Precision in Particle Collection: Flow Rates and Cut-point Paradigms

Understanding the Dynamics of Size-selective Samplers

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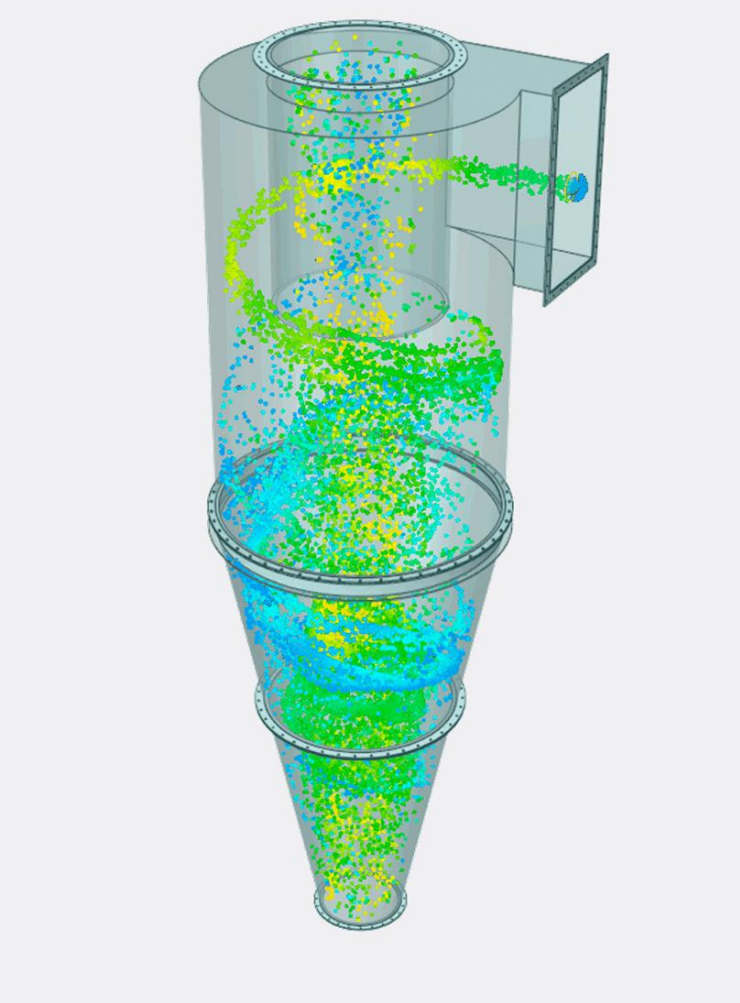
Overview

- Basic Principles of Cyclone and Impactor Operation
- Size-selective Samplers Role in IH Sampling and Worker Health
- Cut-point and Collection Efficiency
- Viability of Samples Taken at Incorrect Flow Rates

