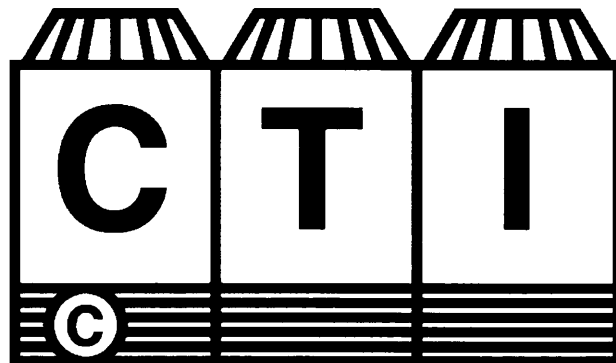


COOLING TOWER INSTITUTE

Recommended Practice For Airflow Testing of Cooling Towers



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This guideline document summarizes the best current state of knowledge regarding the specific subject. This document represents a consensus of those individual members who have reviewed this document, its scope and provisions. It is intended to aid all users or potential users of cooling towers.

Airflow Testing of Cooling Towers

There are two basic instruments for airflow testing of cooling towers: Anemometer or pitot tube. The purpose of each is to measure the velocity at a point. After a number of points are measured to obtain a representative or average velocity, the total airflow is calculated using the net discharge area of the fan. Each of these instruments is discussed below.

1. Anemometer

The anemometer is basically a calibrated propeller. As the air turns the propeller, its speed of rotation is counted mechanically or electrically.

1.1 The oldest design is a vane anemometer, which measures the linear feet, or meters of air moving through it and provides a mechanical readout. When combined with a unit of time (usually 30 sec. or one minute), the velocity in feet per minute can be computed. In use, the anemometer is held in the air stream on a pole at the prescribed spot. A timer calls "start", and the operator pulls a string to start the anemometer. At 30 seconds, for example, the timer calls "stop". The operator stops the reading, retrieves the anemometer, reads the thousands, hundreds and unit counts. He records the reading, resets the counter and moves to the next spot. The readings are later adjusted using a calibration curve and doubled to give a feet per minute reading. As you can see, this instrument is clumsy and takes two skilled people to make repeatable measurements. Note that if a "yaw" measurement were needed, the operator would have to read or estimate and record the yaw angle as well as the counter reading for each spot.

1.2 Today there are many electronic direct reading anemometers available although accuracy and moisture resistance varies with cost. A typical instrument displays velocity in Ft./Min. or M/S and temperature °F or °C. It can average many readings over typically 2 or 16 second intervals and can store readings in its memory which can later be downloaded through a standard RS232L interface into a computer.

1.3 An upscale version would be a propeller anemometer which has a digital readout based on an analog D.C. voltage proportional to the wind velocity. This is an unshrouded propeller with a tiny generator which can be attached to a pole with a standard 3/4" NPT (pipe) thread.

1.4 Propeller anemometers are available as small as 1" diameter to 8 or 9" diameter, shrouded or

unshrouded. Generally the larger the diameter the more accurate the measurement and less the sensitivity to the swirl or yaw effect.

2. Pitot Tube

The pitot tube measures velocity pressure as the difference between total and static pressure at a point. This pressure is measured with an inclined monometer or an electronic pressure transducer. Temperature must also be measured so the density at each point can be computed. Once density and velocity pressure are measured at a point, the velocity can be computed by the formula:

$$V = 1096.2 * C * (VP/D)^{1/2}$$

Where 1096.2 = Unit conversion factor

C = Pitot tube calibration coefficient

VP = Local velocity pressure (inches - H_2O)

V = Local velocity (ft/min)

D = Local Air Density (lbm/ft³)

For wet towers a special pitot tube with larger than normal holes in the nose is required. The purpose of the large holes is to prevent water droplets from clogging the tube, causing erroneous readings.

There are several types of pitot tubes available, some are very sophisticated for high velocity measurements. For our general purposes, velocity pressures will typically be less than 0.5 inches- H_2O .

For fan testing in moist air, the Prandtl type design is recommended. However, other types could also be adapted for cooling tower use.

