TAB Journal

THE MAGAZINE OF THE ASSOCIATED AIR BALANCE COUNCIL • SUMMER 2016

AABC

New Developments in Hydronic Systems

ALSO IN THIS ISSUE:

- Buoyancy Driven Ventilation Systems
- Drywall Chases
- Jobsite Safety

TAB Journal

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From the Publisher

The Summer 2016 issue of *TAB Journal* looks at new developments in hydronic systems with Andy J. Cripe of Aerodynamics Inspecting of Texas, LLC, discussing "sensorless" pump control.

Also in this issue, Sean Bunting, TBE, of National Air Balance Company looks at a the testing procedures for Buoyancy Driven Ventilation Systems.

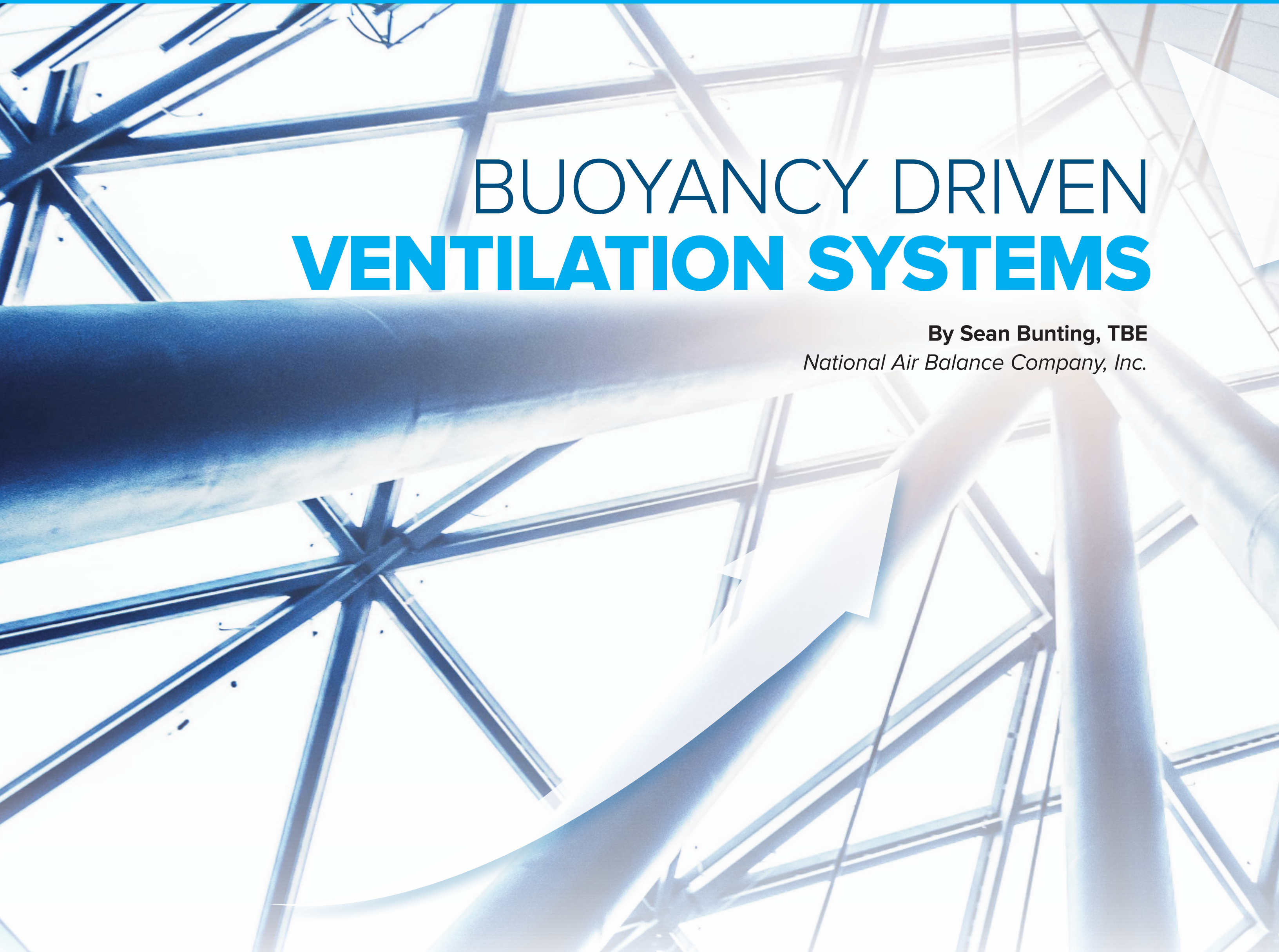
Harry E. Gaines, TBE, of Testing & Balancing Co. of the Ozarks, LLC, details a case study in which exhaust problems required investigation at a hotel, and leakage was discovered inside the drywall chases.

David W. Miller, TBE, of Miller Certified Air, Inc., stresses the importance of proper jobsite safety training.

In this issue's Tech Tip, Dean Steffen, TBE, of Precisionaire of Arizona, Inc., looks at voltage variations that can occur on balancing projects and how to resolve them.

And finally, Surrinder Sahota, TBS, of Designtest & Balance Co., Ltd., discusses why flow measurement taps are needed in variable volume boxes.

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!



BUOYANCY DRIVEN VENTILATION SYSTEMS

By Sean Bunting, TBE
National Air Balance Company, Inc.

National Air Balance Company, Inc. was recently asked by a local Mechanical Engineer of Record (MEOR) to review their TAB specification for a "Buoyancy Driven Natural Ventilation System", and what was found was concerning. Their specification called for very little testing, adjusting and balancing (TAB) to be performed. This issue was discussed with them, with reasons pointed out why a more extensive TAB process was required.

System Operation Overview:

- The, "Buoyancy Driven Ventilation System" is designed to induce air across a Chilled Water (CHW) or Heating Water (HHW) coil to maintain room temperature of a space without the use of any mechanical HVAC equipment to move the air. This is done using Outside Air (OSA) dampers that modulate based on wind speed and the CHW/HHW valve position for the associated coils.

Below is the procedure that was established for testing the Buoyancy Driven Ventilation System.