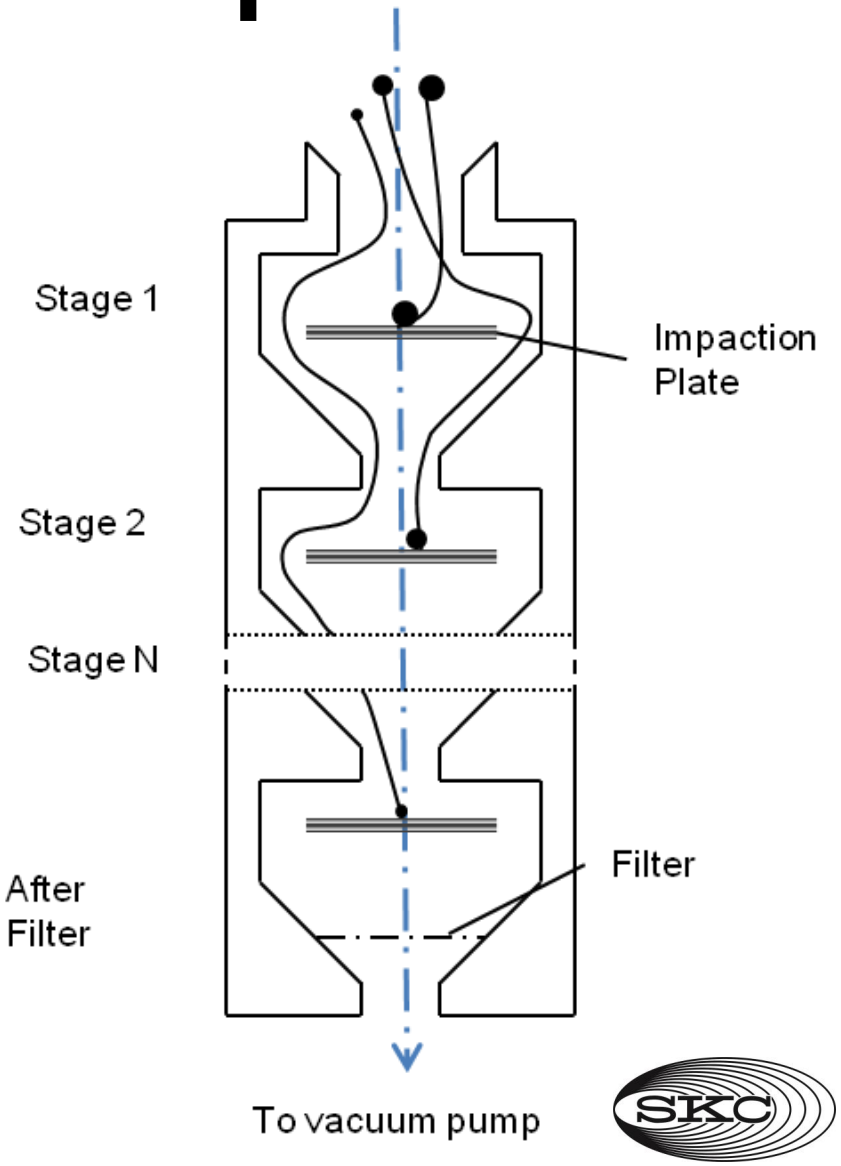
Basic Principles of Cyclone Operation

- **Inlet Flow:** Contaminated air enters the cyclone separator at high speed through a tangential inlet.
- **Vortex Formation:** The air spirals downward in a circular motion inside the cyclone, creating a strong centrifugal force.
- **Particle Separation:** The centrifugal force causes heavier particles to move outward toward the cyclone walls. These particles lose momentum, slide down the walls, and are collected in a hopper or 'grit pot' at the bottom.
- **Clean Air Exit:** The cleaned air, now free of heavier particulates, moves inward to the center of the cyclone and exits through an outlet pipe called a vortex finder at the top.



Basic Principles of Impactor Operation

- **Air Intake:** Air is drawn into the impactor through an inlet.
- **Velocity Increase:** As the air passes through one or more nozzles, it accelerates, increasing the air velocity.
- **Impaction Plate:** The accelerated air stream directs particles towards an impaction plate positioned in the path of the flow. Larger particles, due to their greater inertia, cannot follow the air stream and impact on the plate, where they are collected.
- **Smaller Particles:** Smaller particles, with less inertia, remain in the air stream and are carried to subsequent stages of the impactor or exit the device, depending on the design.



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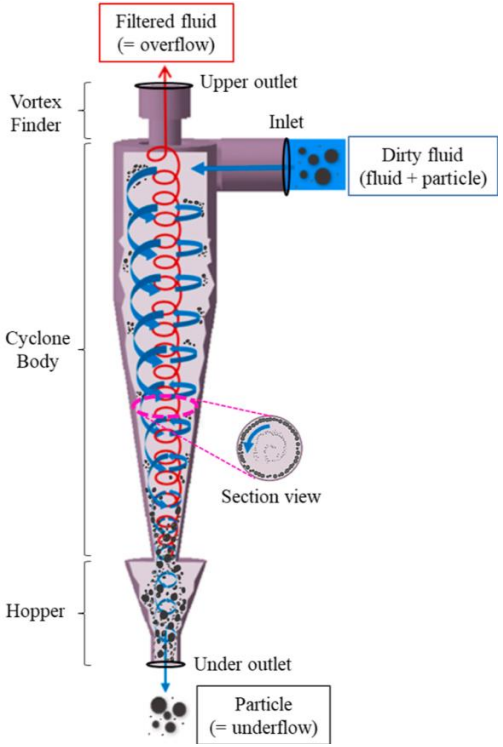
Size-selective Samplers

