An Introduction to TAB

Water flow measurement by Ultrasonic flow meter

Sanjeev Rastogi
Deputy General Manager
Blue Star Ltd., Thane

Introductory Remarks by the Consulting Editor

While the role of the HVAC consultant and contractor is well defined and understood over the years by most clients and their architects, the part played by the Testing, Adjusting and Balancing (TAB) agency is not as well understood or appreciated. A few decades back when new buildings were much smaller and HVAC systems far simpler, the HVAC contractor normally spared minimum time to check out the dry and wet bulb temperature in each important conditioned space, by slinging a Psychrometer and if required adjusting a few duct and diffuser dampers, changing some fan speeds and regulating some globe valves in water lines. In a chilled water system, water flows through AHUs were never checked, since water flow meters were rarely, if ever, installed.

As new buildings became larger with total floor area of one million sq ft and more, to cater to the demands of IT and ITeS companies, with HVAC plant capacities of 6000 to 10,000 TR, differing occupancies such as hotels, shopping areas and offices, primary and secondary chilled water systems, scores of AHUs, variable speed drives, the HVAC contractor always pressed for time and a shortage of trained engineers, could hardly be expected to spend a few months that are required on such large jobs to completely test, adjust and balance all the air and water systems and ensure that the design objectives specified by the consultant were being met.

So, having spent large sums of money to pay for a sophisticated HVAC system complete with a BMS, how does the client ensure that he can expect to obtain the equipment performance and design indoor comfort conditions for the occupancy levels specified by him. Usually, new buildings in a start-up mode rarely have the occupancies and other internal loads envisaged at the planning stage for the future, two or three years down the road and by that time the HVAC contractor and consultant have been fully paid and equipment warranties ended.

This is exactly where the role of the independent, third party, TAB agency comes into play. With a good working knowledge of HVAC system design and functioning, fluid flow, indoor air quality, acoustics and control systems, the objective of the TAB specialist is to ensure that the equipment

About the Author

Sanjeev Rastogi is a mechanical engineer and a post graduate in management from BITS Pilani. After working in Grasim for 12 years, he has been with Blue Star for 6 years in Service Specialists Group. He is a certified TAB professional from NEBB (National Environmental Balancing Bureau, USA), the premier International Certification Association of firms that deliver high performance building systems.

and installation work comply with the capacity requirements and specifications laid down by the consultant and the client or end user is getting his money's worth. An extremely important role that has hitherto been neglected in HVAC contracts in India can now be met by a few companies specializing in the work of commissioning, testing, adjusting and balancing.

Fundamental Rule of Fluid Flow

Air flow through ducts and water flow through pipes follow the path of least resistance, resulting in higher flows near the fan or pump and lower flows further away. If both these fluids could only be educated or programmed to follow the intent of the HVAC plant designer laid down in the drawings, life would become a lot simpler for all concerned, the consultant, contractor and client.

But, since life is not always simple, testing, adjusting and balancing (TAB) is an essential part of any heating, ventilating and air conditioning (HVAC) installation. All facilities require correct flow of air and water to provide optimum operating conditions, comfort levels and energy efficiency available from building systems.

HVAC Systems – Then and Now

In the past, when HVAC systems were less complex and when system designers, owners and occupants were less demanding, system balancing was considered to be simple adjustments of some dampers in the air ducts and valves in water piping. Most of today's HVAC systems are far more complex, being designed with many more individually controlled temperature zones to improve occupant comfort. Variable speed fans and pumps are becoming more common place to provide the exact amount of cooling and heating system capacity in a manner that minimizes overall energy usage. With increased emphasis on fresh and filtered air ventilation for all occupants, tighter building envelopes and constantly changing airflow rates, more emphasis must be placed on fine tuning HVAC system operation.

Correctly balanced air conditioning systems produce the best possible environment for the building occupants at optimal system efficiencies, significantly reducing running and repair costs during the life time of the building. Testing, Adjusting and Balancing (TAB) is a vital part of the overall commissioning plan and is an integrated process that must be followed to achieve the best possible results. Carrying out the TAB correctly on every new building is an important first step in achieving efficient and comfortable operation and ensuring longer plant life. Older buildings may not have been correctly balanced during construction and retro-balancing can have a very significant positive impact on running costs and occupant comfort. Even if balanced at an earlier time, re-balancing may be required as a result of fit out changes and equipment aging. It is therefore recommended that systems be re-balanced every 3 to 5 years. When remodeling a building the existing installation and the new design should be studied by a specialist TAB company to provide professional advice which will ensure the systems can be re balanced and made to work efficiently once the work has been completed.