Inspections to be made prior to beginning the associated testing:

- Visually inspect the building to ensure it is architecturally complete. This includes doors (interior/exterior), glass (interior exterior/ envelope), ceilings, etc.
- Confirm all architectural shafts are complete.

Prerequisites to testing the Buoyancy Driven Ventilation System:

- Controls check out confirmed successfully complete with all design parameters programmed into the Building Management System (BMS).
- CHW/HHW systems are operating in automatic and controlling at their design temperatures.

- Outside Air (OSA)/Relief Air dampers are operating correctly.
- Under Floor Automatic Control Dampers (ACD's) and Air Monitoring Stations (AMS') are operating correctly and have been successfully calibrated.
- Wind Speed and Directional Transmitters are operating correctly and have been successfully calibrated.
- All other HVAC systems have been successfully balanced.

Conditions to be maintained during testing of the Buoyancy Driven Ventilation Systems:

- Supply Air (SA), Return Air (RA) and Toilet Exhaust Air (EA) systems operating in their normal modes.
- All doors and windows must be in their normal positions (open/closed).
- Occupants' foot traffic to be managed and kept to a minimum.

Testing Procedure of the Buoyancy Driven Ventilation System:

- Read and record the velocity across the CHW coil at the top of the intake shaft.
- Read and record the velocity at each ACD/AMS at the intakes to each room (interior/perimeter zones).
- Read and record the velocity of the Relief Air through each damper at the top of the Atrium.
- Read and record the velocity at each Transfer Ducts related to the Buoyancy System (shown on M-212A, B).
- Read and record system static pressures and plenum differential pressures.
- Record intake damper positions.

- Read and record wind speed and direction (to be measured during balance).
- Read and record OSA flow rates in full cooling mode. This will be done one shaft at-a-time. After all shafts are completed, all other modes will be trended for 48 hours. Trend data will be reviewed with the MEOR to determine if further testing is required.
- Read and record entering and leaving air temperatures.
- Read and record Relative Humidity (RH) at the cooling coils.
- Read and record temperature and RH at each ACD, interior spaces and OSA.
- Install filter media upstream of each cooling coil imposing a pressure drop of 0.1" WG. Trend the AMS and temperatures for 48 hours.
- Document the airflow rate of each air outlet in the raised floor by using the manufacturer's flow charts.
- Read and record building pressurization.

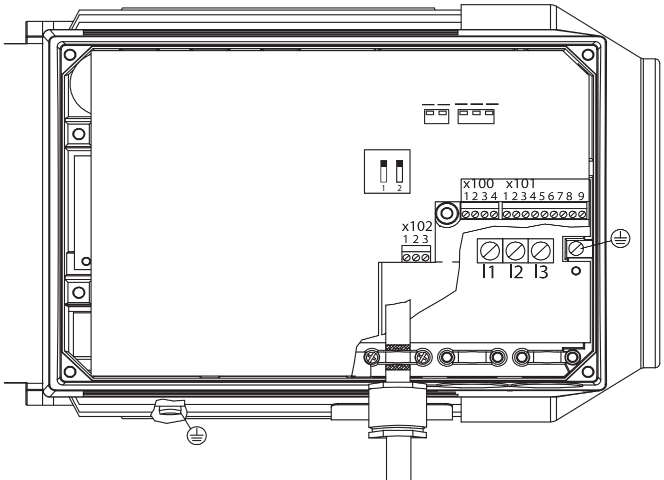
From the points listed above, the procedure is extensive. But as originally specified, much of this testing would not have been required. This is why it is imperative TAB contractors stay actively involved with their local mechanical engineering community, so that as the HVAC industry evolves with newer more sophisticated systems, the TAB industry remains relevant.

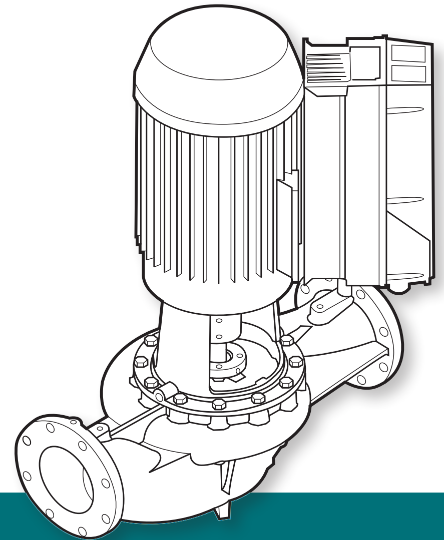
When reviewing a TAB specification and deficiencies are noticed and/or key elements are not listed, reach out to the MEOR to discuss what testing should be added to ensure their design intent is met.