Aluminum Cyclone

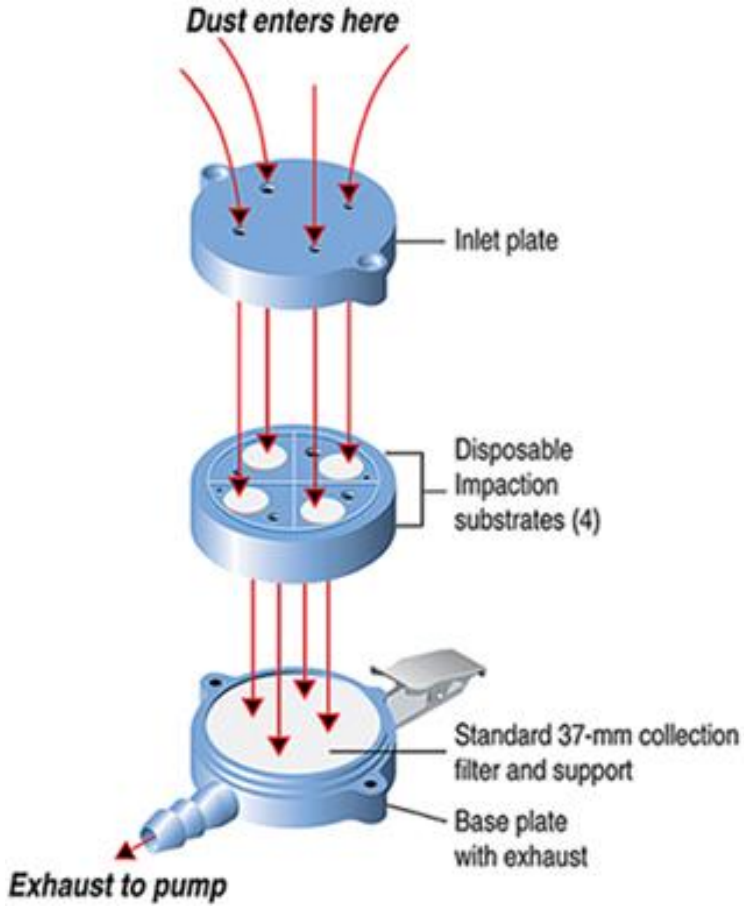


GS-3 Cyclone

Sioutas Impactor

4 L/min PPI

2 L/min PPI



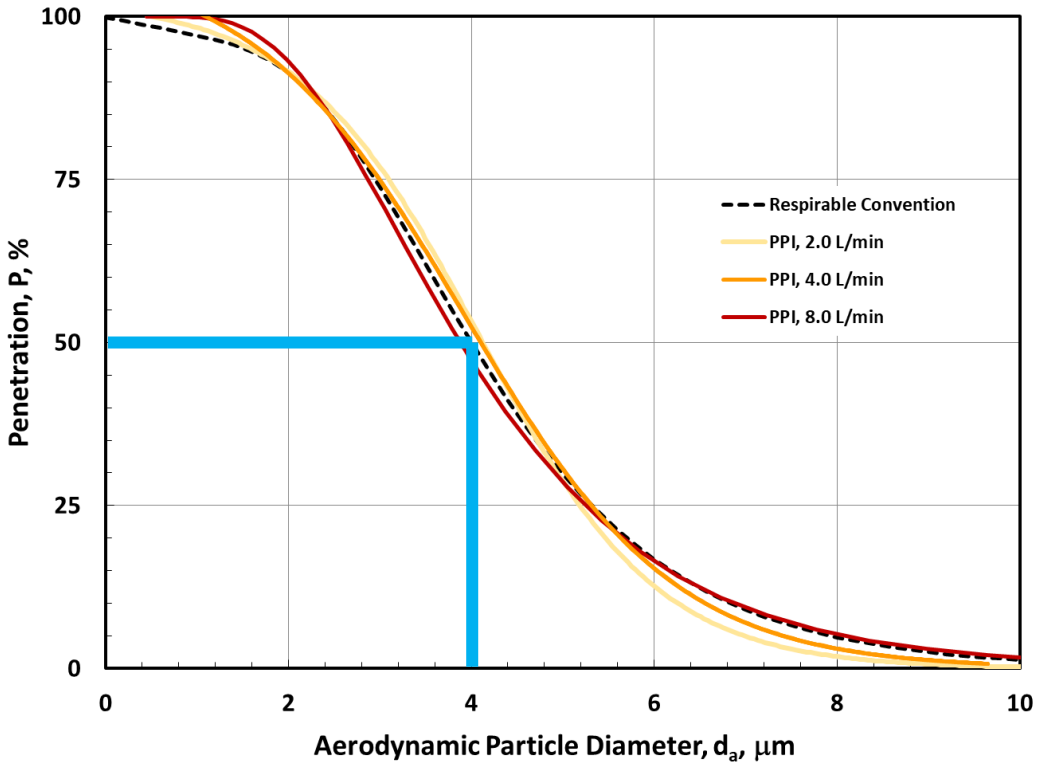
Role in Industrial Hygiene Sampling

Size-selective samplers:

- Allow us to collect a specific range of particle sizes that affect workers' health
- Different size distributions can be collected based on the sampler design and flow rate
- Allow us to protect the health of workers

Collection Efficiency and Cut-point

- Collection efficiency refers to the percentage of airborne particles of a particular aerodynamic diameter that are captured for analysis
- Smaller particles are collected at a higher efficiency and larger particles are collected at a lower efficiency
- The ISO 7708:1995 Respirable curve has a collection efficiency of 50% at 4 µm
  - This is referred to as the “cut-point”
- Each cyclone or impactor has a specific flow rate that must be used to achieve a 50% cut-point at 4 µm

