EMISSION MEASUREMENT CENTER
GUIDELINE DOCUMENT

PARTICULATE SAMPLING IN CYCLONIC FLOW

SUMMARY

Particulate emission sampling in stacks or ducts with cyclonic flow patterns presents significant problems in obtaining representative measurements of concentrations and flow rates. Difficulties also arise in establishing the correct velocity for determining the isokinetic sampling rate. Sections 2.4 and 2.5 of Method 1 describe procedures for verifying the absence of cyclonic or other flow patterns not parallel to the stack or duct axis. These sections also specify limits of acceptability for the angles of flow using the described procedures. The purpose of this guideline is to determine options for consider when the acceptable limits of angular or cyclonic flow are exceeded. Following are three options and recommendations for each for addressing the measurement of particulate emissions when cyclonic or nonparallel flow patterns exist.

RECOMMENDATIONS

1. Find another location.

In many situations, sampling can be conducted downstream of the original location at a point exhibiting less cyclonic flow tendencies. For example, moving from a duct immediately downstream of a venturi scrubber exit to a location in a stack multiple equivalent diameters downstream of the duct-stack intersection can often solve a cyclonic flow situation. Extra cost is sometimes incurred in such a move (e.g., new ports and sampling platforms); however, this option is often less costly or disruptive to the process operation and produces more reliable emission measurement data than do other options described below.

2. Install flow straightening vanes upstream of the sampling location.

Flow straightening vanes, such as are described in Figure 5D-1 of Method 5D, Appendix A of 40 CFR Part 60, may be used. Note that the criteria for locating the measurement site downstream of the straightening vanes are based on the average equivalent diameter of the straightening vane openings rather than the stack diameter (Section 4.1.1, Method 5D). However, straightening vanes may disrupt the process and may affect control efficiency.

Other means of straightening gas flow, such as addition of stack extensions tangential to the stack axis, may suffice.

3. Apply one of the modified sampling procedures.

The Alignment Approach

This approach involves turning the sampling nozzle into the direction of gas flow assuming essentially tangential flow and ignoring the radial flow vector. The procedure is as follows:

Conduct a preliminary velocity traverse of the stack to establish the angle of flow at each sample point located as defined in Method 1. Using an unobstructed type-S pitot (i.e., no nozzle attached), rotate the pitot until a null reading is obtained and determine the flow angle relative to the stack axis from corrected protractor readings. Conduct the sampling isokinetically at each point rotating the sampling nozzle to point into the gas flow and using the velocity values determined during the preliminary velocity traverse. Conduct a post-test velocity traverse in the same manner as the preliminary traverse to verify the velocity (within 5 percent) and angle values (within 5 ^{o}). Calculate the stack velocity by determining the velocity vector parallel to the axis using the velocity values measured at each sampling point and the cosines of the measured angles.

The potential bias resulting from the use of this approach relative to a sample result from a location with acceptable flow conditions is affected by particle size and degree of cyclonic flow formation. The particulate concentration measurement (e.g., gm/m^3, ng/J) bias may be from -15 to 0 percent. The particulate concentration bias will approach zero with a decrease in average particle size. The stack flow rate measurement (e.g., m^3/min) bias may be from -10 to 0 percent. The resulting mass emission rate measurement (e.g., g/hr) will reflect a negative bias of about -20 to 0 percent.

Time-Weighted Alignment Method (Texas ACB Procedure)

The time-weighted approach is a refinement of the alignment method in which a compensation is made in the sampling time at each point by adjusting the dwell time proportional to the cosine of the angle of flow at that point. The purpose of the adjustment is to account for the stratification of particulate matter caused by the centrifugal action of the cyclonic flow. The gas velocities, flow angles, and stack flow rate are calculated as described for the alignment method. The sampling is conducted isokinetically in the same manner as described above except for the adjusted sample time at each traverse point.

The potential biases that result form the use of the time-weighted alignment method relative to a sample result from an acceptable sampling location may be affected by the sampling time adjustments. The particulate concentration (e.g., g/m^3, ng/J) measurement may be from 0 to +25 percent. The stack flow rate measurement (m^3/min) is conducted in the same manner as for the alignment method and the potential bias will be similar (i.e., -10 to 0 percent). The resulting mass emission rate measurement (e.g., g/hr) will reflect a bias range of about -10 to +25 percent with a tendency toward an overall positive bias.

REFERENCES

1. Peeler, James, Isokinetic Particulate Sampling in Non-Parallel Flow Systems-Cyclonic Flow, Entropy Environmentalists, Inc, RTP, NC, 1977.

2. Stack Sampling Cyclonic Flow, Appendix H, Texas Air Control Board Sampling Procedures Manual, Texas Air Control Board, 6330 Hwy 290 East, Austin, TX 78723, Revised July 1985.

2. Westlin, P.R., and K. Alexander, Evaluation of Particulate Sampling Methods for Cyclonic Flow, EPA memorandum, EPA MD-19, RTP, NC, 27711, August 1979.