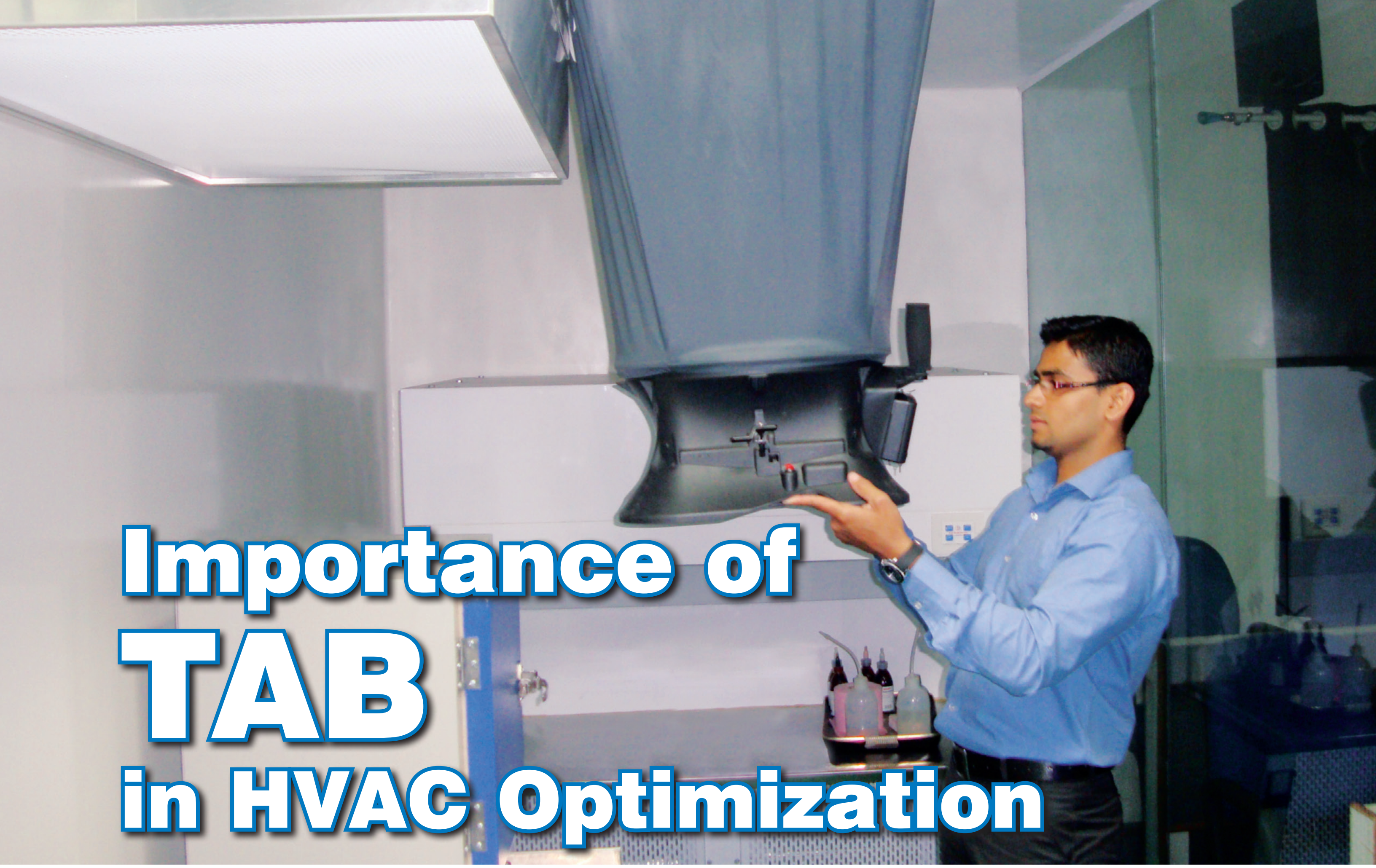
Importance of TAB in HVAC Optimization



Air volume testing with a hood

By Bipin Patil
Managing Director
Aerience Air Science & Contamination Control Pvt. Ltd., Pune

Introduction

HVAC Testing, Adjusting, and Balancing (TAB) is an important part of fluid (air and water) distribution systems. According to National Environmental Balancing Bureau, USA (NEBB), TAB is a systematic process or service applied to HVAC to achieve and document air and hydronic flow rates. The standards and procedures for providing these services are described in the *NEBB Procedural Standards for the Testing, Adjusting and Balancing of Environmental Systems*.

Hydronic balancing is essential for equipment (pumps, chillers, cooling tower and AHUs) to perform at optimum levels, whereas air balancing is important to achieve optimum levels of indoor air parameters (temperature, humidity and contamination).