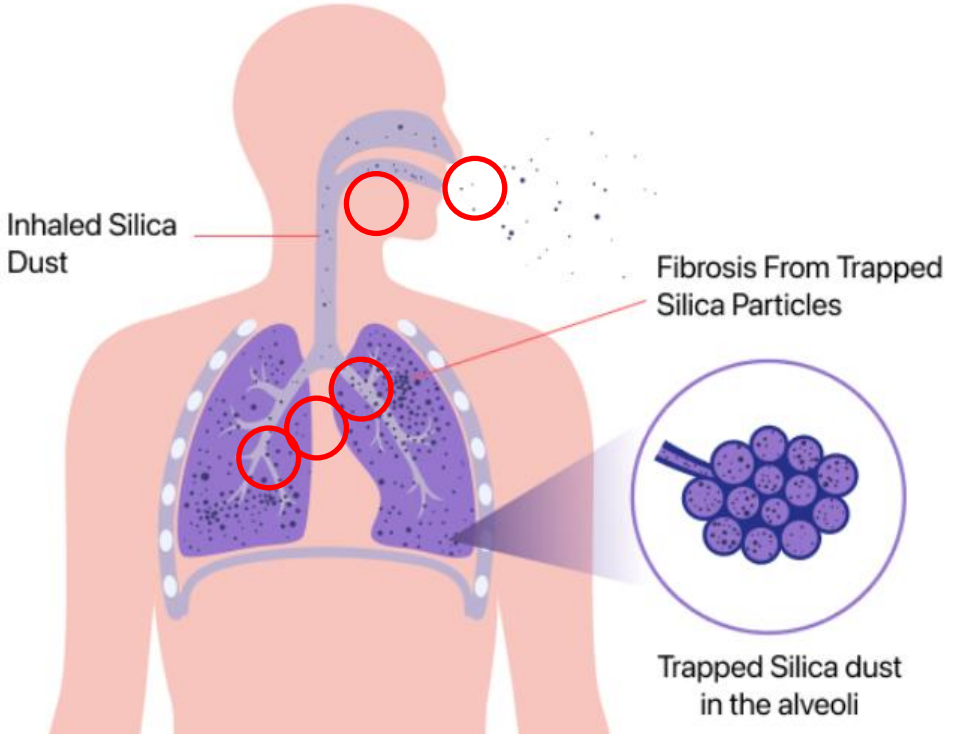


Collection Efficiency: Definition and Importance

- The ISO 7708:1995 curve closely follows what our body naturally does to remove larger particles from entering our lungs

- Our body has several natural impaction or deposition sites:
  - Nose/Mouth
  - Back of Throat
  - Bottom of Trachea
  - Bronchi and Bronchioles

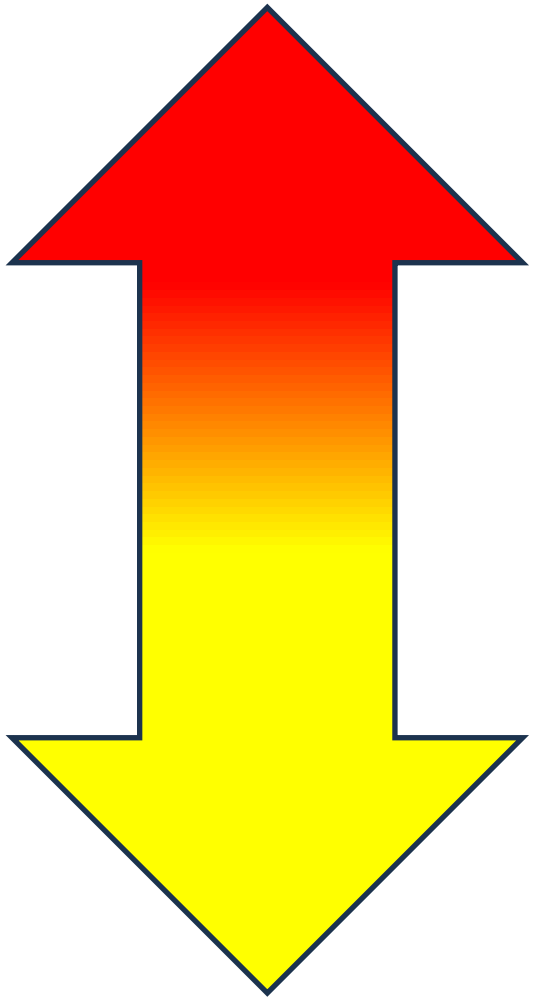
- We are our own ‘Oiled Impactor’



Factors Influencing Cyclone Collection Efficiency

- Particle Size Distribution
  - Cyclones are not very efficient at collecting small particles (this works in our favor)
- Design Parameters
  - Diameter, length, etc.
- Inlet Flow Rate and Velocity
  - Too high can cause turbulence and/or re-entrainment of particles
  - Too low will have insufficient centrifugal force to separate particles effectively
  - Temperature and humidity
  - High/low concentration of dust in the air
- Maintenance and Wear
  - Cyclone walls can be loaded with dust if not cleaned, changing the internal geometry and flow
  - Blockages of the inlet affecting flow

