Chapter 10. Sampling and Measurement of Mass Concentration

Isokinetic sampling

- o Same kinetic energy (i.e., velocity) to ensure that stack velocity = in-probe velocity
- o Sampling probe inlet aligned with stack gas streamlines.
  - Within 10° is OK (Fig 10.3)
  - u probe = u stack (but normally we want to measure Q not u, so:

$$Q_{probe} = Q_{stack}\left(\frac{D_{probe}}{D_{stack}}\right)^2 \quad (10.2)$$

  - See Fig 10.2
  - Super isokinetic ($u_{probe} > u_{stack}$) under samples larger aerosols
  - Sub isokinetic over samples larger aerosols, (eq. 10.6, 10.7)
  - ±10% velocity is OK, even for largest particles (Fig 10.5)
- o Errors due to misalignment: ≤ 10% for ≤15° (Fig 10.3)
- Selection of sampling location – avoid disturbance due to bends, fans, etc.
- Take multiple area-proportionate samples from large ducts.
- Well defined federal standards exist and should be used. (e.g. EPA Method 5; Fig 10.9)

Stagnant air sampling

- Very common
  - PM_{10}
  - ambient aerosols
  - personal monitors
  - rain gauge

- Essentially a filter disk or tube that can be oriented to face up, down, or horizontally (sideways)
  - Upward facing allows large particles to sediment into sample when they should not
  - Downward facing selects against larger particles, which settle rapidly under gravity
  - Sideways – no net bias for sedimentation (but other bias is possible)
- For given flow rate (e.g., set by selection of a pump) the probe diameter range for the largest particle of interest can be estimated (Fig. 10.6).
  - Simpler equation exists (eq. 10.15) for upward facing probe.

Tube Losses

- Loss by sedimentation, impaction, diffusion to the sampling lines can be significant so keep connections short and straight.

Mass Concentration Measurement (e.g. $\mu g/m^3$)

- We will discuss number concentration measurement later.

- Mass is basis of all regulatory requirements, e.g., PM_{10}.
    - Simplest to weigh a filter before/after loading it (Δ_{mass}) by passage of a known volume ($Q\ m^3$) of aerosol-laden air then $C = \Delta_{mass}/Q$
    - Filters should be equilibrated (T, rel. humidity) before/after exposure.
    - Depending on mass sampled, analytical (mg) or electrobalance (μg) is used to determine Δ_{mass}.
    - Often collect samples for hours to days, i.e., temporal resolution not high but OK for annual averages and daily averages.
    - Labor-intensive, long turn-around time.
    - EPA has numerous standards for correct sampling procedures, e.g., http://www.epa.gov/air/oaqps/greenbook/40cfr50_2001.pdf

Direct Dealing Mass Concentration Measurement

- Continuous therefore better temporal resolution (few minutes)
- Piezoelectric crystal resonant frequency changes with aerosol loading (Fig 10.10, eq. 10.20)
- β-gauge (electron transmission through filter decreases on loading increases.

Pumps

- Positive displacement capable of highest vacuum but often only at low flow rate:
    - Syringe/piston pump
    - Diaphragm
    - Need pressure-relief valve downstream when pumping incompressible fluids (intolerant of stall conditions).
- Centrifugal pumps
    - Very common
    - Inexpensive
    - Flat performance curve is fixed for fixed motor speed
    - Tolerates stall