With the advent of modern technologies and the need to reduce power consumption, equipment manufacturers are playing their part in making available high energy efficient products. Architects, builders and facility designers also optimize designs to ensure the best possible construction materials and fenestrations to keep ingress of heat to a minimum, thereby minimizing cooling loads to meet ASHRAE or ECBC (Energy Conservation Building Code) norms. System designers select the best possible combination keeping in view initial capital cost and running costs to optimize performance.

The actual site scenario however, is much different. The activities to be carried out at site such as ducting, piping and equipment installation are left to the site contractor, who normally is not conversant with HVAC-specific requirements, and his quality and workmanship may not be up to the mark to deliver the expected performance.

Besides, operation and maintenance of the plant carried out either by the owner's staff or the contractor's staff is far from what is required and expected, and this leads to a wide variation between what the designer envisaged and the actual performance at the time of commissioning or after a time lapse.

Why TAB?

The assistance of TAB professionals and technicians would help in narrowing the gap between the expected and actual

About the Author

Bipin Patil is the founder of Aerience Institute Air Science & Contamination Control, Pune and the MD of Snowline HVAC Systems Pvt. Ltd., Pune. He has an experience of 29 years in HVAC consultancy. He specializes in cleanrooms, hazard level filtration systems (bio-safety levels 1-4), HVAC energy audits, HVAC TAB, cooling tower performance testing and thermography.

performance of the system. We have made an effort in this article to emphasize the role of TAB from concept to completion of project. A well-performed TAB of an HVAC system is essential for the proper performance of that system and would certainly enhance indoor air quality and efficiency.

Why TAB is Essential for all HVAC Installations?

- Because HVAC consumes nearly 40% of building electrical energy, and efforts to reduce it to the maximum extent are essential.
- Because the cost of electricity is always rising, and power saving is saving of tangible money.
- Because if the owner of the facility does not do it, his competitors will. TAB therefore, gives a competitive advantage, which no organization should let go.
- Because the earlier an organization embarks on electricity savings, the earlier it can achieve payback.
- Because any activities that can reduce fixed expenses substantially without compromising productivity or output are always welcome.
- Because the government encourages organizations to implement energy savings by providing incentives.

Benefits

If we consider all its benefits, TAB does not work out to be an expensive exercise; it is essential that in the changing energy scenario, beyond efficiency and expense, improving HVAC performance can have the added advantage of bringing systems in line with ASHRAE and other international standards, reducing or eliminating VOCs and bio aerosols, identifying and controlling general air quality problems, and reducing greenhouse gases.

Why then is TAB not popular in the HVAC industry in India? The following could be some of the causes:

- The client is not aware of benefits he can derive by implementing TAB in terms of energy savings and equipment life.
- Contractors do not consider it very important, and feel they can do it themselves during the normal commissioning and handing over process.
- Dearth of TAB professionals who understand the correct use of equipment and systematic analysis of obtained and measured parameters.

If these are looked upon as opportunities rather than weaknesses, it throws open a new untapped career field to HVAC engineers and technicians. It is estimated that if every new HVAC installation is subjected to TAB, even a workforce of 500 technicians may prove inadequate, whereas currently there are less than 10 accredited TAB professionals in India.

Challenges

The greatest challenge is how to bridge this gap? TAB is not just about an engineer simply carrying instruments and starting a profession. It requires deep knowledge of HVAC performance and testing. To create 500 professionals within a short span is difficult. It requires state of the art institutes with practical set-ups and calibration benches for various instruments. Laboratories with the latest HVAC equipment, precise test instrumentation, pumping and hydronic balancing system, air handling units with air balancing system, filters and filtration systems etc. are required, needing substantial capital investment.

All this is possible, but the most important requirement is knowledgeable teaching faculty to deliver the course and train the technicians properly with hands-on use of TAB instruments, understand their limitations as well as field requirements.

It is a massive challenge; the ardor to reduce energy usage and improve efficiency is a win-win situation. It does not take much persuasion to show a customer that TAB services are not just about comfort and efficiency, but real, tangible, bottom line savings. TAB professionals can show buyers return on investment (ROI) figures that are compelling.

Discipline and Responsibilities

Testing, Adjusting and Balancing is a critical step in HVAC system installation. As mentioned above, a system designed by the world's best engineers and installed by the industry's leading contractors will be rendered useless if it is not balanced properly.

Based on my experience of over 29 years with projects and HVAC installation contractors I have met during my career, I venture to make the following statements that some in the industry may disagree with, but which have been proven right time and again:

- Every new HVAC system should be tested and balanced by owner-company hired third party independent TAB professionals.
- If TAB is left to the HVAC subcontractor as a part of performance guarantee before handing over the plant on his own or through his hired TAB agency, it is likely that at least 50% of the systems are *not* being actually balanced at all with laid down systematic procedures.