THE CARE AND FEEDING OF SENSORLESS PUMP CONTROL

Andy J. Cripe, TBE
Aerodynamics Inspecting of Texas, LLC

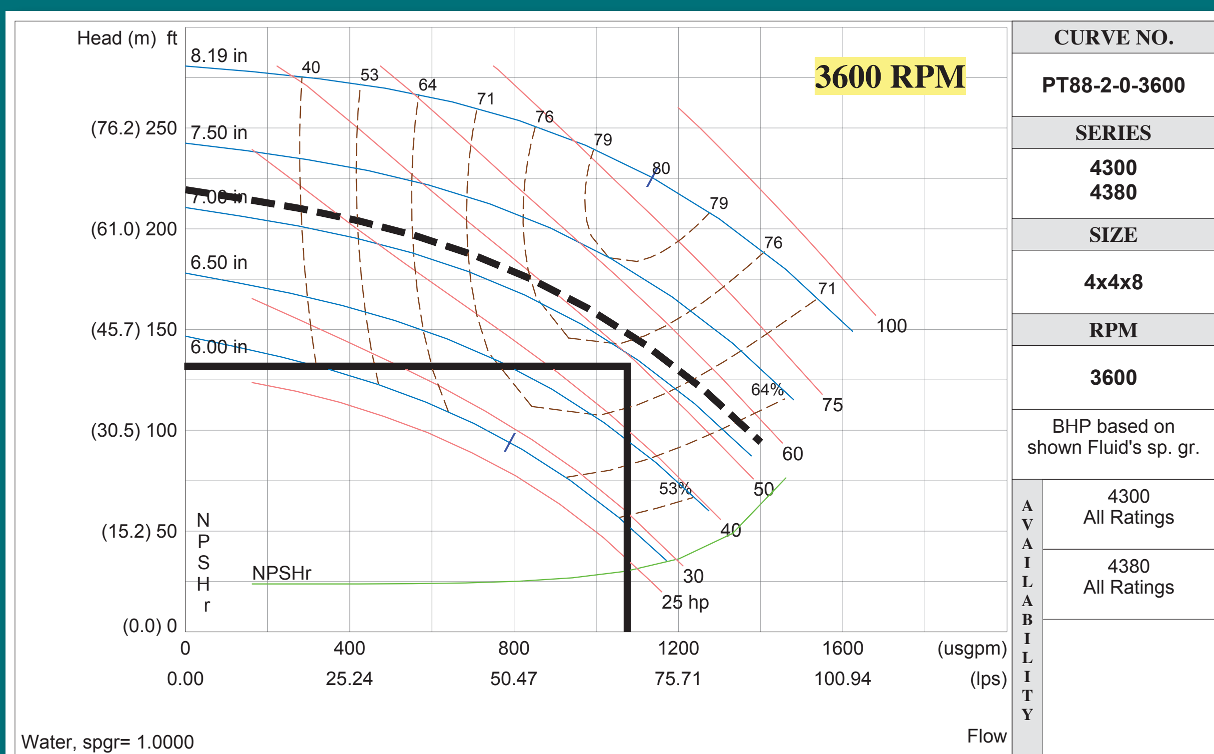
A recent development in hydronic systems has been the emergence of "sensorless" pump control, offered by several manufacturers. Sensorless pump control typically consists of a pump packaged with a pump-mounted VFD (Variable Speed Drive), supplied and programmed by the manufacturer, offering variable-speed control of the pump without the need of a downstream differential pressure transducer.





PUMP PERFORMANCE CURVE

This is the pump curve for that pump with the operating point shown:



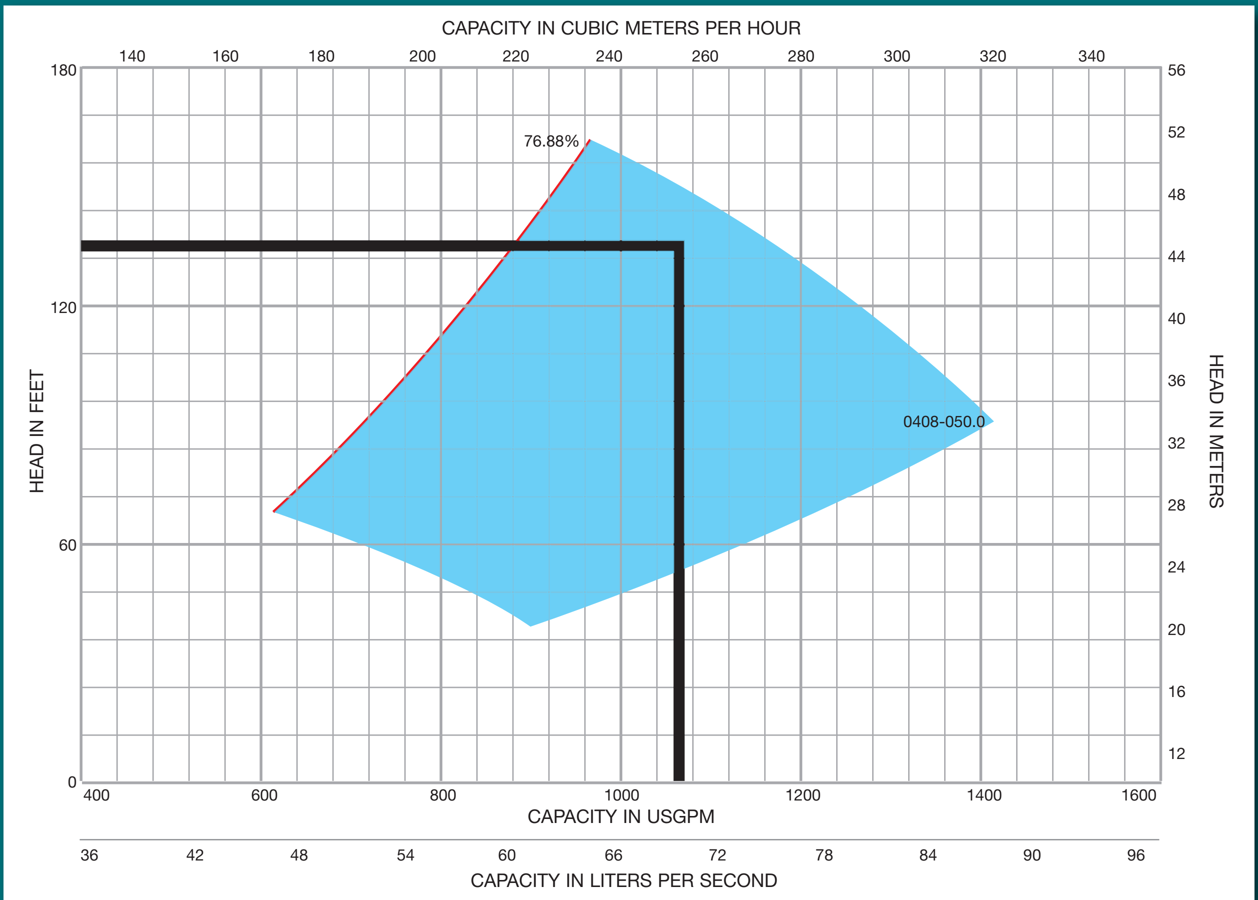
With the operating point located on the pump curve, it is apparent that the impeller is oversized for the application, which means the pump submitted will reach the design operating point at something less than full speed or 60 Hz at about 48 HP, nearly full load for the motor.

The premise of sensorless pump control is that based on a given pump, impeller and a system curve, the VFD can calculate pump flow at any speed based on pump power consumption and can use this to keep the pump operating on the system curve. The challenge for the Test and Balance industry is how to deal with these animals so they function reliably and as-intended.

Pump Curves

Hydronic balancing (after system control valves are opened to their design flow configuration) begins with setting the flow at the pump by measuring the pump shut-off head and using that figure to determine the pump impeller size. Once impeller size is known, the manufacturer's pump curve allows us to determine flow based on the pump head.