What Exactly Does TAB Do?

Testing is the process of making sure that performance of plant and distribution network is measured and recorded against design specifications to establish the starting point for adjustment. It is at this stage that it becomes clear which systems need to be adjusted to achieve the desired balance conditions. For example, if the rating chart of a pump indicates 600 gpm water flow against 80' head, at the testing stage it is to be ascertained that the pump is actually delivering the rated flow.

The testing process is most effective when carried out in accordance with the accrediting-body-recommended procedures and processes, such as NEBB (National Environmental Balancing Bureau, USA).

Adjusting is the process of systematically changing the settings on valves and dampers, adjusting fan speeds and pump impellers etc. to cause the flow rates and pressures in all systems to match design specifications and building requirements.

It is during this phase that construction defects, equipment and system specifications issues are finally confronted and resolved. Sometimes equipment and installed distribution network has to be changed to resolve the problems encountered. This generally happens when the pre-TAB testing and commissioning phase has not been executed to a proper commissioning plan.

Balancing is the systematic process by which the distribution network is adjusted to obtain the correct flow at every terminal unit. All adjustment results are collated and verified against design specification to demonstrate that each and every system has efficiently achieved the required level of balance.

TAB for New Buildings

Testing, adjusting, and balancing of all HVAC systems in a new building is needed to complete the installation and to make the system perform as the designer intended. Assuming that system design and installation meet the comfort needs of the building occupants, TAB fine tunes occupant comfort levels while keeping energy use to the lowest level possible. This is extremely important in the context of energy conservation.

TAB for Existing Buildings

There are few buildings in existence that have not experienced changes in internal loads and space layout changes since they were designed and built. These buildings should periodically have their HVAC systems rebalanced to achieve maximum operating performance, efficiency, and comfort.

Instrumentation Required for TAB

Air flow measuring instruments

- *Manometers:* to measure pressure drops, which can be translated into flow rates.
- *Digital manometers:* to provide very accurate readings at very low pressure differentials, such as across air filters. Can automatically adjust for barometric pressure, store readings with recall in average or total numbers. Pitot tube and static tube along with manometer will give the Total Static Pressure (TSP), External Static Pressure (ESP) and velocity pressure to measure the AHU performance.

Water flow measurement using a differential manometer

Grille air temperature measurement using air probe and thermocouple thermometer

Cfm measurement at diffusers using an air volume hood

- *Velocity matrix:* to measure the flow at AHU filter end.
- *Anemometers:* available in configurations like rotating vane, deflecting vane, and thermal. Used primarily to measure air velocities at duct branches, registers, grilles, coils, etc.
- *Flow measuring hoods:* to directly measure CFM of air distribution devices.

Temperature Measuring Instruments

- *Glass tube and dial thermometers:* to measure air and fluid temperatures.
- *Thermocouples/ thermometers:* to measure temperature differential and surface temperatures.
- *Sling psychrometers and electronic thermo-hygrometers:* to measure relative humidity.

Hydronic Flow Measuring Instruments

- *Digital differential pressure gauges:* to measure pressure drop across a piece of equipment, a balancing device or a flow measuring device.
- *Flow meters:* to measure volume flow rates in a fluid system. This works on ultrasonic wave principle and measures the flow velocity.
- *Flow Control Valves:* to establish the flow by using the manufacturer's charts. These valves have dial settings and pressure differential.

