2367 LAKESIDE DRIVE, SUITE A-1 BIRMINGHAM, AL 35244
PHONE (205) 453-0236 FACSIMILE (205) 453-0239
www.innovativecombustion.com

STANDARD PROCEDURE FOR CALIBRATING FLOW NOZZLES, VENTURIS, AIR-FOILS OR AVERAGING PITOT TUBES

1.0) **Equipment Required:**

1.1) Standard pitot tube, calibrated "Forward-Reverse Pitot Tube" or "Fecheimer Probe."

1.2) (2)-Two combination vertical incline-manometers.

1.3) U-tube manometer.

1.4) Thermocouple, Digital thermometer and sufficient length of lead wire.

1.5) Stainless steel tubing for static probe.

1.6) Heavy-wall clear "Tygon"™ tubing or equal.

1.7) Personnel safety equipment.

1.8) Tools to remove test connection for access.

2.0) **Local Data Required:**

2.1) Differential pressure (Δp in. w.c.) from primary element sensing lines. Differential pressure should be recorded prior to start of the test, during and at the end of the test.

2.2) Temperature (°F) at flow nozzle exit.

Note: Temperature will be a traverse of at least four points. More points may be necessary if temperatures are stratified more than 25° F.

2.3) Static pressure (in. w.c.) at traverse plane; one measurement at each of the traverse ports.

2.4) Velocity head (in. w.c.) measured using a calibrated velocity probe for a multi-port traverse. A minimum of (24) points for round ducts and 30 points for square or rectangular ducts are required; or (1) traverse point is needed for every 4ft² of duct cross-sectional area.

2.5) Run tests at three load points to verify "K" factors. During the tests, all related flow control devices should be locked into "manual".

3.0) Preparations:

3.1) Prior to testing, blow out ash or other deposits from sensing lines.

Note: Valve transmitters out of service so that they are not damaged from over pressurizing.

3.2) Plug the sensing lines, using rubber compression stoppers with bolts through them, or other suitable stoppers. Apply 100 psig compressed air and use soap suds or other leak checking fluid to confirm tight connections.

3.3) If connections are hidden, as in airfoils then, pressurize to 10 psig and monitor the leak down rate after air supply valve is closed. Pressure should hold for at least several minutes.

3.4) Internally measure the dimensions of the ductwork or flow nozzle throat to confirm the drawing dimensions. The manual traverse calculations are the basis for the flow determination, and therefore, the area used must be correct. The flow is based on the formula: Q_{cfm}=(Area * Velocity).

3.5) Set-up steady conditions for the test with control room operators.

3.6) Connect the vertical-inclined manometer across the differential pressure transmitter sensing lines, valve manometer in and record the ΔP at regular intervals. Transmitter differential should be smooth and steady with little fluctuation. Excessive fluctuations should be investigated to determine if flow is changing or turbulence at the flow measurement elements are causing fluctuations. Excessive turbulence inside the ducting will cause most likely cause excessive shift in "K" factors at different flows. If this is the case, action should be taken to "streamline" flow at the measurement element(s).

4.0) Calculating "K" Factors:

4.1) Data Required:

A) Flow rate (lbs/hr) calculated from hand traverse.
B) Density (lbs/ft^3) calculated from local static pressure, barometric pressure and temperature.
C) Flow transmitter Δp (in. w.c.) from test manometer.

4.2) Calculations:

Q_{cfm} = (Area ft^2) * (Velocity fpm)

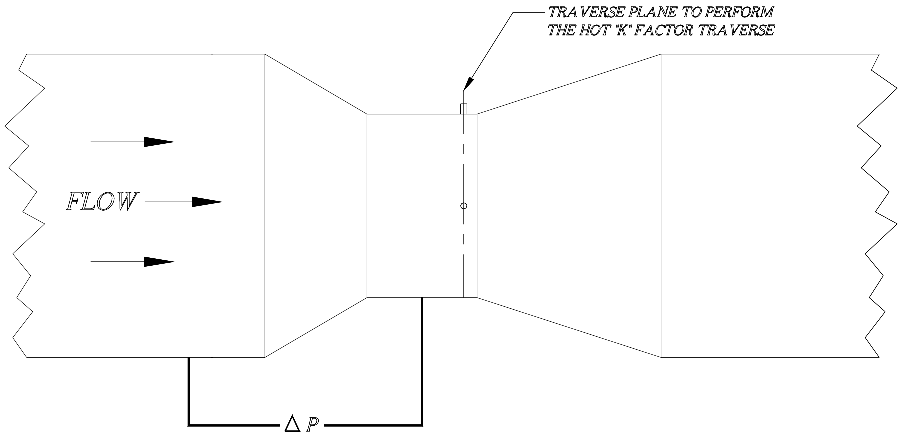
W = (Q_{cfm}) * (60 min/hr) * (Density #/ft^3)

The weight flow relationship of the primary element* can be expressed by the fundamental formula below:

$$W = "K"\sqrt{(density) * (\Delta P)}$$

* Flow Nozzle, Venturi, Air-Foil and Averaging Pitot Tube.

FOR A VENTURI/FLOW NOZZLE:



4.0) Calculating "K" Factors:

Flow is held steady during the testing traverse. The differential pressure is recorded across the flow measuring element at regular intervals, usually every (15 Minutes). The area of the traverse plane is known, by prior measurements. Density and flow are determined at the traverse plane by field measurements concurrent with ΔP recordings of the primary measuring element.