A pitot tube developed for cooling tower use should first be calibrated against a well designed pitot tube in a dry air situation. ASME PTC 19.2 - 1987, Part 2 describes a method of calibration of a pitot tube. This will allow any correction factors necessary to account for the true performance of the modified tube to be determined.

2.1 Pressure Measurement

The velocity pressures which must be measured in a cooling tower application are typically less than 0.5 in- H_2O . Impact and static pressures are somewhat higher and can occasionally exceed 1.0 in- H_2O . Their pressures fluctuate rapidly due to the turbulence of the flow and the proximity of the measurement to the fan blades. This makes some method of dampening advisable. This can be accomplished by using a porous-plug damper in the capillary tube of the manometer or using

an electronic read-out with a provision for calculating an average signal or pressure over a set time interval.

Any pressure measurement device suitable to these conditions can be used. A simple inclined manometer is often used. Pressure gauges and electronic pressure transducers have also been used successfully. The pressure measurement device should be checked against a reliable standard before the test and at least once during the test.

When pressure measurement is desired in addition to flow measurement, a system of valves is often used to connect the various pressure signals to the measurement device. These valves can be operated either manually or electrically.

2.2 Temperature Measurement:

Air temperature should be measured with an electronic temperature sensor attached to the pitot tube. Hand held thermistor types work well for this purpose.

Air temperature is measured to determine the density of the air. In cases where saturation cannot be assumed, it may be necessary to measure both wet and dry bulb temperature. In these cases, a wetted wick must be provided for the wet bulb sensor.

2.3 Barometric Pressure Measurement:

Barometric pressure can be measured by any suitable means. Mercury manometers are often used. Electronic absolute pressure transducers have also been used.

2.4 Other Apparatus:

The pitot tube should be attached to a light aluminum tube with sufficient strength and length to traverse the radius of the fan cylinder. This tube is usually supported by the fan cylinder itself and by a tripod mounted on the fan deck. The pitot tube should be connected to the pressure measurement device by flexible hoses. The temperature sensor must be connected to the output device by a suitable length of wire. The wire and hose should be firmly attached to the aluminum tube to prevent their being entangled in the fan or other cooling tower structure.

3. Where to Measure

Generally there is a precise distance from the edge of the fan ring in each of four quadrants of the inlet or discharge area where measurements are taken. A minimum number of points for a fan would be 20, four

points in each of five equal area bands. These points are calculated on the basis of the fan ring diameter and seal disc or hub diameter if no seal disc is used. Some fan manufacturers specify an "aerodynamic hub" diameter when defining net free area. In this case, consult the manufacturer for the recommended inside diameter used to calculate equal area band locations. These measurements are all in one "plane". Where that plane of measurement is chosen is discussed in section 3.2.

Imagine a fan discharging air. On the inlet side, the air flow is fairly uniform - except around beams or other obstacles. On the discharge side the direction is significantly changed and at the center, airflow becomes negative but is blocked by the fan's seal disc or hub. The air at the blade tips is still axial but the air vectors near the center of the fan are progressively "bent over" by the effect of the torque applied by the fan blades. At the center of the fan, the air actually wants to reverse direction 180°. This is called the "swirl effect". The net effect would be turbulence close to the center of the fan on the discharge side.

Also, consider if the fan has a short fan ring or a tall velocity recovery stack. The closer the measurement to the fan the less swirl effect is seen. For a tall stack, there is a cone of swirling air which travels many fan diameters before all discharge air becomes uniform (axial) again.

Using a pitot tube close to the exit or inlet side of the fan may require drilling four holes approximately 1 1/2" diameter at 90° through the stack for access. Plug the holes with a rubber plug or other means after the test is completed.

3.1 Yaw

The fan imparts a horizontal and a vertical velocity component to the air. The angle produced by these two components is the "YAW" angle. The vector resolution of these components yields the actual air velocity. However, to correctly determine the air flow leaving the tower, only the vertical or axial components of the velocity need be measured. This can be accomplished by two methods:

(a) Position the anemometer perpendicular to the fan axis so that only the axial component of velocity is measured.

(b) Tie a string or streamer onto the anemometer rod. The streamer will show the "local" velocity direction so if you hold the anemometer perpendicular to the streamer it will measure the air velocity in its "yaw" direction. You then must read the yaw angle from a protractor on the an-