PUMP PERFORMANCE ENVELOPE CURVE



Meanwhile, the pump curve in the equipment submittal looks like this (also with the operating point added). While somewhat informative, the performance envelope curve is not much help in balancing the pump. It shows that the pump selected is capable of performing at design and it can operate down to about 70% of design load. It does not show RPM or impeller sizes.

Using a recent middle-school project as an example, the installed secondary pumps were Armstrong 4300IVS-8 0408-050.0 which translates as a 4800 series pump 4x4x8 (3600 RPM) with a 50 HP motor. The pump is rated for 1065 GPM at 135 ft. head with a 7.11 in. impeller.

The premise of the sensorless pump technology is that for a given pump and impeller size and a given system curve, there is a unique pump head and flow for each combination of pump speed and power input. With a system curve defined, the pump VFD can calculate pump head and flow at any operating point and uses pump speed control to stay on the system curve. This replicates variable speed control with a downstream differential pressure transmitter installed without requiring its actual installation. Settings are also available for maintaining constant flow or constant head.

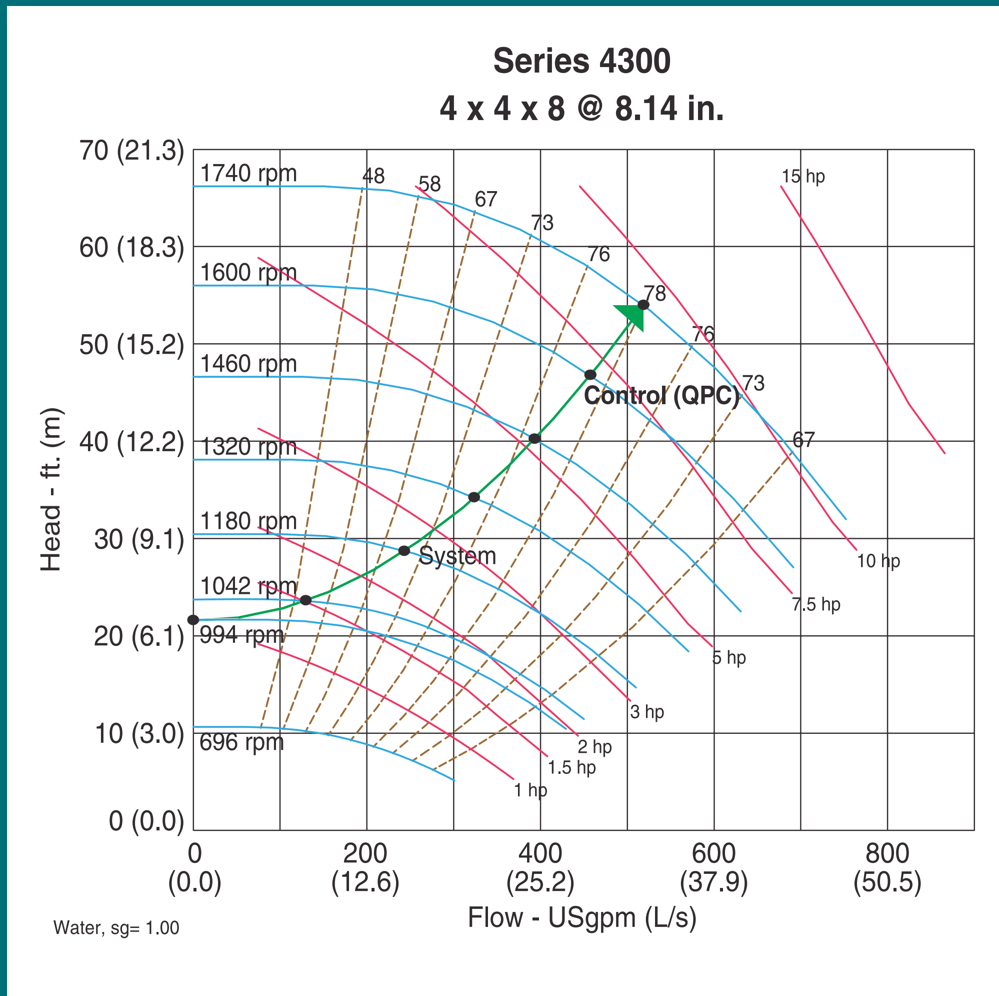
Balancing Sensorless Pumps

For the purposes of this example, Armstrong IVS pumps will be used. IVS Sensorless pumps generally ship with the design system curve loaded into the VFD; however the curve is just the engineer's best guess at system head and is usually on the conservative side. This will result in pump speeds higher than necessary and added pump energy consumption, the same as a conventional system with the differential pressure setpoint set too high. Calibrating the setup requires determining the actual

SENSORLESS PUMP PERFORMANCE CURVE

The operating curve for a sensorless pump application takes the standard performance curve and turns it on its ear. Instead of pump speed being constant and pump impeller size and pump head variable, the pump impeller size is constant and pump speed and head are variable. This is an example of just such a curve (though it is based on an 1800-RPM motor instead of the 3600-RPM examples above):

The green line on the pump curve is the system curve. It starts at the rated flow and head, in this case 525 GPM at 55 ft., and assumes the system reaches no-flow conditions at a default 40% of the design head. In this case, pump speed would be at max at the rated design flow; however, design pump speed is often less than 100% for a given application.



head required to meet design flow under design cooling conditions.