Flow Rates and Their Impact on Cut-point

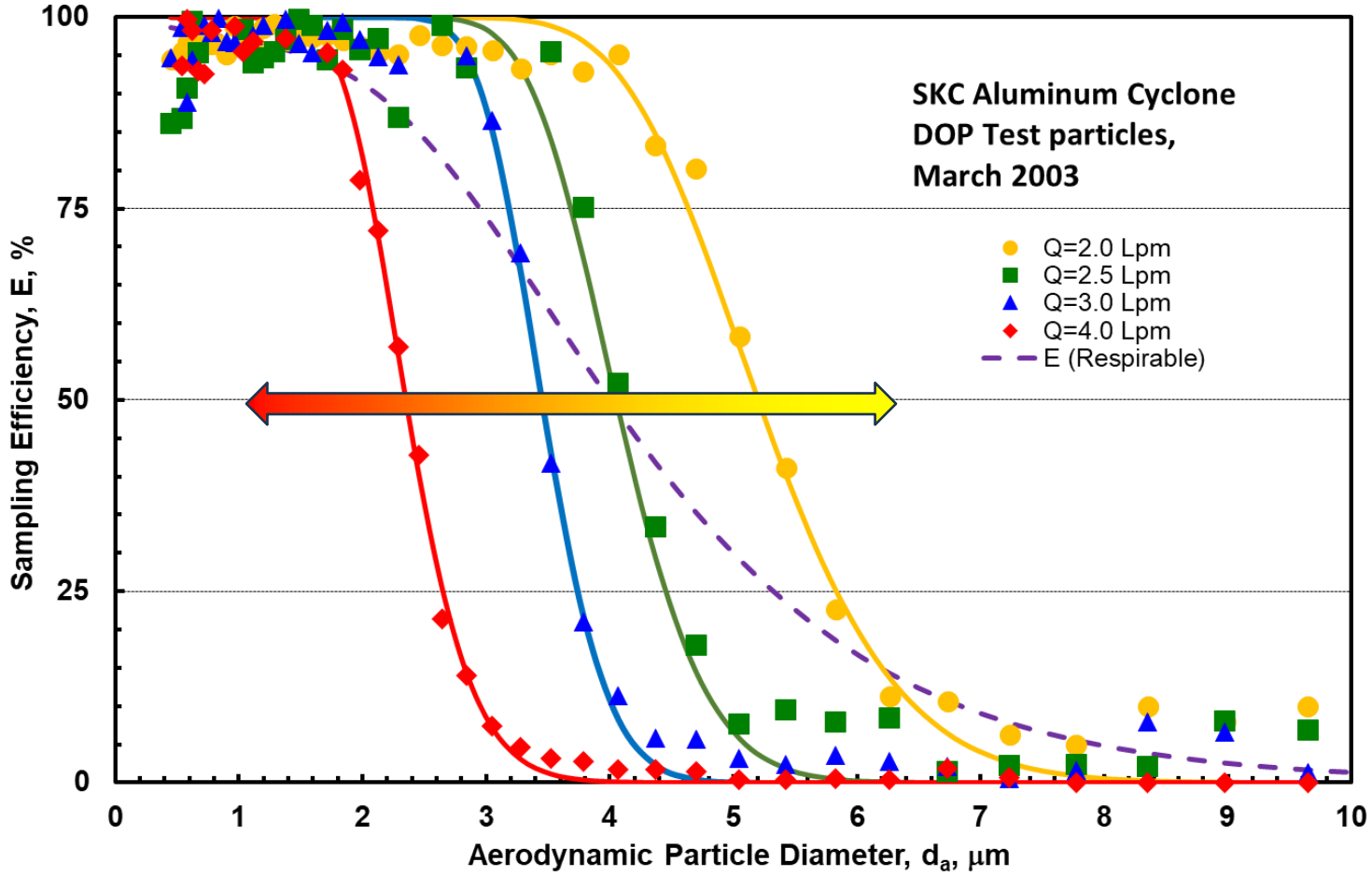


- Flow rate is inversely proportional to the cut-point
  - Higher flow rate results in a lower cut-point
  - Lower flow rate results in a higher cut-point

Flow Rate Affecting the Aluminum Cyclone

- As the flow rate increases, we see the cut-point decrease
- As the flow rate decreases, we see the cut-point increase

