**Pitot tubes and Multi-hole Pressure Probes for Measuring Stack Flows**

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Abstract

We present experimental measurements and CFD simulations of the responses of pitot tubes and multi-hole pressure probes to low-turbulent flows over ±45° of pitch and yaw angles, and airspeeds from 5 m/s to 30 m/s using a three-dimensional calibration rig, together with well-defined procedures for measurements, data reduction, and uncertainty estimates. These results will enable us to estimate the uncertainty of stack-flows deduced from pressure-probe surveys that comply with Method 2F published by the United States’ Environmental Protection Agency (EPA). The EPA Method 2F permits stack-flow measurements using prism-shaped and spherical-shaped probes. (“Determination of Stack Gas Velocity and Volumetric Flow Rate with Three-Dimensional Probes.”) Method 2F specifies a nulling procedure for using these probes. The probes must be rotated around probe axis until the differential pressure between corresponding ports (specified in EPA Method 2F as P2 and P3) is zero and angle of rotation in this position corresponds to yaw angle of the flow. In the same orientation, the differential pressure between the remaining two ports is used to calculate the pitch angle and the dynamic pressure. In addition to Method 2F, the EPA has published a draft non-null method. This method calculates the pitch angle, yaw angle, and velocity components from 4 or 5 differential pressure measurements. For the prism-shaped and spherical-shaped probes, the draft method specifies neither calibration procedures nor interpolation procedures for implementing the non-null method. We will suggest calibration and interpolation procedures.

sensing head is presented in Figure 2F–4. Typical probe dimensions are indicated in the illustration.

6.1.3 *A manual 3–D probe* refers to a five-hole prism-shaped or spherical probe that is positioned at individual traverse points and yaw nulled manually by an operator. An automated 3–D probe refers to a system that uses a computer-controlled motorized mechanism to position the five-hole prism-shaped or spherical head at individual traverse points and perform yaw angle determinations.

6.1.4 *Other three-dimensional probes.* [Reserved]

6.1.5 *Probe sheath.* The probe shaft shall include an outer