My experience has shown that if left to the HVAC subcontractor to have one of their startup technicians perform TAB, many of the systems will never be balanced. If the occupants never complain, how will anyone know balancing was not performed? On more than one occasion, I have experienced HVAC contractors submit balancing reports to include in their project final submission documents without ever balancing a single piece of the system. This practice is quite common. Owners need to understand the significance of third party TAB performance.

> *TAB is an excellent first step in reducing energy consumption and optimizing Heating, Ventilation, and Air Conditioning system performance. Just like tuning up a car, tuning up an HVAC system can reduce the operating costs by up to 20% and prolong the life of the equipment. TAB guarantees payback in less than one year.*

Who Should be a TAB Professional?

TAB personnel should not be just instrument readers/operators; they must have a comprehensive knowledge of system fundamentals, theory of fluid flow, heat transfer, psychrometrics and state of the art control systems.

The *only* way to ensure that a system is balanced properly, so that the occupants will be comfortable, is to have the system balanced by a technician following the guidelines of the three international balancing agencies NEBB, TABB (Testing, Adjusting and Balancing Bureau) or AABC (Associated Air Balance Council). NEBB procedural standards are available for free download. Visit *http://www.nebb.org/resources/standards*.

Commencing TAB

Before commencing TAB, remember two important quotes by Lord Kelvin:

To *measure* is to know. If you cannot *measure* it, you cannot improve it.

There is nothing new to be discovered in physics now; all that remains is more and more precise *measurement*.

The first quote relates to testing and measurements. The accuracy of an instrument is its capability to indicate the true value, whereas precision is its ability to produce repeatable readings of the same quantity under the same conditions. Therefore, the second quote is allied with the accuracy of measurements and precision of measuring instruments.

Pre-functional

Prior to TAB, involvement of TAB professionals in the following three activities would avoid rework on errors during installation and commissioning startup.

Project Monitoring

Involvement of TAB professional during execution would ensure narrowing installation errors. The project monitoring team working hand in hand with TAB professional would leave no errors during performance evaluation of the installed HVAC system.

Installation Qualification

The single largest cause of HVAC system failure is installation and startup by untrained persons. As with any profession or craft, there are many skill levels; there are some truly great HVAC installers, but most are inexperienced and just beginning to learn the craft. Incorrectly installed system components may result in reduced life and require costly replacement. Installation Qualification verifies correct material and equipment installation; it verifies that the installation meets construction details and manufacturer's instructions and documents the condition of equipment.

Startup and Commissioning

The final steps prior to TAB are startup and commissioning. After HVAC equipment is installed and electrical power wiring is completed, the equipment must be *started up*. The startup process is usually performed by engineers with the HVAC subcontractor, but may also be performed by engineers from the equipment manufacturer.

HVAC commissioning is a proactive, systematic process that facilitates communication between owners, designers, and contractors. It utilizes the commissioning process to verify that the design meets the owner's requirements, the equipment is installed and operated according to the construction documents and manufacturer's instructions, devices are calibrated, and equipment operates together smoothly.

Startup and commissioning witnessed by a TAB professional would ensure that no errors are left. HVAC systems initially installed in a building will not function at design specifications upon startup. Adjusting the system to design specifications requires TAB of control devices.

Pre TAB Requisites

Pre-Functional Test (PFT): An inspection or test that is done before functional testing. PFTs include installation verification and system and component start up tests.

Startup Tests: Tests that validate that the component or system is ready for automatic operation in accordance with the manufacturer's requirements.

Test Procedure: A written protocol that defines methods, personnel, and expectations for tests conducted on components, equipment, assemblies, systems, and interfaces among systems.

Test Instrumentation: The use of specialized and calibrated instruments to measure parameters such as temperature, pressure, vapor flow, air flow, fluid flow, rotational speed, electrical characteristics, velocity, and other data in order to determine performance, operation, or function.

TAB Sequence and Recommended TAB

Pre-TAB Inspections

Before commencing TAB, thermal scans or thermographic pictures taken with an infrared thermographic camera show the relative temperatures of objects and surfaces and are used to identify leaks, thermal bridging, thermal intrusion, electrical overload conditions, cable undersizing, moisture containment, insulation failure and many more.

Figure 1: Infrared Thermography

Advanced infrared technology allows for detection and identification of problems invisible to the naked eye. Additionally, infrared scanning provides physical documentation of problems that often go unseen during standard visual inspections.

- It is a non-destructive test method.
- It is able to find deteriorating, i.e., higher temperature components prior to their failure, resulting in increase in life of equipment.
- It can be used to measure or observe areas inaccessible or hazardous for other methods.
- It can be used to find defects in shafts, pipes, and other metal or plastic parts.

TAB Pumps

Roughly 25% of world power is consumed by pumping systems. Pump performance testing can help reduce energy costs by identifying poor efficiency, and maintenance costs by diagnosing chronic

continued on page 50

continued from page 48

pump problems. How often do pumps operate from their design points? How much power is being wasted? How do these conditions impact pump reliability and repair costs?