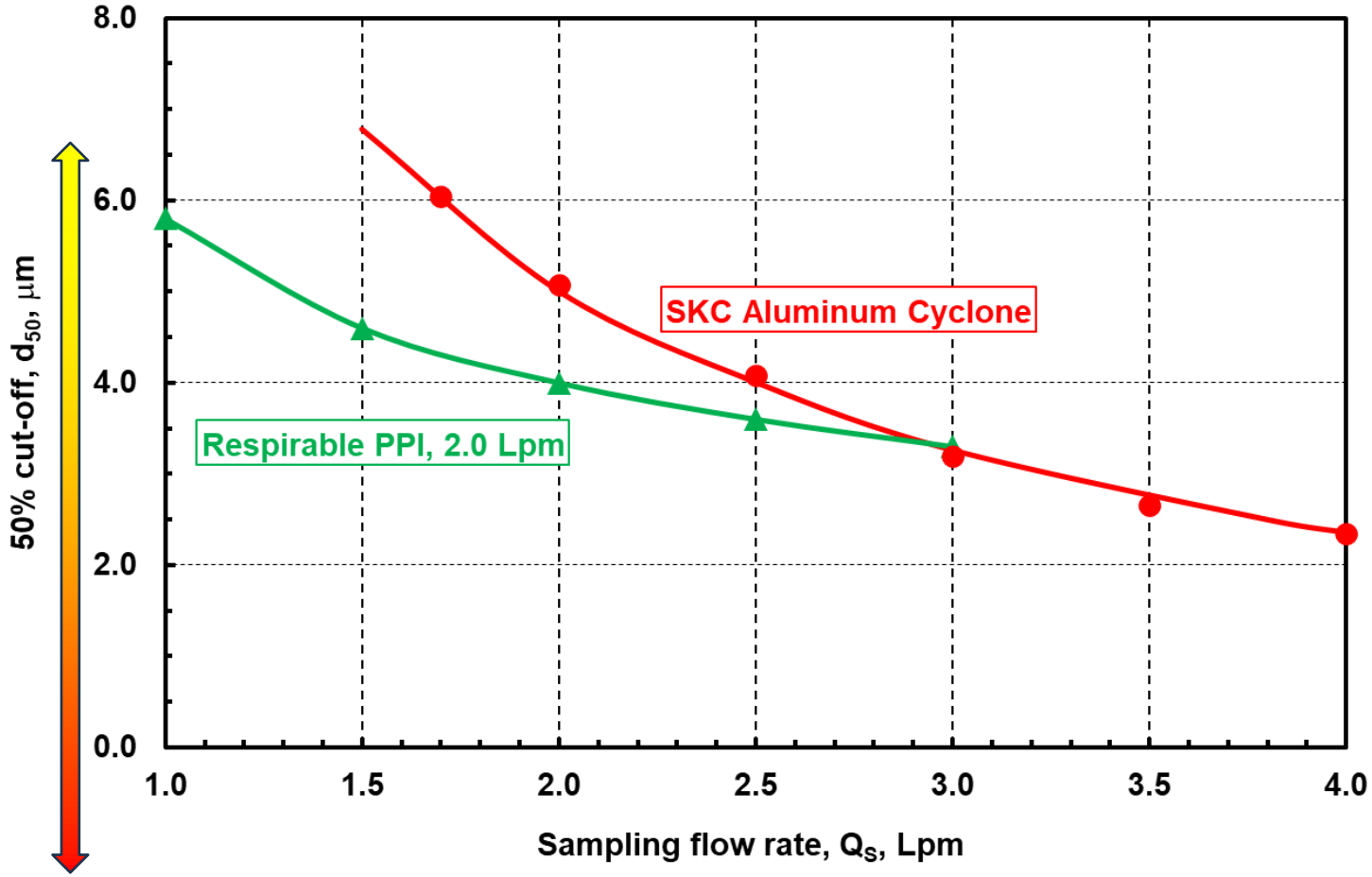
SKC Aluminum Cyclone



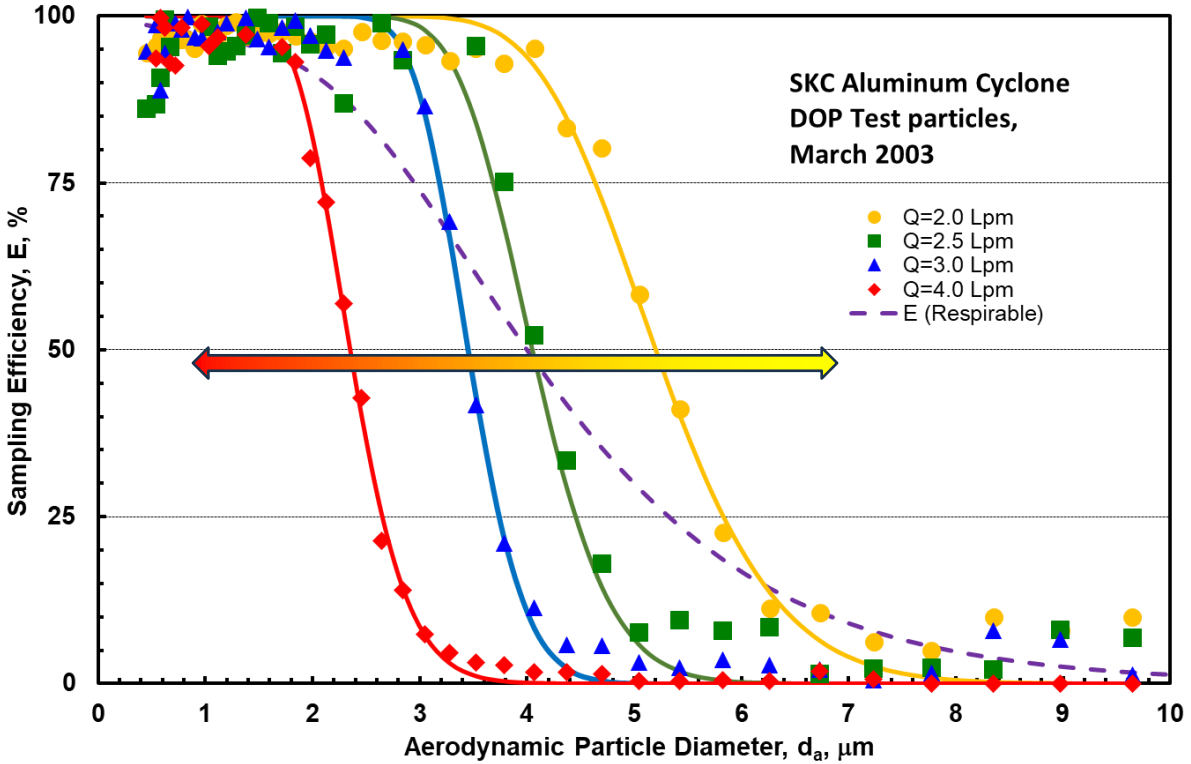
Flow Rate Affecting the PPI

- As the flow rate increases, we see the cut-point decrease