Typically, the only pump curves available to the test and balance crew on a project are the standard curve with the pump at full speed, showing the range of impeller sizes. The pump may not be programmed to run at full speed, so a jumper needs to be installed to bring the VFD up to 60 Hz. This is taken from an Armstrong brochure for IVS sensorless pumps:

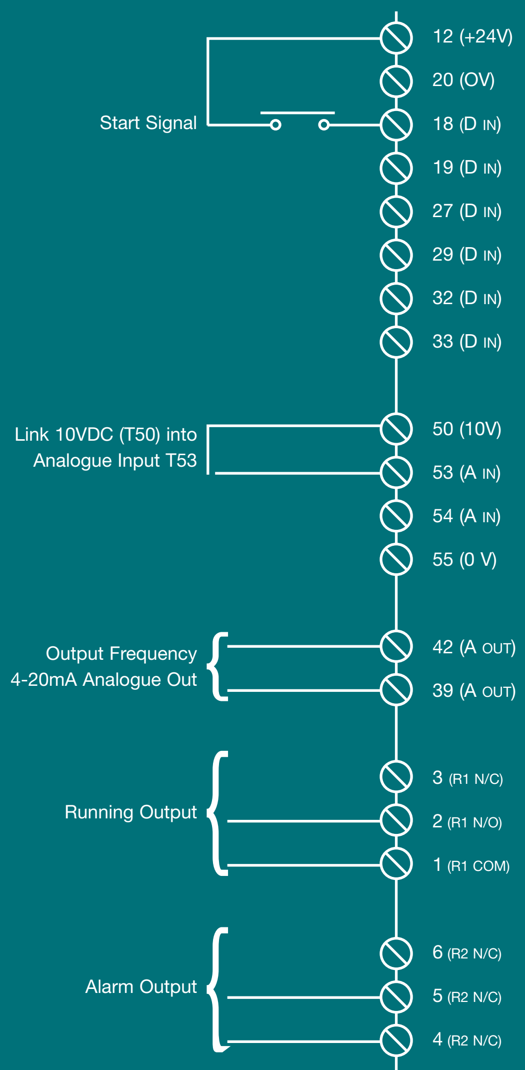
Adding a jumper between terminals 39 and 42 will bring the VFD to 60 Hz. With the pump at full speed, use the pump discharge valve to throttle flow to design, then measure system pressure somewhere downstream of the discharge valve. If no ports are available downstream of the discharge valve, check pressure drop across a coil. Open the discharge valve and reduce pump speed manually until the pressure drop matches the earlier pressure drop. This will have the pump at design flow and at the head required to match that flow.

These are the parameters used in the VFD’s for sensorless pump operation for the Armstrong IVS pumps:

Parameter 20-21 is the key parameter used to adjust pump settings from the scheduled head for the pump to the actual head. With that parameter adjusted, system flow should be at design with chilled water valves calling for full cooling (accounting for any

CONSTANT CURVE MODE - BMS SIGNAL

It may be requires to run the pump at full speed without automatic speed control (eg. during system commissioning.) This can be achieved without programming changes by making the connections below.



VFD PARAMETERS FOR ARMSTRONG IVS SENSORLESS PUMPS:

It may be requires to run the pump at full speed without automatic speed control (eg. during system commissioning.) This can be achieved without programming changes by making the connections below.

DRIVE CLOSED LOOP	20-00 Feedback 1 source	Sensorless pressure
	20-02 Feedback 1 source unit	Unit used for feedback 1 source
	20-12 Reference/feedback unit	Unit of par 2021 (ex: ft wg)
	20-13 Minimum reference/feedb.	
	20-14 Maximum reference/feedb.	Max of head and flow mapped
	20-20 Feedback function	Minimum
	20-21 Setpoint 1	Design head in unit in par 2012
	20-60 Sensorless unit	Unit of par 1850 (ex: gpm)
	20-70 Closed-loop type	Not used
	20-71 pid performance	Not used
	20-93 pid proportional gain	Start at 0.05
	20-94 pid integral time	Start at 0.1
APPLICATION FUNCTIONS	22-43 Wake up speed [Hz]	Not used
	22-50 End of curve function	Off
	22-80 Flow compensation	[1] Enabled
	22-81 Square-linear curve approx.	100%
	22-84 Speed at no-flow [Hz]	Not used
	22-86 Speed at design point [Hz]	Not used
	22-87 Pressure at no-flow speed	40% of maximum system head
	22-89 Flow at design point	Flow at design point

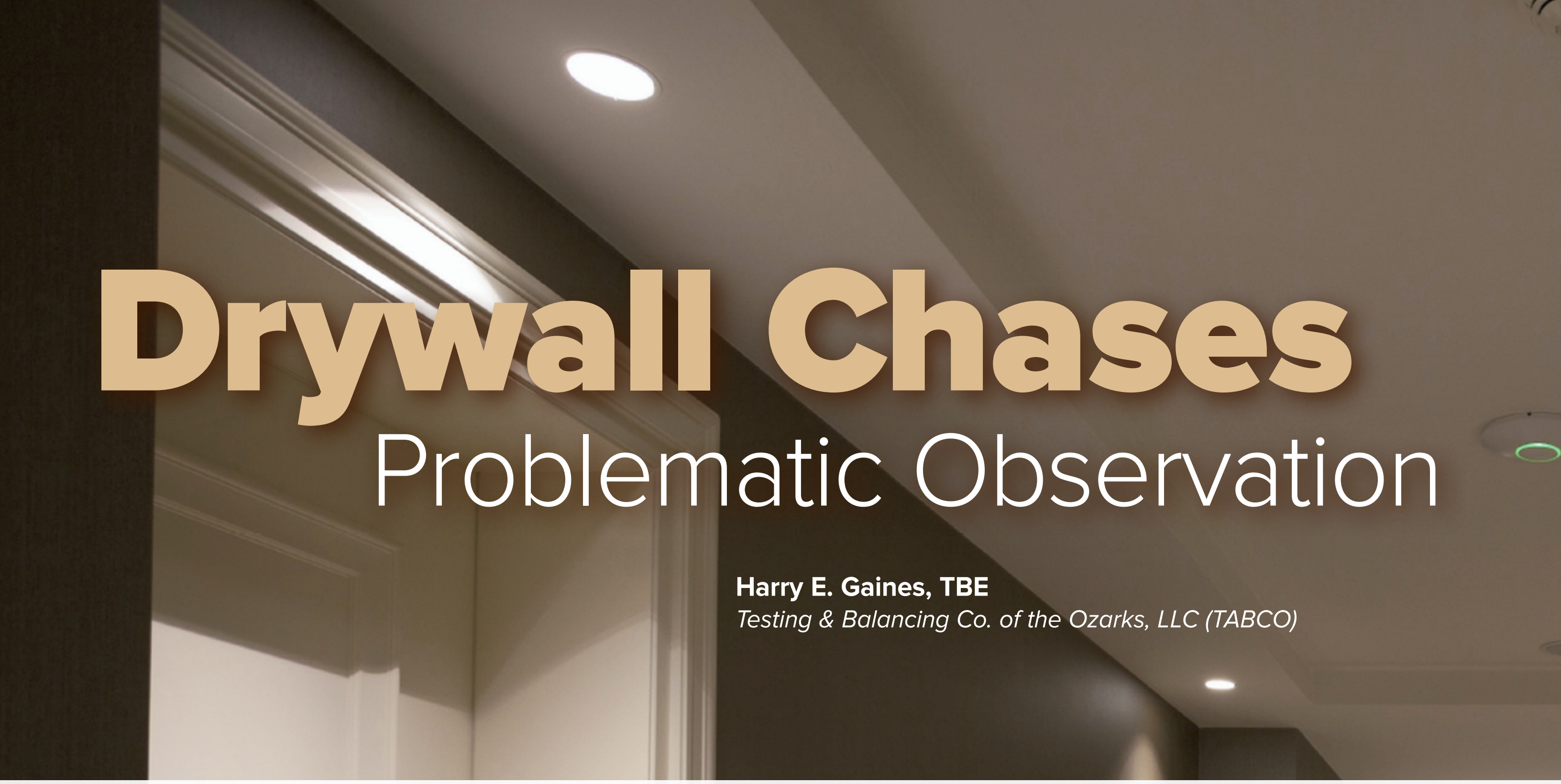
diversity in the system). The pump should then operate satisfactorily, providing variable speed control in sensorless mode.