Efficiency tests help facilities staff identify inefficient systems, determine energy efficiency improvement measures, and estimate potential energy savings. These tests are usually conducted on larger pumps and on those that operate for long periods of time. For details, see Hydraulic Institute Standards *ANSI/HI 1.6-2000, Centrifugal Pump Tests,* and *ANSI/HI 2.6-2000, Vertical Pump Tests.*

Table 1: Liquid flow equations

Select equations below to solve for a different unknown		Select equations below to solve Net Positive Suction Head and Cavitation	
$WHP = \frac{Q\,x\,H\,x\,G}{3960}$	Solve for water horsepower	$NPSH = \frac{V^2}{2g} + \frac{p}{SW} - \frac{pv}{SW}$	Solve for NPSH - net positive suction head
$Q = \frac{3960\ x\ WHP}{H}$	Solve for flow rate or discharge	$V = \sqrt{2g\left(NPSH - \frac{p}{SW} + \frac{pv}{SW}\right)}$	Solve for fluid or liquid velocity
$H = \frac{3960\ x\ WHP}{Q}$	Solve for total head	$p = SW\left(NPSH - \frac{V^2}{2g} + \frac{pv}{SW}\right)$	Solve for pressure at impeller inlet
$\eta = \frac{WHP}{BHP}$	Solve for pump efficiency	$pv = -SW\left(NPSH - \frac{V^2}{2g} + \frac{p}{SW}\right)$	Solve for fluid or liquid vapor pressure
$BHP = \frac{100QH}{3960n}$	Solve for brake horsepower	$SW = \frac{p - pv}{NPSH - \frac{V^2}{2g}}$	Solve for specific weight of fluid or liquid
Where : WHP = water horsepower é;; Q = flow rate or discharge H = total head η = pump efficiency BHP = brake horsepower NPSH = net positive suction head		Where : V = velocity of fluid or liquid p = impeller inlet pressure p_v = vapor pressure of fluid or liquid SW = specific weight of fluid or liquid g = acceleration of gravity	

Flow rates can be obtained with reliable instruments installed in the system or preferably with stand-alone tools such as ultrasonic (doppler type) or transit time flow meter or a pitot tube and manometer. Turbulence can be avoided by measuring the flow rate on a pipe section without fittings at a point, where there is still a straight run of pipe ahead.

Improving Pumping System Efficiency

Internal leaks caused by excessive impeller clearances or by worn or misadjusted parts can reduce the efficiency of pumps. Corrective actions include restoring internal clearances and replacing or refurbishing worn or damaged throat bushings, wear rings, impellers or pump bowls. Changes in process requirements and control strategies, deteriorating piping, and valve losses all affect pumping system efficiency.

Pumping system efficiency incorporates the efficiencies of the pump, motor, and other system components.

Why TAB pumping system is essential?

Because in parallel pumping system 100 + 100 ≠ 200 and 300 ÷ 3 ≠ 100. *Figure 2* shows what happens when two identical centrifugal pumps, connected in parallel, intersect a system curve, and when three pumps are run in parallel, the third pump often does not seem to be making much of the difference.

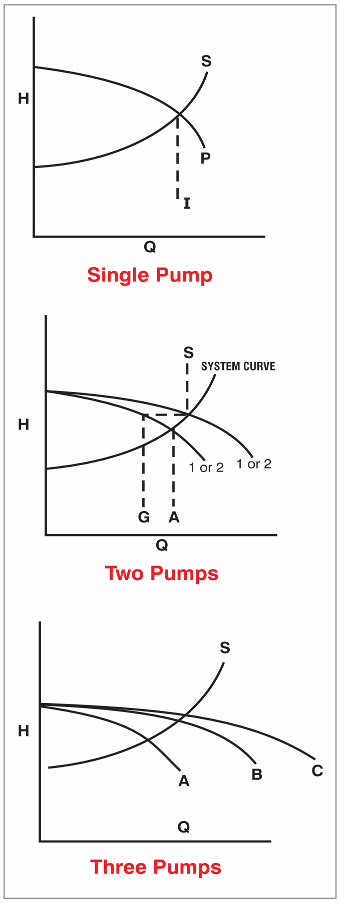
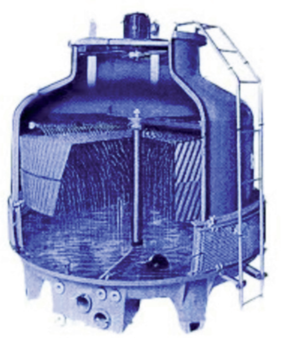


Figure 2: Centrifugal pump curves

TAB Cooling Tower



Cooling tower operation and maintenance is the key for improved energy efficiency. According to ASHRAE, every 1^0F increase in cooling tower water temperature corresponds to 2% decrease in chiller efficiency.