The calibration is performed at normal operating temperatures and flows at steady conditions. Then, knowing the weight flow of the air through the venturi, the "K" factor is determined as follows:

$$\frac{Lbs./Hr.}{\sqrt{\Delta p \; density}} = \text{"K"}$$

"K" = Coefficient/constant of primary measuring element.
Lbs./Hr. = #/hr flow calculated from traverse.
ΔP = Differential Pressure of primary measuring element (In. W.C.).
Density = Density calculated from local traverse (In. #/ft^3).

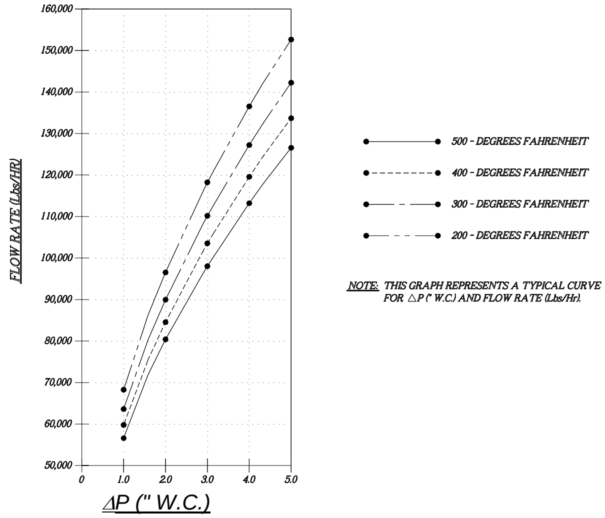
Note: For "K" factor using Lbs./Min. divide by 60 Min./Hr.

5.0) Calibration Curve Development:

5.1) Three Load Points for Curve:
A) Normal flow
B) Maximum flow
C) Minimum flow

Data Required:
A) Weight flow of air
B) ΔP of primary element
C) Density of air (which requires temperature and static pressure of air)

5.2) Typical Curve:



5.3) Minimum flow signal is set by adjustments to the transmitter's span.

6.0) Test Tap Layout:

There are to be (2) two test taps 90° apart for the calibration of round ducts. Measuring points for (2)-twelve point traverses are shown on Figure No. 2. Measurement points for rectangular and square ducts are shown on Figure No. 3.

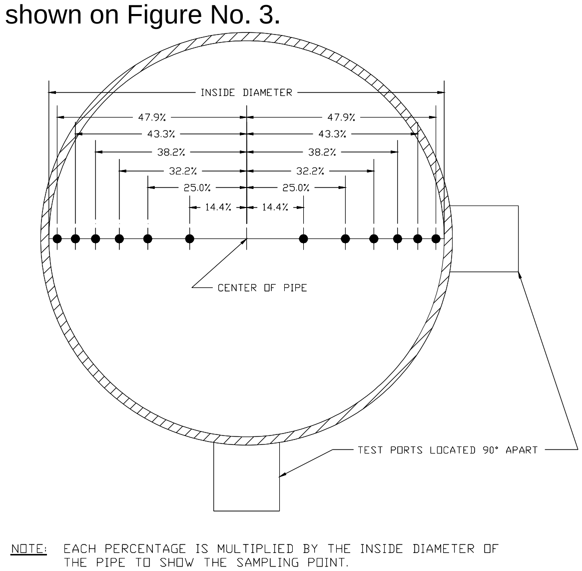
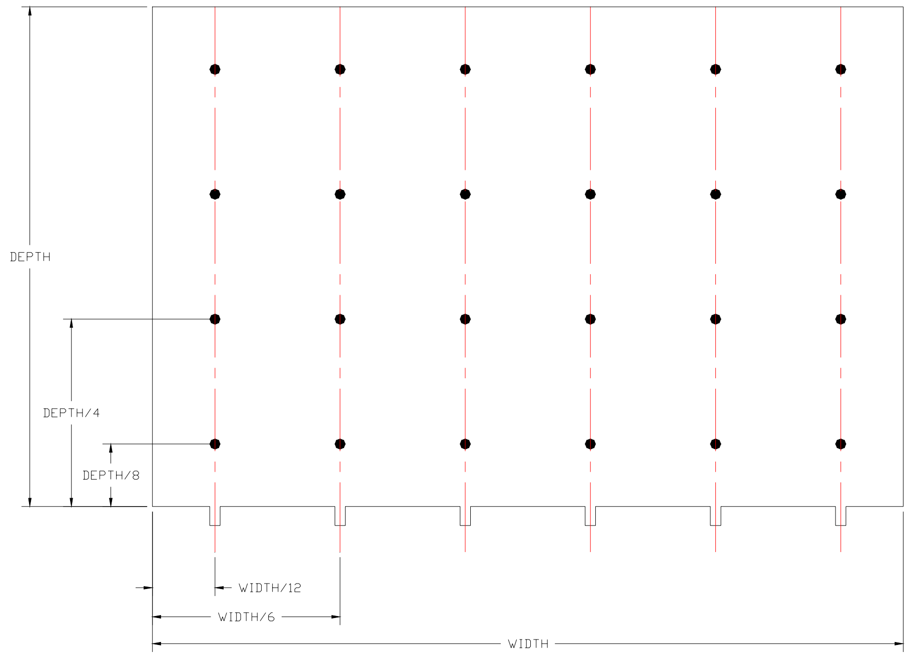


FIGURE No. 2



NOTE: IT IS IMPORTANT TO HAVE A SUFFICIENT NUMBER OF SAMPLING POINTS FOR REPRESENTATIVE MEASUREMENTS. THE DIMENSIONS ON THE SKETCH ABOVE MAY VARY DEPENDING ON THE NUMBER OF TEST TAPS REQUIRED DUE TO SIZE OF DUCT BEING TESTED.

TEST TAP AND SAMPLING POINT LOCATION
LAY-OUT FOR RECTANGULAR DUCTS

FIGURE No. 3