooled chillers with two primary chilled water pumps and two secondary chilled water pumps.

The classroom buildings were typical, with each having three variable air volume (VAV) air handling units (AHUs) providing air to VAV terminal units with electric heat. Each of the VAV units provided a constant flow of outside air (O/A) via an O/A monitor.

The administration building and the multi-purpose building utilized fan coil units (FCUs) that served the different zones of each building. Each FCU had electric heat. Each FCU received its O/A from a 100% O/A unit that distributed the air to each FCU via a duct system.

The cooling coil performance issue was discovered on one of the 100% O/A units. The unit is designed to distribute 1615 cfm of O/A at 55°F. The design entering air is 95°dry bulb (db) / 78.5° wet bulb (wb); design leaving air temperature is 55° db/54.1° wb. Entering water temperature is 42°F, leaving water temperature is 55°. Design water flow is 22 gpm.

Upon completion of air and water balance, the airflow was at 1683 cfm (104 % of design). The water flow was determined to be within 5% of 22 gpm as there was an auto flow device installed on the coil. The pressure drop was within the specified 2-32 psid range on the valve (thus the flow was deemed at +/- 5% of design per the manufacturer's submittal data).

The problem was discovered while measuring cooling coil performance. The O/A temp was only 83°db/71°wb and the discharge temperature would only reach 58°db/56°wb.

A much lower discharge air temperature was expected, as the entering air was much less than the design of 95°F. Additionally, the coil water delta T was only 8 degrees, not 13 degrees as designed. The problem would worsen closer to design temperature days, which are experienced frequently in the region.

Using the as-measured and expected temperature, the following was calculated with the heat transfer equation. However, the cause for the low coil performance was still unsolved:

AIRSIDE

Sensible Cooling = 1.08*cfm*delta T(db) = 45441 BTUH
Total Cooling = 4.5*cfm*delta H = 84150 BTUH

WATERSIDE

Total Cooling = 500*gpm*delta T= 88,000 BTUH

Thus heat transfer by the coil makes sense as comparing the Total Cooling on the water and air side shows that they only vary by an acceptable 4.6%.

To ensure that all measurements were accurate, all airflows, temperatures, pressure drops, etc. were double checked and all were found to be the same within reason (+/- 5% as previously measured). Also, to check the accuracy of the water flow through the auto flow valve, a non-invasive clamp-on portable energy water meter (ultra sonic) was utilized to measure the flow. The result closely approached the desired flow of 22 gpm (21.89 gpm to be exact), so the flows were not problematic.

Another possible cause for the low performance could have been air bound in the coil, causing the top of the coil to trap heat, thus mixing cold air with unconditioned air, resulting in a higher than expected leaving air temperature. This was checked and no air could be found in the coil.

Finally, it was determined that the velocity of air across the coil may be the cause for the low coil performance. Velocities were measured at the inlet to the coil and were found to be considerably higher on the left half side of the coil (looking from the direction of air flow). Thus the temperature of the air coming off of the left half of the coil was around 62˚ and the temperature of the air coming of the right half of the coil was around 54˚, with a measured mixed air of 58˚. Thus the cause of the poor coil performance was determined.

Further inspection of the unit found the cause of the uneven velocities through the coil. Prior to the coil, inside the unit casing after the air filter, there is an electric duct heater for pre-heating installed in the unit. This heater and its wiring components are all installed inside the unit cabinet. The wiring compartment comprises about 50% of the free area of the unit so that all the air from one side of the unit is directed through the heater coils. This is installed about 12" from the coil, which does not present enough linear feet for the air to straighten out or be evenly distributed, prior to hitting the coil. Relocation of the coil is necessary to correct the issue.

So, the cause of the low performance was not due to any flow issue, as is most commonly found, but due to uneven air velocities through the fins of the coil.

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).**

Air Calculations

QUESTION: ***I heard a comment that the air MBH calculation was expected to be a Total MBH calculation. There is no indication on the data sheet, or in the manuals. Am I overlooking something, or is this just a matter of preference to use Sensible or Total in the Air MBH row?***

AABC: It should be total MBH. In a heating coil, sensible heat = total heat.

Coil capacity verification is covered in the AABC National Standards for Total System Balance, on page 39 section 4.4.1. The cooling coil form (Appendix 1.5.18) requires, as a minimum, Design and Actual: CFM, GPM, Coil P.D. Ft, EWT°F, LWT°F, EAT DB°F, EAT WB°F, LAT DB°F, LAT WB°F, Air MBH, Water MBH.

I don't think it could be any clearer.

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

Testing DX coils

QUESTION: ***I'd like to get your thoughts on the requirements for testing of DX coils. At one time, NEBB and AABC had virtually identical requirements—air flow; entering and leaving temps – DB/WB—then calculate the sensible and total capacity of the coil. Compare these to the design. Is this still the same for AABC?***

I have heard an argument (not from an AABC firm) to measure only airflow, because there is nothing to adjust. True; but how does one know if the coil is the correct coil, properly charges, etc.?

AABC: AABC requires capacity testing including temperatures and control operation verification on all coils. See AABC National Standards Chapter 4, specifically 4.4.1 and Chapter 6 - 6.5.1.9. On Dx equipment there is no water, so of course water temperatures are not required.

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

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Texas Precisionaire, Ltd.
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Texas Test and Balance
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RSAnalysis, Inc.
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(801) 255-5015

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Arian Tab Services, Inc.
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C&W-TESCO, Inc.
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Mid-Atlantic Test and Balance,
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South Boston, Virginia
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Eagle Test & Balance Company
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Penn Air Control, Inc.
Vancouver, Washington
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TAC Systems, LLC
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Analysis, Inc.
Germantown, Wisconsin
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Accu-Air Balance Co.
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Air Movement Services, Ltd.
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Airwaso Canada, Inc.
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Caltab Air Balance Inc.
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Groupe Danco Televac, Inc.
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Kanata Air Balancing &
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Pro-Air Testing, Ltd.
Toronto, Ontario
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Scan Air Balance 1998 Ltd.
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INTERNATIONAL MEMBERS

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

Penn Air Control, Inc.
Kangbuk-gu, Seoul
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