One of the best ways to improve cooling tower and chiller efficiency is to balance the hydronic flows.

Cooling tower and chiller efficiencies are typically based on the unit design and given standardized rating values; however, this always depends upon whether hydronic flows are balanced to the rating values. Remember always, unbalanced cooling water flow reduces condenser heat transfer effectiveness and causes the condenser pressure to rise. As approach temperature between the leaving condenser water temperature and the saturated condenser temperature increases, it indicates that the condenser heat transfer is poor. Therefore, it is necessary to set hydronic balancing to the design flows.

A cooling tower is a specialized heat exchanger in which two fluids (air and water) are brought in direct contact with each other to effect heat transfer. The scientific method of tower performance test is very well explained in *Standard ATC-105* of Cooling Technology Institute (CTI). This standard is available for downloading at US$ 75. Visit *http://www.cti.org/pub/cticode.shtml*

continued on page 52

continued from page 50

Acceptance Test

This is conducted to verify if the new or rebuilt tower meets contract performance specification requirement.

Status Test

This is conducted to determine the thermal capability or actual operating parameter of an older tower. Both the above tests are often used as baseline tests prior to upgrade.

Cooling towers are rated in terms of *approach* and *range*, where;

- *Approach* is the difference in temperature between the cooled water temperature and the entering air *wet bulb* (t_{wb}) temperature
- *Range* is the temperature difference between the water inlet and exit states (t_i - t_o)

Since a cooling tower works based on evaporative cooling, the maximum cooling tower efficiency is limited by the wet bulb temperature of the cooling air.

Cooling Tower Efficiency

The cooling tower efficiency can be expressed as

$\mu = (t_i - t_o)\ 100 / (t_i - t_{wb})$

Where;

μ = *cooling tower efficiency*

t_i = *inlet temperature of water to the tower (°C, °F)*

t_o = *outlet temperature of water from the tower (°C, °F)*

t_{wb} = *wet bulb temperature of air (°C, °F)*

Tab Chiller

Just like a car, tuning up an HVAC system can reduce the operating costs up to 20% and prolong the life of the equipment.

Heat exchanger efficiency in chillers and condensers can be drastically reduced when flow is not balanced, and be very costly in the long run when one looks at how much increased energy has to be used to get the same amount of cooling capacity.

A well balanced system ensures the working of chillers at high efficiency and reduces the electricity and chilled water bills. Accurately assessing the actual performance of an installed chiller that needs extra capacity is straightforward, if thermodynamic principles are applied correctly, equipment definitions are adhered to, and proper test procedures are followed.

Monitoring flows and temperatures over time can provide all the necessary information to evaluate chiller performance. Performance rating of water chilling packages using vapor compression is well explained in *ARI Standard 550/590 (2003)*.

Fluid flows in chillers cannot be same unless TAB is implemented.

TAB Hydronic

Hydronic balancing is the process of optimizing the distribution of water in a building's heating or cooling system, so it provides the intended indoor climate at optimum energy efficiency and minimum operating cost.

Figure 3: Flow meter

In an unbalanced system, there will always be favored circuits that receive more water than they require. These favored circuits steal flow from un-favored circuits which will not then be able to provide the required heating or cooling.

Control valves may temporarily help by gradually reducing the flow in favored circuits, thus allowing un-favored circuits to regain the correct flow. But during high-load periods (e.g. winter for heating plants and summer for cooling plants), all the control valves operate in a near-permanent open position. As a result the un-favored circuits still receive too little flow.

Hydronic balancing limits the flow in favored circuits, forcing water through un-favored circuits. As a result, the required design flows are available to all circuits and the system can provide the required indoor conditions.

Verify pump performance before hydronic balancing. As stated above, in parallel pumping system, 100 + 100 ≠ 200 and 300 ÷ 3 ≠ 100.

TAB Air Handling Unit

The air handler is a fundamental component of forced air ventilation. HVAC system efficiency depends on how you balance or tune the air handler/s. Measuring air handler performance requires the combination of airflow, static pressure, airflow traverses, temperature, fan speed, fan laws, air density correction, psychrometrics, fluid dynamics, velocity and electrical measurements to agree before a sound decision of air handler performance can be made.

The most accurate and accepted field test of fan airflow is a pitot tube traverse in the supply air duct. Air stream in the duct is turbulent; therefore, the traverse should be at least 10 duct diameters upstream and 5 duct diameters downstream in case of straight duct, or 8 duct diameter downstream and 2 duct diameters upstream from elbows, transitions, takeoffs, dampers or other obstructions which cause turbulence.

To determine the equivalent duct diameter of a rectangular duct, use the following equation:

$$D = \sqrt{4ab/\pi}$$

Where: D = equivalent duct diameter in inch

a = length of one side of rectangular duct in inch

b = length of second side of rectangular duct in inch

π = 3.14159

In situations where a pitot tube traverse is not possible, the system airflow may be determined by fan performance using a fan curve or performance rating chart; it is necessary to take amperage, voltage and static pressure readings across the fan.