- As the flow rate decreases, we see the cut-point increase

SKC 2 LPM PPI



Practical Representation

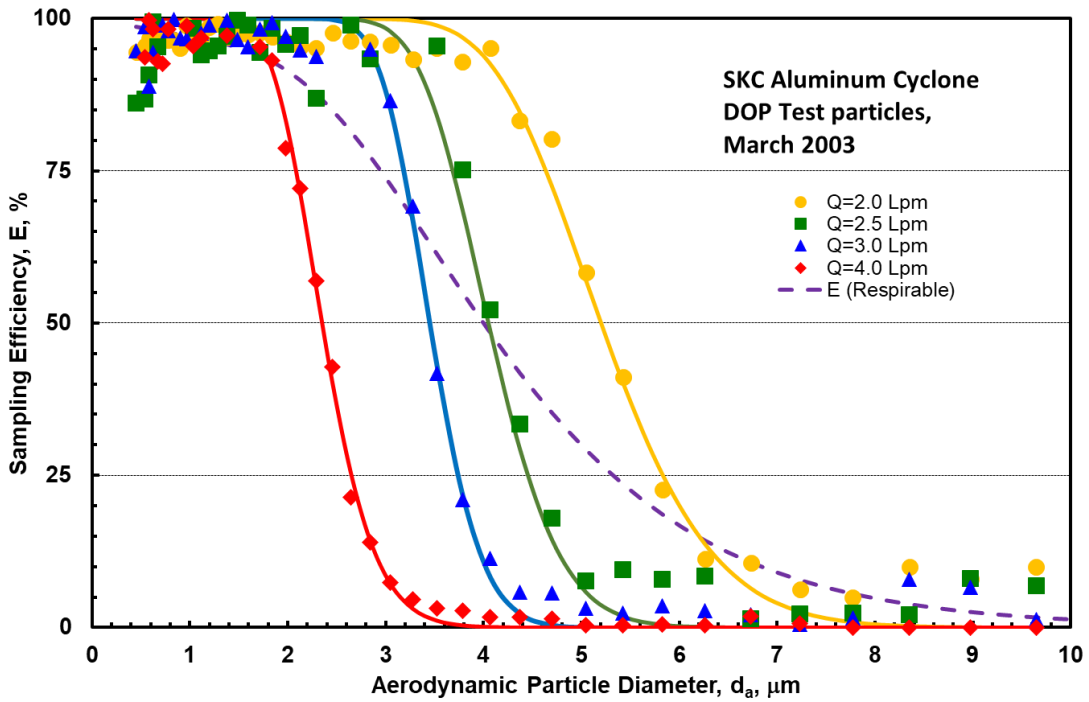


Why are we talking about this?

