TAB for the HVAC Service Professional

TAB can help techs and contractors position themselves as strategic partners to existing commercial buildings customers.

BY SCOTT GORDON, NEBB CP, CEM, CM

Images courtesy of the author.

Author's note: The focus of this article is how Testing, Adjusting and Balancing (TAB) can benefit HVAC contractors, technicians and their customers when working in existing buildings. It will examine a project that demonstrates how TAB is used in situations that HVAC service professionals face every day.

The National Environmental Balancing Bureau (NEBB) defines Testing, Adjusting and Balancing (TAB) as "a systematic process or service applied to HVAC systems, and other environmental systems, to achieve and document air and hydronic flow rates."

TAB is a well-established service used widely in new construction and major replacement projects and is specified in construction documents. Common practice is for an independent TAB firm to provide services either directly to the owner, or as a subcontractor to the mechanical contractor.

TAB is a technical skill that requires specialized training and experience. Experienced HVAC contractors and technicians have the required "transferable skills" that can position them to become TAB professionals. TAB is too broad of a subject to address in a single article, as there are various books and manuals written on the subject. For additional information on TAB training and certification, visit www.nebb.org.

The existing building market and TAB

As discussed in the April 2017 issue of *RSES Journal* on Technical RCx, the Commercial Buildings Energy Consumption Survey (CBECS) database estimates that there were 5.6 million commercial buildings in the United States in 2012, comprising 87.4 billion sq. ft. of floor space. The inventory of existing buildings across North America is exponentially greater than new buildings that are constructed each year, and every new building turns into another existing building.

Existing buildings are known to have changes/modifications in how floor plans are configured, space is used and the number of people (occupancy density) that work within the space. For example, walls are often moved in office areas when space changes are made with little to no regard of the air distribution system layout. Space use changes are made as well. Such as cubicle areas to offices, a conference room into offices, or offices into a conference room.

Existing buildings have installation issues that can be skeletons in the closet to be found. One example would be poor inlet connections on the medium pressure inlet air side of a Variable Air Volume (VAV) box, making it difficult to obtain accurate flow readings through the velocity controller. Other issues that are often discovered with VAV boxes are: cracked flow rings, plugged tubing, incorrectly calibrated boxes and boxes that are configured incorrectly in the setting up through the control vendor software.

TAB is the process that a technician uses to identify the wide range of air and hydronic issues that are common in existing buildings. TAB is a service that HVAC service professionals can use to help customers improve comfort, enhance Indoor Air Quality, and often reduce energy costs in their existing buildings.

TAB instrumentation

Owning and maintaining the correct type of currently calibrated test instruments is a critical part of TAB. Instruments are used to obtain operating data, including air/water flows and pressures, fan RPM, motor voltage and amperage. The recorded data must be accurate so that correct determinations of equipment and system performance can be made. In TAB, decisions are made based on field measured data and the analysis of the data, and there can be significant financial costs associated with these decisions.

« Having the correct type of currently calibrated instruments is a critical component of TAB.

The best instrumentation in the world, used incorrectly, will yield incorrect readings. It is critically important to use instruments correctly and maintain calibration to obtain accurate and repeatable results.

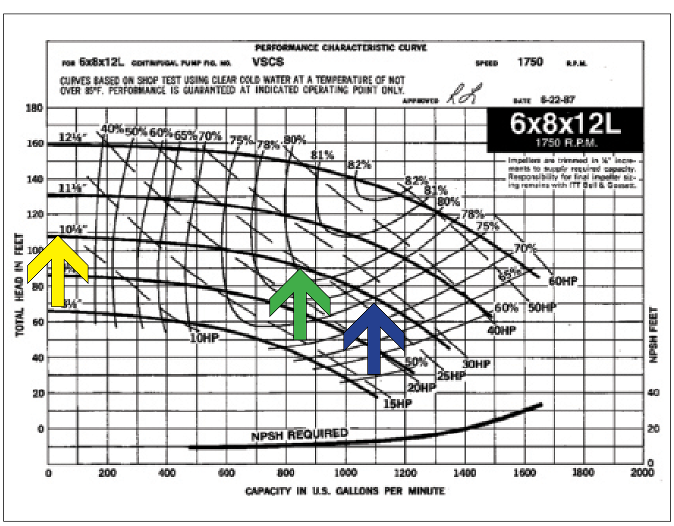
HVAC service professionals likely have many of the instruments required to perform TAB work, and some may already have everything that is required. The primary instruments that are required for TAB are:

→Digital manometers, 0-10 in. wg
→Air velocity instrument, 50-3900 fpm
→Pitot tubes (various sizes up to 60 in. long)
→Rotating vane Anemometer, 50-2500 fpm
→Digital temperature meter with calibrated sensors
→Humidity meter
→Voltage meter, 600 V
→Amp meter, 0-100 amps True RMS
→Digital tachometer, 60-5,000 RPM
→Hydronic pressure measurements, -30 in. Hg to 200 psi
→Hydronic differential pressure measurement, 0-80 psi

One final point regarding instrumentation in the HVAC service world versus instrumentation in the TAB world is that in service, instruments are used primarily for troubleshooting, diagnosing and verifying that repairs are made and equipment is operating correctly. In the TAB world, instrumentation is also used in all the above, in addition to documenting and certifying air and hydronic flow rates. Additionally, with TAB, instruments are used to calibrate field-installed sensors such as airflow measuring stations, building pressure controls and differential pressure sensors that control pump speed. Motor kW is calculated to determine actual brake hp. Accuracy is important in both realms, however it is critically important to have calibrated instruments that have documented calibration certificates when performing TAB work.