Remember that fan performance can deviate from fan curves due to System Effect; installation defects and measurement errors

continued on page 56

continued from page 52

need to be noticed and corrected during performance evaluation. When performing static pressure reading on fan systems, it is necessary to take the readings based on a common static reference point.

The system airflow may be determined by alternate methods, such as anemometer or velocity grid traverses across coils and/or filters, or the summation of air outlet measurements. These alternative methods are not recommended for evaluating AHU fan performance as standard practices and are subject to a greater degree of error than pitot tube traverses; therefore, they should be used with caution.

Identifying System Deficiencies

Fan air flow

Compare actual results of the tests conducted with the specified performance of the fan. If the fan air flow is not within +/- 10% of design, evaluate the reasons.

Determine whether pressure drops across the duct system components such as coils, filters, dampers, etc. are in line with the manufacturer's ratings.

Observe duct system configurations at the inlet and discharge of the fans. Compare these with the contract drawings. Notice, if any radical changes were made to the duct system layout during installation.

Fan adjustments

If it is determined that everything is in order, but the total air is still below design, there is a need to increase fan speed.

Whenever a damper is closed during balancing, there will be a rise in static pressure and fan will discharge less air. Hence, it is a good practice to set the fan at 110% of design flow to allow for the loss of air during dampering.

If fan speed is to be increased, use fan laws to calculate not only the needed adjustment to the sheaves and belts, but also new required brake horse power. It is critical, when increasing fan speed, to determine if adequate horse power is available. Never increase the fan speed to the point where the motor is overloaded. If air flow is greater than 120% of design, fan speed needs to be reduced to bring the air volume down to 110% of design.

When the system does not perform as designed, new drives and motor *or* fan are often required.

Qualifying the installed air handler is a must prior to commencing TAB Air. Factory test certificate should not be considered as final.

TAB Air

Air balance is not an easy technique that simply involves carrying balancing instruments, checking the flows and throttling the dampers to adjust the flows. It requires repetition of adjustments till all the terminals show readings within ±10% of desired values.

Air in a duct follows the path of least resistance. Since the branches

Figure 4: Air volume hood

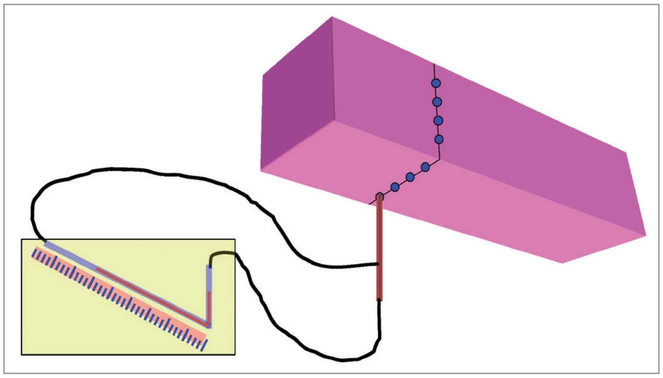


Figure 5: Pitot tube traverse

have excess static pressure, they need to be balanced. Unless a system is balanced, air will not be distributed properly. Some outlets will receive too much air, while others will not receive enough, creating unbalance.

Air velocity is lowest near the sides of the duct and highest at or near the centre, because of friction at the sides. Therefore, a pitot tube traverse of the duct is needed to determine the average velocity at the point of traverse. Having found the average velocity, the volume of the air in the duct can then be mathematically calculated using the equation Q=AV.

Prior to air balancing, follow the sequence below:

Preliminary checks

- Air distribution system qualifies to design, confirming good installation practices.
- Duct leak is tested to the allowed pressure and leakage class.
- TAB provisions are made.
- Every item affecting the airflow of a duct system is ready for TAB, such as doors and windows being closed, ceiling tiles (return air plenums) in place, etc.
- All automatic control devices will not affect TAB operations (deactivate control system).
- Establish the conditions for the maximum demand system airflow, which generally is a cooling application with wetted coils.

Air Distribution

- Begin the testing of the system by setting the automatic temperature controls on full cooling. (Cooling capacity is more critical than heating capacity.)

Damper Check

- Verify that each automatic damper, that has not been blocked or disconnected, is being controlled automatically and is in correct position.
- There will be some effect on air flow if these dampers are hunting. This is undesirable for air balancing.
- All dampers should be set for full flow cooling solutions.
- Make sure that all system dampers are set and operating for the TAB work.

Report Forms

- Prepare report forms for each system being tested.
- The *test balance report* is a complete record of preliminary and final test data.

continued on page 58

continued from page 56

Air Balancing

Proportionally balancing constant volume low pressure system, balancing constant volume multi-zone system, balancing dual duct system, balancing variable air volume system, branch balancing using static pressure, balancing procedure for pressure independent system and balancing procedure for pressure dependant system require different skills and techniques. These different techniques are well-explained in the manual *Testing and Balancing HVAC Air and Water System* by Samuel C. Sugarman.