- Regulatory and industry health-related exposure limits are based on a 4 µm cut-point
- Sampling with the wrong flow rate/cut-point may result in unusable data
- This picture represents a year-long study on burning sugar cane in under-developed countries. All samples were taken at the wrong flow rate

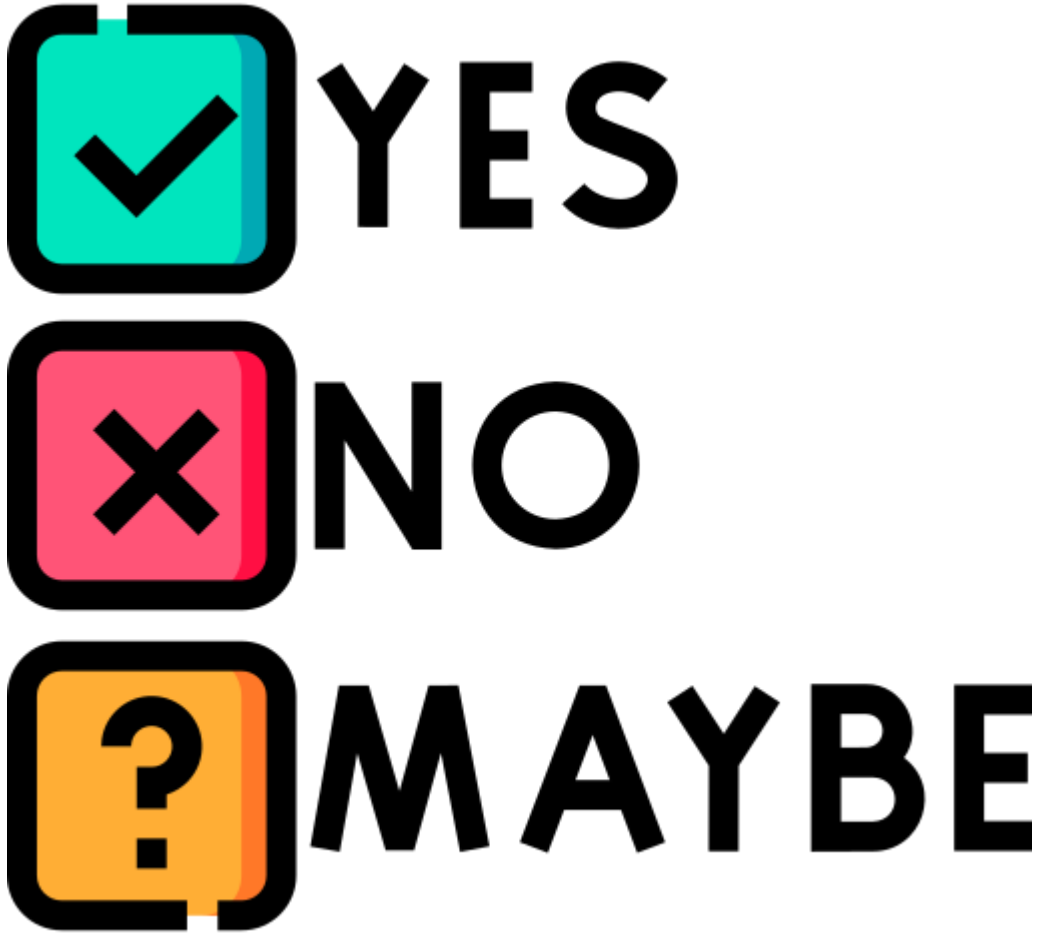
What if I sample at the wrong flow rate?

- Increased flow rate can end up with a decreased sample mass = under-reporting*
- Decreased flow rate can end up with an increased sample mass = over-reporting*



** Once increased or decreased volume has been accounted for

Can I use my data if I use the wrong flow rate?



Flow Rate Affecting Cut-point and Size Distribution

Higher flow rate results in a higher percentage of smaller particles being collected

Lower flow rate results in a higher percentage of larger particles being collected

Higher Flow Rate Viability

- Higher flow rate leads to lower cut-point. This means collecting smaller particles in greater quantities and excluding larger particles

- If lab results show dust levels are above the OEL, you can also assume that the true exposure would have been above the OEL if sampled with the correct flow rate

  – If the correct flow rate had been used, the mass on the filter would have been higher due to the higher cut-point, resulting in a higher exposure level

Lower Flow Rate Viability

- Lower flow rate leads to increased cut-point. This means collecting larger particles in greater quantities resulting in a higher mass

- If lab results show dust levels are below the OEL, you can be confident that the employee's exposure is below the OEL

  - If the correct flow rate had been used, the mass on the filter would have been lower due to the lower cut-point, resulting in a lower exposure level

Ideal Flow Rate Viability

- Ideal flow rate leads to the correct cut-point that follows the ISO 7708:1995 curve

Conclusion

- While not ideal, size-selective samplers accidentally used at a wrong flow rate can still provide some valuable information
- Remember you are human, and use this as a learning opportunity
- We have all done it at least once…

Questions?

THANK YOU!

Here's how to contact ME for more information!

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