This same routine should work well with other makes of sensorless pumps as well.

- Drive the pump to full speed.
- Throttle the pump to design flow using the pump curve.
- Measure system pressure downstream of discharge valve.
- Open discharge valve and reduce pump speed to get back to design flow.
- Adjust design head parameter at the VFD to measured pump head.

Sensorless pump applications will probably become more and more common with time. With the proper setup and balancing, they will perform satisfactorily.

Reference: Armstrong Design Envelope 4300 Pumps - I&O



Drywall Chases

Problematic Observation

Harry E. Gaines, TBE
Testing & Balancing Co. of the Ozarks, LLC (TABCO)

A Springfield, Missouri hotel management and ownership company reached out to inquire as to whether exhaust problems could be investigated that they were having at one of their newer resort hotels that they owned in another state. A meeting was planned at their local office to discuss the particular concerns with this facility and to review the original testing and balancing report submitted for this project.

Review of the test and balance report revealed that the exhaust fans serving the (120) guest rooms were not delivering the design CFM required for each bathroom inlet. It was also determined that the direct drive exhaust fans were running at maximum speed which, according to the design requirements, was not required in order to achieve the design CFM. The owners were questioned to see if their perceived problem was low airflow at the inlets or if the building was drawing in outside air at the entrances to the building. Their response was that they believed both to be true and that there was a whistling noise when the doors were closed.

It was requested during the meeting that we would accompany their head maintenance person to the hotel to check the conditions and report back the findings.

During the visit to this hotel, it was decided that (2) bathroom exhaust fans would be tested at random. For discussion purposes, these (2) tested fans will be called **EF-A** and **EF-B**. The following information was tabulated from the testing:

It was obvious from the original TAB report that there was a problem with the leakage inside the drywall chases which

"… a request was made during the construction phase by the general contractor to expedite this part of the construction with drywall chases for the bathroom exhaust."

were constructed to carry the bathroom exhaust out of the building by way of the exhaust fans located on the roof above the fourth floor. It is worth noting that it was during the construction phase that a request was made by the general contractor to expedite this part of the construction by constructing these drywall chases to carry the bathroom exhaust. This was signed off on by both the architect and the mechanical engineer. No testing of the drywall chases was done to demonstrate integrity of the chases.

EF-A design for the (4) bathrooms was 180 CFM. The inlets were read and totaled at 123 CFM. A traverse at the roof read 333 CFM. This shows that there was 210 CFM of leakage occurring.

EF-B design CFM for (8) bathrooms was 360. The inlets again were read and totaled 304 CFM. The traverse at the roof read 771 CFM. This shows that there was 467 CFM of leakage into the chase serving EF-B. Both fans were running at their maximum RPM of 1725.

At this point, their head maintenance person suggested an inspection of the drywall wall chases from inside the chase from the roof and outside the chase itself from one of the bathroom ceilings. A hole was cut next to the chase for **EF-B** in the ceiling of the bathroom on the fourth floor and a high intensity spotlight was pointed at the chase. Upon going to the roof and removing **EF-B** from the roof curb, an extreme amount of light could be seen pouring from where the drywall met the roof pan which looked to be sealed with fire caulk.

It was concluded that this similar scenario would be found throughout the other drywall chases in the entire building. This information was reported to the owners and the recommendation was made that each bathroom have its own exhaust fan installed that would be controlled by a light switch and that the exhaust fans on the roof be set to design CFM. The best recommendation would be to seal the chases but due to their 14x14 size, it would be impossible to seal the chases from the outside which would require removal of drywall ceiling and walls in all (120) bathrooms.

In conclusion, a poor choice was made during construction to eliminate ductwork inside the drywall chases causing the exhaust system to perform poorly, producing other unintended consequences. It is recommended that drywall duct chases should never be used for supply or exhaust due to leakage and the possibility of mold growth within a moisture-laden environment.

This is just another example of the value of early testing and balancing professional recommendations in lieu of "under pressure decisions" made to expedite a project which often includes eliminating testing and balancing altogether when project budgets overrun and general contractors and construction managers are searching for ways to bring the project budgets back in line and the job delivered in the timeline promised.

Jobsite Safety and **OSHA Regulations**

David W. Miller, TBE
Miller Certified Air, Inc.

Jobsite safety has always been a necessity for those working in the testing and balancing industry. On a typical project technicians work with numerous ladders, electrical components, rotating machinery, high temperature fluids and occasionally hazardous chemicals. OSHA regulations require that a minimum understanding of basic safety procedures be demonstrated in every aspect of construction.

In an area of the country where nearly all construction is performed by union craftsman, the Associated General Contractors (AGC), as well as specific trade unions, offer and require safety training of all personnel working in the field. Field technicians can attend 40-hour comprehensive training programs and technical office staff can attend a 10-hour OSHA program. The Associated and Builders and Contractors, Inc. (ABC) also offer training programs to meet OSHA regulations.