Troubleshooting with the help of TAB

1. At a site in Mumbai we were called to rebalance air as occupants at the farthest end were not feeling comfortable. We found that the AHU was installed with a VFD, which was getting its control signal from the return air temperature. On measurement we found that the maximum return was coming from the passage and entering the AHU room through the opening provided in the AHU room door. This air was cooler than the return air of the last zone. When we checked the air distribution at 50Hz, we found it to be as per design. But the area near the AHU was unoccupied and because of cooler return air from this area, the AHU was getting the signal to reduce its speed and correspondingly the cfm was getting reduced.
   Air distribution was re-done according to the loading pattern, and AHU VFD was locked at a minimum of 30 Hz to enable the minimum air circulation even when the temperature had been achieved.
2. At another site in Mumbai, there was a 6000 cfm ceiling suspend AHU. The problem reported to us was that half the room was getting sufficient cooling and the other half was warmer.
   The AHU was delivering almost the design cfm. On air flow measurement at grills it was found that air was not coming from one of the ducts. The duct was checked above the false ceiling. It was found that one Y piece with offset was positioned just in front of the AHU. During site observation it was found that this was done due to space constraint because of a column.
   The Y piece was taken out and redesigned with a distance piece and guide vanes to divert the air almost equally in both the ducts. Finally air balancing was done to achieve the comfort level.
3. During air balancing at an International airport we found that the smoke exhaust fans supplied by a leading fan manufacturer were not delivering the design cfm. We checked almost 30 fans but found the same results. We suspected our instruments. On cross checking the measurements by another method, the same results were repeated. Finally when we asked the supplier to check the fans, we found that the blade angles of all the fans were not adjusted in the factory to deliver the design flow. It was quite painful to adjust the blade angles of fans installed at about 50′ height and connected with 52″ ducting.

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4. In a software workstation located at Andheri in Mumbai, sweating of ceiling diffusers was the problem reported. The client suspected either duct air leakage or dehumidification not taking place in AHU chilled water coil. The TAB team was called to investigate. AHU performance was checked and found OK, full condensation was observed in the drain tray, canvas temperature was also found in the range of 12°C. Some duct leakage was observed, which was well within the limit of comfort air conditioning ducting. When we checked the RH above the false ceiling we found it to be more than in the rooms. We suspected fresh air infiltration above the false ceiling, but no opening was found. On further checking we found that the fresh air ducting (not treated or cooled) had been opened above the false ceiling to mix with return air. This caused the sweating in the diffusers. The fresh air duct was extended to the AHU return air and the problem was solved.
5. During water balancing at an industrial installation in Vapi, we found that when we were running condenser pump no. 1 the system was running ok with chiller no. 1, but while running 2 pumps with 2 chillers we found that the chiller was not getting sufficient flow and the flow switch was sending an alarm. We checked the piping size, valve openings, strainer choking, pump rating etc. When we checked the pumps it was observed that pump no. 2 had a 1440 RPM motor instead of 2900 RPM as specified in the pump specification for rated flow. This installation mistake was resolved after motor replacement.
6. At a site in Hyderabad we were asked to balance the condenser water line. There were 6 cooling towers and 7 condenser water pumps. The diameter of the common header from cooling tower to pump was 32", which was sufficient for running the pumps. The cooling tower and pumps were on the same floor and the condensers were on the ground floor.

   At the site we found the flow varying from almost 0 to maximum flow. This clearly showed that air was entering the condenser pump. The pump suction side flanges and valves were checked for sucking of air. Grease was applied to all flanges to prevent air entry. But the problem persisted. On further checking it was observed that out of the six cooling towers, three had a height difference of about 2". Due to this, three cooling towers were overflowing and the remaining three had low water levels. Water distribution in cooling towers was also unequal. The low level in cooling tower basin was causing swirl formation, and air was getting sucked into the pipe line and causing malfunctioning of the chiller flow switch.

   Proper water balancing was done and an extra curved plate was incorporated to break the swirl so that atmospheric air could not enter the condenser water.
7. In an auditorium in Mumbai near the sea shore, we were asked to study the air system as there was water dripping on the stage. During site study, air cfm, DBT and WBT were measured on the stage. They were found well within design limits. We checked the source of water droplets, and found that they were deposited on the MS channels that were installed to support the curtains and other accessories. When we went to the top of the stage we found that above 30 feet of height (the ducting was at 24 feet), the RH was above 90%. This was due to stagnation of air above the ducting. It was suggested to install an SA fan and an RA fan, but this suggestion was not accepted since silence is required at the stage. As this problem occurred only during rainy days and not in the summer, it was suggested to make two openings with grills in the supply air ducting from the top, to enable cool air to circulate in the stagnant area of the stage. This solved the problem of droplets, and removed the temperature imbalance also.

Conclusion

TAB and trouble shooting of air and water systems in an HVAC plant can help deliver rich dividends to all the persons concerned with the systematic growth of the air conditioning industry in the country and bring in a level of confidence among customers of these systems in the ability of the industry to deliver on the promises made during the award of the contract. ❖