Proportionally Balancing Low Pressure Systems

I. Determine which outlet has the lowest percent of design flow (%D).
   - This outlet will be called the *key outlet*. Typically, the outlet with the lowest %D will be on the branch farthest from the fan.
   - Design flow is either the original design flow as per the contract specifications or a new calculated design flow.
   - Percent of design flow is equal to the measured flow (M) divided by the design flow (D).

   $$\%D = \frac{M}{D}$$

II. Starting with the *key outlet* as needed, adjust each outlet on that branch duct in sequence, from lowest percent of design flow to the highest percent of design flow.
   - Find the ratio with respect to key outlet (%D of any outlet w.r.t. %D of the key outlet).
   - If the ratio is within +/- 10% (0.9 to 1.10), lock the damper.
   - If the ratio is not within +/-10%, continue until all the outlets of that branch have been balanced to within +/-10% of each other.
   - To reduce airflow, volume dampers in the system should be adjusted in the branch ducts and takeoffs and not at the outlet, since dampering at the outlets results in excessive noise and poor air distribution.

III. Go to the branch that has the outlet with the next lowest percent of design flow as determined from the initial readout. Typically, this key outlet will be on the second farthest branch. Balance all the outlets to the key outlet to within +/-10% of design flow.

IV. Continue until all the outlets on all the branches have been balanced to within +/-10% of each other.

V. Starting with the branch with the lowest percent of design flow as the key branch, proportionately balance all branch ducts from the lowest %D flow to the highest %D flow of each other.

VI. Continue until branches have been balanced. (Branch balancing can also be done using Static Pressure Method.)

VII. Once the terminals and branch ducts are balanced to the specifications, go back to the air handler and reset the fresh air intake damper to the desired values.

VIII. Fan performance may get affected during the air balance process. Adjust the fan speed if needed, to bring the system to within 10% of design flow.

IX. Read all the outlets once again and make final adjustments, if needed.

Balance Report

The proper use of a consistent set of reporting forms assures that TAB work is being done in a systematic manner and produces documented test results that can be easily understood. The following list is an example of forms with a brief description of each to illustrate the steps in the TAB process. Each project may require fewer or more forms and steps depending upon the TAB project goals and the system complexity.

- *System Diagram*: A schematic that depicts the system to be tested, its major components, distribution system sizes, the quantities of flow, the location of regulating devices and terminal units and other relevant data.
- *Apparatus Test Report*: Provides details of actual measured flow rates, motor loads and other information that will be useful to compare design to actual system component performance.
- *Coil Test Report*: Used to record performance of chilled or hot water, steam, DX, or other types of energy exchange coils.
- *Gas/Oil-fired Apparatus Test Report*: Tracks performance of unit heaters, furnaces, and boilers for use in comparison and as a supplement to factory-provided data.
- *Duct Heater Test Report*: Provides documentation of airflow rates across electric furnaces and heater coils and verifies minimum/ maximum airflow rates as required by manufacturers.
- *Duct Traverse Report:* Used as a worksheet for recording velocity pressures in a prescribed manner to determine actual airflow for ducts — round and rectangular.
- *Air Outlet Test Report*: Provides documentation of preliminary and final air distribution devices and possible reasons for deviations from design.
- *Terminal Unit Test Report*: Used to check and document the performance of terminal units.
- *Major Equipment Test Reports*: Each major mechanical HVAC device that is present and part of the TAB project — Chiller/ Packaged HVAC/ Compressor/ Condenser/ Cooling Tower/ Pump/ Boiler — is tested and the results recorded according to industry-recognized procedures. Specific test requirements may be requested for any major component to verify operating performance or efficiency.
- *Instrument Calibration Report*: Document the tested accuracy of instruments used to conduct the TAB project.

Acceptance criteria for the results of the comparisons are the responsibility of the TAB professional. TAB engineer must understand the importance of using accurate instrumentation in the field, and should be prepared to have witnesses verify their work with the calibrated set of instruments.

Results of data verification must validate the accuracy of instrumentation used to perform the work. Instruments should be used in accordance with manufacturer's recommendations. The most suitable instrument, or combination of instruments, should be employed for any measurement or reading. For example, a traverse may be accomplished with a pitot tube and manometer (digital, analog, or

continued on page 60

continued from page 58

inclined); it is not acceptable to use a pitot tube with another device that does not provide the same overall accuracy.

TAB helps Green Certification - a Case Study

TAB of a building's HVAC systems helps make a building green. The Marriott Hotel and Convention Centre in Pune has recently been awarded the *Leadership in Energy and Environmental Design* (LEED) Gold Certification by the Indian Green Building Council (IGBC). In the LEED Rating 2012, 35 credit points are allotted to Energy and Atmosphere and 15 to Indoor Environmental Quality. TAB professional can contribute significantly in achieving these credit points.