The OSHA Standards for the Construction Industry is a comprehensive book that details all of their requirements. It also describes the fines for infractions of those requirements. While a large portion is devoted to activities that would not normally be required of a TAB technician, it is wise to at least be aware of their existence. The AGC and ABC training programs offer an effective way for becoming familiar with jobsite practices. The training programs also covers safety

information for the proper use of ladders, tying off and safety procedures to be followed while working with electrical systems. This is extremely valuable information that all should be aware of and practice every day.

Technicians can benefit from enrolling in one of the AGC or ABC programs which are available throughout the country. The time required is well spent if only one accident can be prevented.

The OSHA Standards for the Construction Industry is a comprehensive book that details all of their requirements. It also describes the fines for infractions of those requirements.

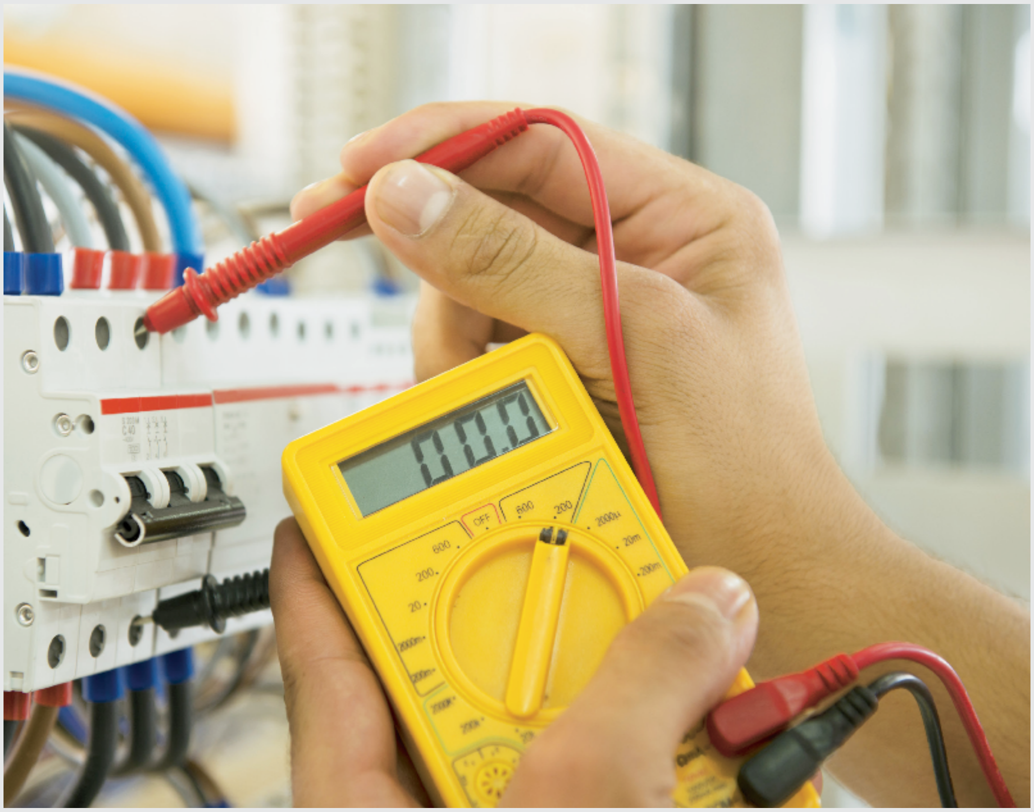
Tech tips

Wild Voltage Leg

Dean Steffen, TBE, Precisionaire of Arizona, Inc.

On a lot of our remote testing and balancing projects problems are encountered with voltage variations between the three phases. Electricians call it a wild leg on the line voltage. It is usually within tolerance of the equipment it is operating, but can vary as much as 10-12%. This may cause an amperage draw problem when trying to load the fan close to nameplate amps.

One recent incident involved increasing a MUA unit to nameplate amps of 5.2 to achieve as much air as possible. The amp draw went to 5.0/5.1/5.9. This was unacceptable to the engineer. By rolling the phases, L-1 to L-2, L-2 to L-3, and L-3 to L-1, it was possible to even out the amp draw to 5.1/5.4/5.1 without changing rotation on the fan. This does not always work, but for the short amount of time it takes, it is well worth a try.



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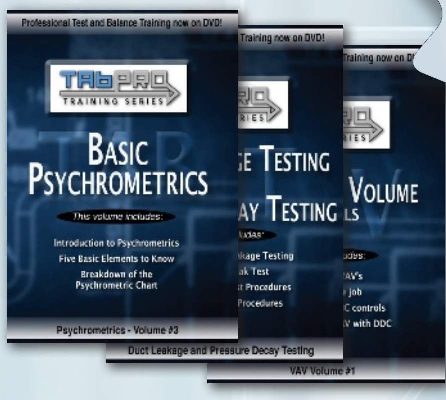

Basic Psychrometrics

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
Run time: 42 minutes
List price: $200.00
Member price: $150.00

This volume consists of two lessons covering standard duct leakage testing and pressure decay leakage testing. These lessons take the viewer through an introduction to leakage testing, essential job preparation, instrumentation used during testing, general procedures for leakage testing, multiple calculations used during testing and final reporting.

Variable Air Volume (VAV) Terminals

DVD format
Run time: 45 minutes
List price: $200.00
Member price: $150.00

This volume consists of two lessons covering standard VAVs and parallel fan-powered VAVs, both using DDC controls. These lessons take the viewer through an introduction to VAV terminals, essential job preparation, instrumentation used during testing, general procedures for testing and balancing, and final reporting.