Using TAB to uncover pump energy waste

Next time inside an equipment room, look at the position of balancing valves (or Triple Duty Valves) that are installed on the discharge side of pumps.



A correct pump curve is required to establish a baseline for pump performance.

Though there are exceptions, it has been my experience that valves are generally either wide open and the pump is over-pumping, or the valve is significantly throttled down. In the latter scenario, the pump is oversized and, to achieve the design flow rate, the balancing valve is closed significantly to artificially place the design head across the pump, since the actual system head is less than estimated in the design of the system.

To make matters worse, often one will see a balancing valve throttled down on a pump that has a variable frequency drive (VFD) installed. This combination is a complete waste of energy and requires further investigation. The balancing valve should be opened 100% and let the VFD ramp down to maintain the required flow.

Energy codes across the country have started to specify limits to how much a pump can be balanced down before the impeller must be trimmed. If a pump must be throttled down more than 20%, then the pump curve should be analyzed to determine if the impeller can be trimmed or if the pump is so grossly oversized that another selection should be made. Pumps that are grossly oversized typically operate at a low-efficiency point and impose an energy penalty for the life of the pump.

Energy codes are forcing design engineers to be more diligent in estimating system head, and not drastically overdesign pumping capacity. This is a delicate balancing point that the engineering community must work with, as engineers must allow for unknowns in their design such as jobsite conditions, piping offsets and fouling factors, especially in open cooling towers.

Determining pump performance

A hydronic differential pressure meter is used to measure the actual pump head, or (in the picture on page 17) system head.

The head across the pump, also known as Total Dynamic Head (TDH), is the difference between the discharge pressure and suction pressure across the pump, as measured in ft of water.

The meter used here is a Shortridge HDM-300 and is well known in the TAB world as a workhorse when dealing with hydronic pressure measurements. The HDM (Hydro Data Meter) measures either single or differential pressures in psi, ft of water, in. of water, in. of mercury and temperature.

A real world example

And now for a real-world example of determining if a pump is oversized. The information that follows is provided as a general overview of the procedure. Please refer to www.nebb.org and the current version of NEBB's TAB Procedural Standards for additional information.

To protect the identity of the customer, the facility is described only as a commercial office building located in the southeast United States. The pump in question is a chilled water pump with a design flow of 840 GPM at 90 ft of head.

To establish a baseline of how the pump is performing, it is necessary to obtain the correct pump curve for the pump that is being tested. Most pump manufacturers have their pump curves available online. The older curves may be listed under a tab or link of obsolete pumps; however, they are typically available through the manufacturer's website. Occasionally a curve cannot be found. A call to the pump manufacturer generally resolves this. There has only been one time that the author was not successful in obtaining a pump curve, with a 35-year-old pump, when the original manufacturer sold their pump line to another company and the old curves no longer existed.

The pump curve on page 16 is for the example project. It is important to make sure that the pump curve is correct for the RPM of the pump that is installed. For this project, the motor RPM is 1750. The green arrow indicates the design point of 840 GPM and 90 ft of head. The pump size is 6 in. x 8 in. x 12 in., which represents a 6 in. discharge, 8 in. suction and a maximum impeller diameter of 12 in. The design impeller diameter for the project is 10-1/8 in.

A pump curve represents a pump's performance at various operating points. The first step in the TAB process is to verify that the impeller inside the pump is the correct size. Impellers can be trimmed, worn, replaced or possibly incorrectly supplied from the factory. To verify the impeller size, the pump is dead-headed to determine the head at zero flow. The head that falls on the zero-flow line establishes the impeller diameter.

Before dead heading a pump, equipment that the pump serves must be considered. With existing buildings, this procedure will likely need to be scheduled after hours, or if there are redundant pumps, the work possibly can be performed during normal hours. It is advised to setup testing with the building O&M staff to make sure that equipment, such as chillers, will not shut down on a fault, such as low chilled water flow.

To dead-head a pump, first connect a differential pressure meter across the pump. It is important to connect at the suction and discharge flange of the pump, as pump manufacturers test their pumps at this point. If the tech uses pressure readings in the piping that includes pressure drops of suction diffusers, valves, strainers, triple duty valves, then the reading will be meaningless while trying to use a pump curve.

If the correct pressure taps are not installed at the pump suction and discharge flange, then install them as part of the testing job.

