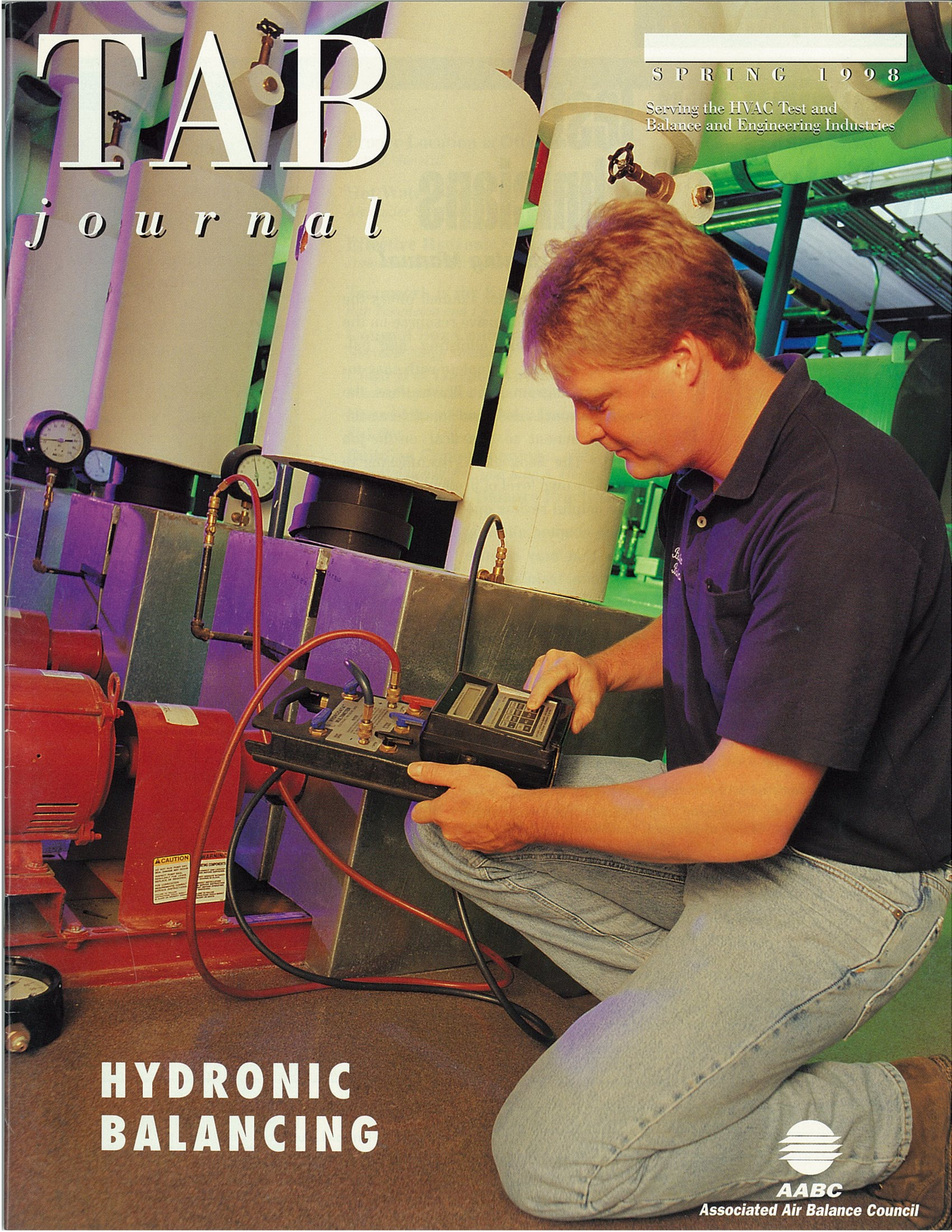
# TAB journal

SPRING 1998

Serving the HVAC Test and Balance and Engineering Industries




## HYDRONIC BALANCING

AABC
Associated Air Balance Council

# HVAC Test and Balance Practical Applications

**Frederick A. Seed**
*Arizona Air Balance Company*

There are many special procedures of the trade that technicians have learned through experience. Comments from field technicians often refer to "real world" conditions, which challenge the absolutes listed in technical "how to" text books.

Just about any experienced technician will have developed their own procedures and insights if they have been paying attention to what their test numbers really mean. We all have been burned, or at least singed, by a little oversight or ignorance in our work, and as a result learned a few lessons from which we may all benefit. Many test and balance agencies have applied these lessons to develop "secret" procedures to help give them an edge over the competition, only to learn later that their competition has been doing the same "secret" procedure for years. In truth, we all have exceptions to normal procedures, and although these exceptions don't appear in text books or written standards, we take them in stride as being common knowledge.

This article will explain a few of the more common real-world conditions. Perhaps it will open a dialogue to refute the following premises, or invite additional procedures based on actual field test conditions in variation of text book standards.

## Fan Speed and Horsepower

A common fan law states that motor horsepower will change directly by the cube of the fan speed (or CFM) change: $HP_{Final} = HP_{Initial} (RPM_{Final} / RPM_{Initial})^3$. This law is useful, but is dangerous if misapplied. The considerations of motor and fan efficiencies in energy conversions, motor and air power ratings, drive loses, and even system effect, may combine into a result not even close to this simple fan law. Whenever an appreciable change in fan speed and air flow is desired, the manufacturer's published fan curve will provide the most expedient and accurate relationship of resulting speed, flow, pressures and final horsepower.