Table 2: LEED rating points that can be achieved using TAB

Energy and Atmosphere		24 Possible Points
Credit - 1	Optimize Energy Performance	1–19
Credit - 3	Enhanced Commissioning	2
Credit - 5	Measurement and Verification	3
Indoor Environmental Quality		**4 Possible Points**
Credit - 1	Outdoor Air Delivery Monitoring	1
Credit - 2	Increased Ventilation	1
Credit - 6.2	Controllability of Systems – Thermal Comfort	1
Credit - 7.2	Thermal Comfort – Verification	1
Total Possible Points		**28**

Let me share my experience during TAB conducted at the Marriott, Pune by Aerience Air Science and Contamination Control Pvt. Ltd., and how it has contributed adding credit points to save energy and achieve IGBC gold rating. In this installation, the total installed capacity was 1760 TR (350 x 4 chilled water and 120 x 3 hot water generation) with 26 pumps, 4 cooling towers, 3 hydro-pneumatic systems with 15 pumps, 60 AHUs, 510 FCUs, 14 treated fresh air systems, 5 kitchen hoods and 8 ventilation systems located at 20 different levels.

How difficult was the task? A team of 10 technicians was deployed for almost 9 months right from installation qualifications to HVAC TAB to the handing over of the project, with multiple agencies involved. The first challenge was indentifying and minimizing installation errors and qualifying the systems prior to installation, start-up commissioning and TAB. The initial response to get the errors rectified was very slow. We shot more than 3000 snaps showing installation errors and sent them to the concerned agencies with copies to the project head and consultants. The resultant change in the perception of installation agencies helped in getting the errors rectified fast, due to their quick response.

Our involvement during *startup and commissioning* also saved a lot of time in improving minor operational slip-ups to set design parameters. As stated above, thermographic scanning with infrared camera helped resolve invisible and inaccessible errors like identifying leakages in the AHUs and air distribution system, insulation failure, thermal intrusion, electrical overload conditions, undersized cables, loose connections, and many more.

The final step was commencing TAB. While hydronic balancing within the plant in the basement went smoothly, terminal balancing (74 AHUs and 510 FCUs located at 20 different levels) was real hard work. The biggest problem was immediate access to different levels due to all agencies working simultaneously and occupying the lifts for long durations. Balancing the hydro-pneumatic system also involved multiple hurdles.

Duct air balancing was effortless compared to kitchen hood balancing. Balancing 5 kitchen hoods with common exhaust requires different skills and cannot be done using an anemometer, pitot tube or capture hood. The method used was based on the working principle of differential pressure using static pressure probe with micro-manometer.

Treated fresh air quantity distributed among 420 guest rooms was 60 cfm each. Measuring and balancing such small air quantities at each terminal was a difficult task. Setting the treated fresh air to design parameters ensured that indoor air quality in each guest room was within acceptable IAQ limits.

Cooling tower performance checks were conducted as baseline tests with verification of range, approach and performance efficiency.

After all the operational parameters were set and TAB work was completed, nearly 2000 performance evidences with energy evaluations submitted as qualification reports helped the Marriot to achieve IGBC gold rating.

Even more important was the fact the cooling tower model installed was CTI certified. A year later, during re-certification required by CTI, the manufacturer selected the model installed at the Marriott. Fortunately, our organization got an opportunity to work and witness the test. The hydronic flows set during TAB were found intact. The functional test result also was within the acceptable parameters, and the cooling tower got re-certified. There are only four licensed CTI Thermal Testing Agencies worldwide (3 in the USA and 1 in Australia). The expert involved in the above certification was Thomas E. Weast from the USA. The set of test instruments used were aspirated psychrometers, transducer with accuracy of $\pm$0.05°C (0.1°F), data logger and hydronic pitot tube (which costs more than 5 times the cooling tower cost due to its high accuracy levels). I was fortunate to experience such a high level cooling tower performance testing.

Conclusion

Building owners and tenants are concerned about their buildings' environmental systems, so performance must be at a maximum, while costs should be at a minimum. These Green goals can be accomplished only when a building's environmental system is properly tested, balanced and/or commissioned by well-trained third party professionals as *no other industry affects the quality of life and impacts energy efficiency as the HVAC industry*.

References

ASHRAE *(www.ashrae.org)*

NEBB *(www.nebb.org)*

ICB/ TABB *(www.tabbcertified.org)*

AABC *(www.aabchq.com)*

Hydraulic Institute *(www.pumps.org)*

CTI *(www.cti.org)*

Technical Editor's Note: *Please see* An Introduction to TAB *by Sanjeev Rastogi in the July - September 2011 issue of the* Journal.