Never trust gauges that are installed on a piece of equipment. Valve off the gauge, install the correct fitting (typically 1/4 in. pipe to 1/4 in. flare) and connect a calibrated hydronic differential pressure meter. A tech can only rely on their own instruments, which are calibrated and maintained in proper working condition.

After the meter is installed across the pump, read the head and record, both the head and the position of the balancing valve on the discharge side of the pump. Then slowly close the balancing valve and record the pump head at zero flow. Then slowly open the valve to 100% wide-open position and record the head across the pump. Motor amperage is also measured and recorded during this process. Finally, reset the balancing valve to the as-found position and verify as-found head across the pump.

« A hydronic differential pressure meter is used to measure the actual pump or system head.

This project established that when the pump was deadheaded, the measured head at zero flow was 109 ft, determining that the impeller diameter inside the pump was 10-1/8 in. This point is shown on the pump curve (on page 16) by the orange arrow. Once the impeller size is verified, the pump curve can be used to determine flow at various operating points.

Pump head at 100% wide-open valve position was measured at 73 ft, which is the same position that the pump was initially operating at before testing took place. Using the pump curve, following 73 ft across to the 10-1/8 in. impeller curve indicates a flow of 1,100 gpm as shown by the blue arrow. The design flow is 840 gpm, so the pump has been operating at 131% of design flow with the balancing valve wide open.

Based upon the discovery of information that the hydronic testing has provided, a recommendation was made to install a VFD on the pump and adjust the pump speed down to achieve the required flow. Since GPM and RPM have a direct one-to-one relationship with each other, the following calculation was used to determine the pump speed:

$$\frac{GPM2}{GPM1} = \frac{rpm2}{rpm1}$$

$$RPM2 = \frac{840\ gpm}{1{,}100\ gpm} \times 1{,}750\ rpm$$

$$rpm2 = 0.764 \times 1750 = 1{,}336\ rpm$$

Speed reference HZ on the VFD = 60 HZ x .764 = 45.8 HZ

Building Automation Systems and TAB

The ability to work with Building Automation Systems (BAS) is an important part of TAB. When performing TAB, equipment must be setup to provide design flow rates for both airside and waterside testing. With new construction projects, the control contractor is typically onsite and can assist the TAB firm with this work. When working in existing buildings, the control contractor is generally not onsite, so the TAB firm or HVAC service professional must decide how to handle the controls.

An HVAC service professional can hire the control company to work with them. However, this is typically not necessary and can be expensive since controls need to be adjusted throughout the workday, and what will the control technician do when they are needed at various times within several hours throughout the day?

The best approach is to operate the controls on their own so that they can move along from one piece of equipment to another efficiently throughout the day. This type of control work is considered operational versus control programming. One only needs to know how to override equipment, such as place VAV boxes into max flow positions, change static pressure set points on VAV AHUs, and override water valves and pumps.

If a tech is not familiar with a control system, they should consider providing four to eight hours of time in their labor estimate for the control contractor to work with so they can ultimately handle the work on their own. They need to make a list of what they need to be able to do, take notes and obtain user name, passwords, interface devices, etc. so that they can be self-sufficient with the controls once the control technician leaves the job.

Conclusion

This project provided value to the customer by reducing energy costs through installing a VFD. The project also provided value to the contractor by creating the opportunity to provide the testing service, which kept a technician busy, plus selling a 30 hp VFD and associated control work as the solution. The energy saved by installing the VFD was estimated at $4,900 per year.

The project cost was $12,000, yielding a simple payback of 2.5 years for the customer. Additionally, a utility rebate of $50/hp for installing a VFD provided a customer incentive of $1,500, which brought the customer's cost down to $10,500, yielding an after incentive simple payback of 2.1 years ($10,500/$4,900).

It should be noted that when making changes to a hydronic system such as this, additional balancing of the chilled water coils may be required if the coils were not correctly proportionally balanced.

This real-world example of a pump that is over pumping is currently playing out in literally thousands of sites across the country. Every equipment room has opportunities to improve comfort and reduce energy costs for customers. There are hundreds of other opportunities that TAB helps to uncover, ranging from airside, waterside and control system optimization.

HVAC service professionals who combine TAB as a service, with energy analysis, will position themselves as a strategic partner and valuable resource to their customers. HVAC service professionals have many transferable skills that can be used to develop TAB as a valuable service to offer. Once TAB is part of a company's service, opportunities to help customers grows exponentially.

Scott Gordon owns EBCx Services, and has over 40 years of HVAC industry experience. Gordon learned the trade from his father, Cal Gordon, founder of Tropic Air Conditioning in Miami, FL. He obtained his Journeyman license at the age of 19, and earned his Class-A Certified Air Conditioning Contractor License (FL) at age 21. His career includes decades of real world experience, coupled with continuous training. He holds certifications with NEBB for TAB, Cx, RCx and Building Enclosure Testing. Additionally, he holds multiple certifications with the Association of Energy Engineers (AEE), and is a LEED AP Operations & Maintenance. Gordon can be reached at scott@ebcxservices.com or 423-737-5085.