Quantity	Title	Price Non-Member	Member
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_______	Duct Leakage	$200	$150
_______	VAV Terminals	$200	$150
_______	Bundle of all 3 DVDs	$468	$351

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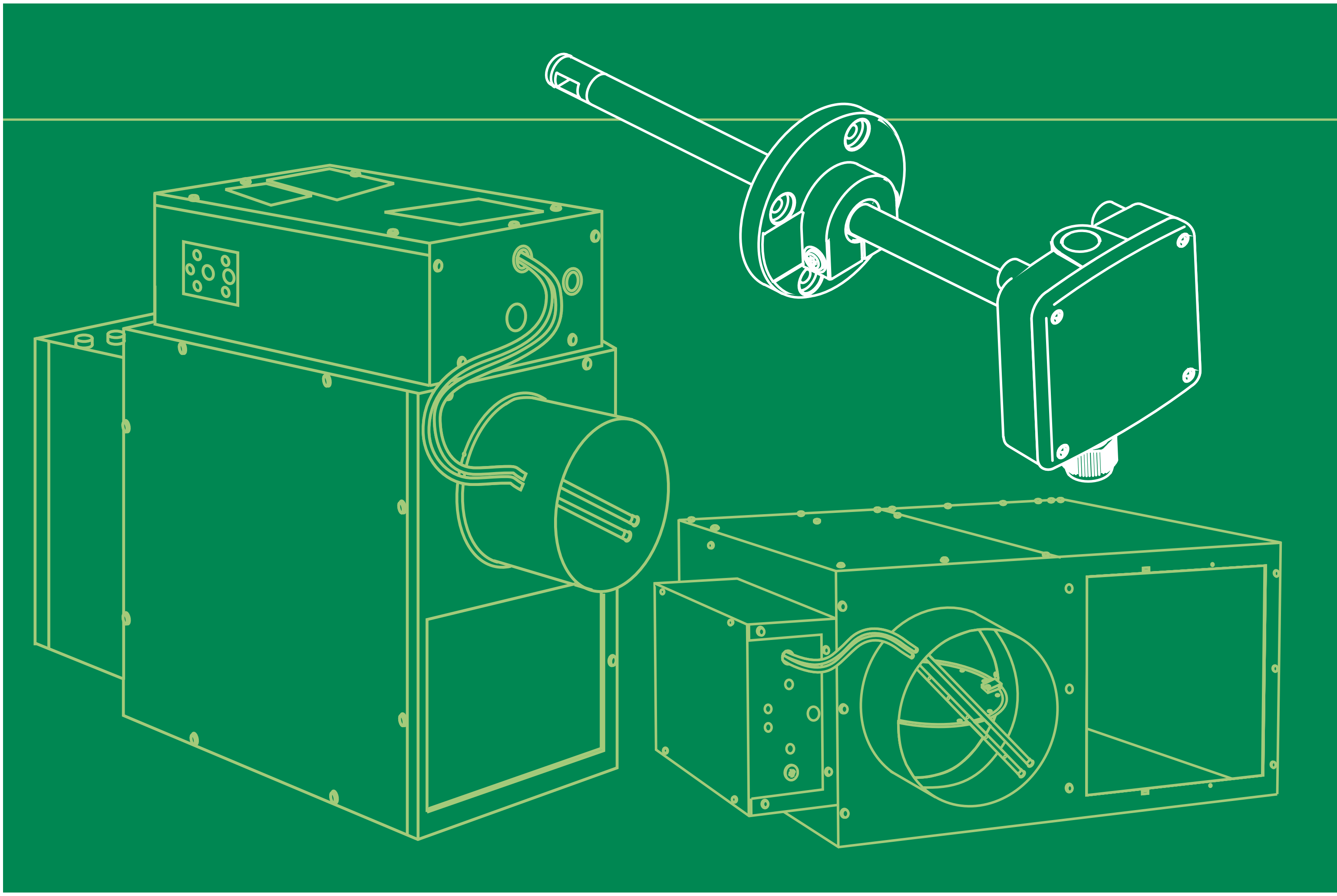
FLOW MEASUREMENT TAPS IN A VARIABLE VOLUME BOX

Surrinder Sahota, TBS
Designtest & Balance Co. Ltd.



Each variable box or fan-powered box has a flow measurement tap which is connected from the measuring grid to the controller. The measuring grid has multiple measuring points and sends the average velocity pressure to the controller. The manufacturer marks high and low on the outside of the box. High is the total pressure and low is the static pressure. When connected to the controllers, the controller maintains the difference of high and low which is velocity pressure.

The air balancing technician connects to the high and low tap and adjusts the controller to the required velocity pressure and converts to CFM by looking at the chart provided by the manufacturer. Accuracy can be verified with inlet traverses.

Once design CFMs are adjusted, the technician can balance the outlets downstream of each box. On fan-powered boxes, the air balancing technician sets the primary air by measuring the velocity pressure and converting to the CFM. Total air is adjusted from the speed controller.

Most of the variable volume boxes and fan powered boxes are DDC with the technology change. Some air balancing technicians are starting to take the CFM from the computer readout and informing the manufacturer that they can read and calibrate the CFM from the computer readout. Some manufacturers have stopped installation of taps, their claim being that some balancers say they do not need them.

Here are some reasons flow measurement taps are needed:

1. Verification of airflow at the box vs. flow at the outlets; the correction factor for the flow hood or other velocity meter can be determined because the grid inside the box is a multi-point traverse station which can also be verified by an inlet traverse

2. Verification of third party. When a consultant engineer or a commissioning agent wants to spot check the readings it needs to be verified that the VAV box air volume has not changed since the balancing was done. It could be difficult to convince a third party that the balancing report is accurate without being able to actually measure the controller velocity pressure.

3. Helpful to the building staff to verify the flow when they get a complaint. All they need is to measure the velocity pressure and compare with the certified report.

4. Balancing technician's instrument is more accurate than the transducer supplied by the box manufacturer. Transducers can go out of calibration after a while and air volume will change but if taps are available, the velocity pressure can be verified and recalibrated by adjusting the K factor.

5. When duct distribution downstream of the VAV box is above the solid ceiling and measured flow is in doubt. The flow can be measured by connecting to the taps to find out if there is any opening left in the duct or some broken duct joints. When using the velocity pressure vs. CFM on DDC system, care must be taken because some transducers have airflow going through from high to low but most of them do not have flow going through. When flow through transducers are used, measured velocity pressure can be used for reference only. Each size VAV box must be traversed, and CFM calculated from the duct traverse should be compared with the box manufacturer. If airflow measured by the duct traverse does not match, either call the manufacturer for an updated chart or use a correction factor to determine most accurate measurements.

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Pacific Test and Balance, Inc.
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Penn Air Control, Inc.
Cypress, California
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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
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Huntington Beach, California
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Southern Independent Testing Agency, Inc.
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Test and Balance Corporation
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Test and Balance Corporation
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Performance Test and Balance, LLC
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Coastal Air Balance Corp.
Terry, Mississippi
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