> *Whenever an appreciable change in fan speed and air flow is desired, the manufacturer's published fan curve will provide the most expedient and accurate relationship of resulting speed, flow, pressure and final horsepower.*

Many energy surveys have predicted wonderful cost savings based on applying this fan law unconditionally to speed or flow reductions of main air movers. However, do not spend the savings until you see the money.

When field work requires an expedient speed/flow change and a fan curve is not in hand, it is important to visually check the fan type and realize that the forward curved fan will change motor horsepower suddenly with only slight adjustments. Therefor, the motor must be tested immediately after start-up — which is always good practice anyway. (If contemplating a drive pulley change, be sure to place a phone call to the manufacturer's representative to verify maximum or minimum fan speed is advised.)

## Total Pressure on Inline Fan

In common field practice a fan discharge static pressure measurement maybe in error. Be cautious when using static pressure probes. At a fan discharge, the energy conversion, erratic and high velocities, and turbulent air flow across the static holes of the probe will confuse a "static" measurement. This is evident when a negative static pressure is measured on a fan discharge, which everyone knows isn't real.

Instead of inserting a probe, cover the test hole in the duct wall with duct tape, poke a small hole in the tape with your pencil point, and press the square-cut end of the rubber test hose firmly against the tape. By doing this you should receive a positive static pressure measurement that is more likely to compare with the fan curve. This is especially important for inline centrifugal fans. It might even help on a vaneaxial fan discharge. If time permits, even more accuracy may be obtained with averaged measurements from four locations — one from the center of each side of the fan discharge duct.

## Fan Curves and Performance

There are four components to plot on fan curves: CFM, RPM, SP and HP. With accurate field test data, we may feel satisfied if three values plot close together on the curve. If all four values actually plot together, we deserve a pat on the back, perhaps a pay raise, and should offer gratitude for the design, application and installation. However, if only two values are close, go back and reevaluate the test methods. Recognize the difference between fan brake horsepower at the fan shaft, and motor input horsepower (which is usually approximated with calculations from measured voltage and amperage). Also consider the many variables created by system effect on fan performance and field measurements.

There once was a time when most published fan curves and tables were optimistic. Most fans are now AMCA certified, and should perform as rated if they are not used for an application which is different from what is certified by the manufacturer. In particular, high quality fans for large air handlers and industrial applications should perform near the rated values. If the test data indicates otherwise, my advice is to go home and sleep on it, and then perform a retest the next day. However, this time have a colleague oversee the test methods and data before you decide to challenge the manufacturer or confer with the building owner.

There are several possible circumstances which could cause the fan not to perform as rated. First, there could be an error in the discharge pressure measurement, or the discharge or inlet duct may have experienced an adverse system effect where a representative static pressure is especially difficult to measure. Perhaps the air volume is in error where there may be extremely high velocities in 5% of the duct area that are not accounted for in the typical equal-area traverse.

Field testing for fan total pressure is commonly based on static pressure of the inlet and outlet. A general standard for "Fan TSP" uses discharge static pressure, and total pressure measured directly on the fan inlet — but unless you are prepared to buy a fan when the sensing probe gets sucked in, or worse yet, loose a hand, do not do this as part of a standard routine. Realize that fan performance is related to fan total pressure, and fan total pressure is represented by static and velocity pressure. Depending on the configuration of duct connections, actual fan total static pressure may be represented by any individual or combination of: velocity, static or total pressures. Be prepared to discuss variations in fan pressures and practical test procedures, to show you know that variables exist and that measured static pressures at the fan are not absolute fan total static pressure.

The following are a few more considerations you should examine if test data will not plot reasonably well on the published fan curve: 1) Verify fan diameter/width and model, and investigate for assembly errors. 2) Verify if the curve is with or without inlet vanes or cones. 3) Realize that an AMCA certification is probably with a static regain transition and duct on the discharge, and fan performance may appreciably decrease (approximately 15%) when an air handler manufacturer has installed the fan with a plenum discharge. 4) And of course, there are always various system effects with inlet/outlet ducts.

*It is important to measure all test holes for drilling through the duct wall, and mark or tape all test intervals on the velocity probe.*

## Duct Velocity Traverse

To begin with, if there is not time to provide a complete equal-area (or log) velocity traverse with test points at the recommended centers, do not even bother with an attempt. When measuring duct velocity traverse, it is important to measure all test holes for drilling through the duct wall, and mark or tape all test intervals on the velocity probe. Then, obtain readings for all points. To insert a probe and wiggle it around may be applicable in some endeavors, but not in duct traversing — it provides totally inaccurate and unrepeatable readings, and overall has no value. The pattern of laminarity of air flow down a duct changes when flow rates are changed, and over-dependence on a center point velocity may create severe problems down the road. This is especially true in industrial, medical, and laboratory exhaust systems where air flow measurements must be exacting and repeatable for routine recertification. Also, if duct static pressures are referenced for balancing air flow, it is essential that accurate air flow measurements are used for initial and final SP/CFM relationships.

When traversing an exhaust duct, the first readings near the test hole will be in error due to negative pressure in the duct drawing air through the hole, around and along the test probe. The more negative the duct, the bigger the error. A common practice is to cover the test hole with electrical tape, punch a hole in the tape with a pencil, and inset the probe. The tight fit of the plastic tape around the probe will provide a reasonable air seal. This is not so important with a Pitot tube, which samples velocity pressure upstream of the test hole. (The seal is especially applicable to temperature probes.)

These are just a few of the more common experiences in air balancing that have worked for us. Every TAB technician worthy of the title could add to these experiences. There are many more variations to standard field test procedures for air and hydronic systems, and many exceptions to the written “rules.” In the end, experience teaches one TAB absolute: You can’t believe everything you read.