Best Practice Use of Particle Counters In-Situ

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Introduction

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- ★ Thanks for having me here today!

Topics to be Discussed

- ★ Particle Counter Basics (Particle Counter 101)
  - ★ Particle Counting Terminology
  - ★ Theory of Operation
- ★ Particle Counters In-Situ
  - ★ Placement of Isokinetic Probes, Tubing, etc.
  - ★ Applicable Standards
    - ★ Eurovent 4/10 – 1996
      - ★ In-Situ Determination of Fractional Efficiency of General Ventilation Filters
    - ★ ASHRAE GPC 26 (Proposed)
- ★ Particle Counter Options

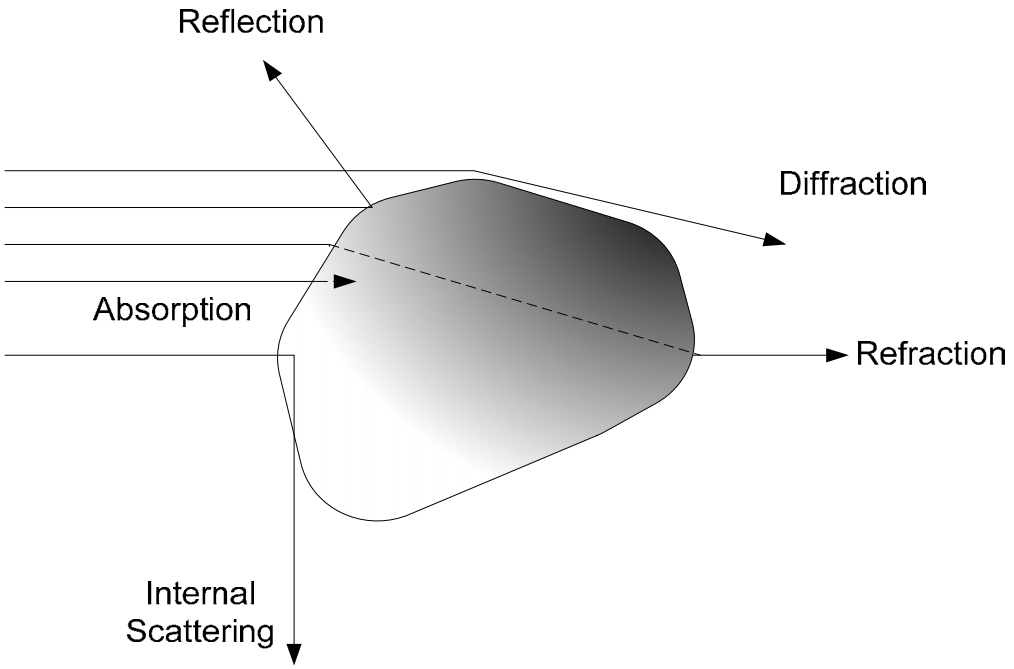
Particle Counting 101 – Common Terminology

- ★ **Particle:** Solid Material Ranging in Size from 5nm to 100µm
- ★ **Particle Counter:** Device Used to Count and Size Individual Particles
- ★ **View Volume:** Percentage of Sample Measured
- ★ **Sample Flow Rate:** Volume of Fluid Passing Through the Particle Counter per Unit Time
  - ★ Cubic foot / minute
- ★ **Sample Time:** Duration of Sample
- ★ **Concentration Limits:** Maximum Particle Concentration Permitted for Particle Counter Operation allowing no more then a 5% Coincidence Error
- ★ **Coincidence Error:** Counting Error from More Then One Particle Entering View Volume at the Same Time
- ★ **Channels:** Particle Sizing Bins

Particle Counting 101 – Common Terminology

- ★ **Sensitivity:** Minimum Detectable Particle Size.
- ★ **Air Velocity:** The velocity that the air is moving within the ductwork, usually reported in Feet / Second or Meters / Second.
- ★ **Zero Count Level (False Count):** Number of False Counts When Inlet Fluid Stream is Particle Free.
- ★ **Isokinetic Sampling:** Sampling method used to ensure smooth transition of the particles from the airstream to the particle counter.
- ★ **Particle Loss During Transport (through Tubing):** Larger particles tend to "fall out" of the airstream when being transported through lengths of tubing.
- ★ **Particle "Washout":** Occurs during non-isokinetic (turbulent) sampling. Particles never reach the particle counter, and are redirected back into the airstream.
- ★ **Aerosol Dilutor:** Instrument used to dilute the concentration of particulates being sampled. Ratios range from 100 / up to 1000/1.

Particle Counting 101 – The Particle



When a particle is illuminated by a light beam, it is redirected or absorbed

Reflection redirects light through surface interaction

Refraction redirects light from the light entering the particle

Particle Counting 101 – Particle Counters

Particle Counting 101 – Particle Counter Components

There are three basic elements in all particle counting systems:

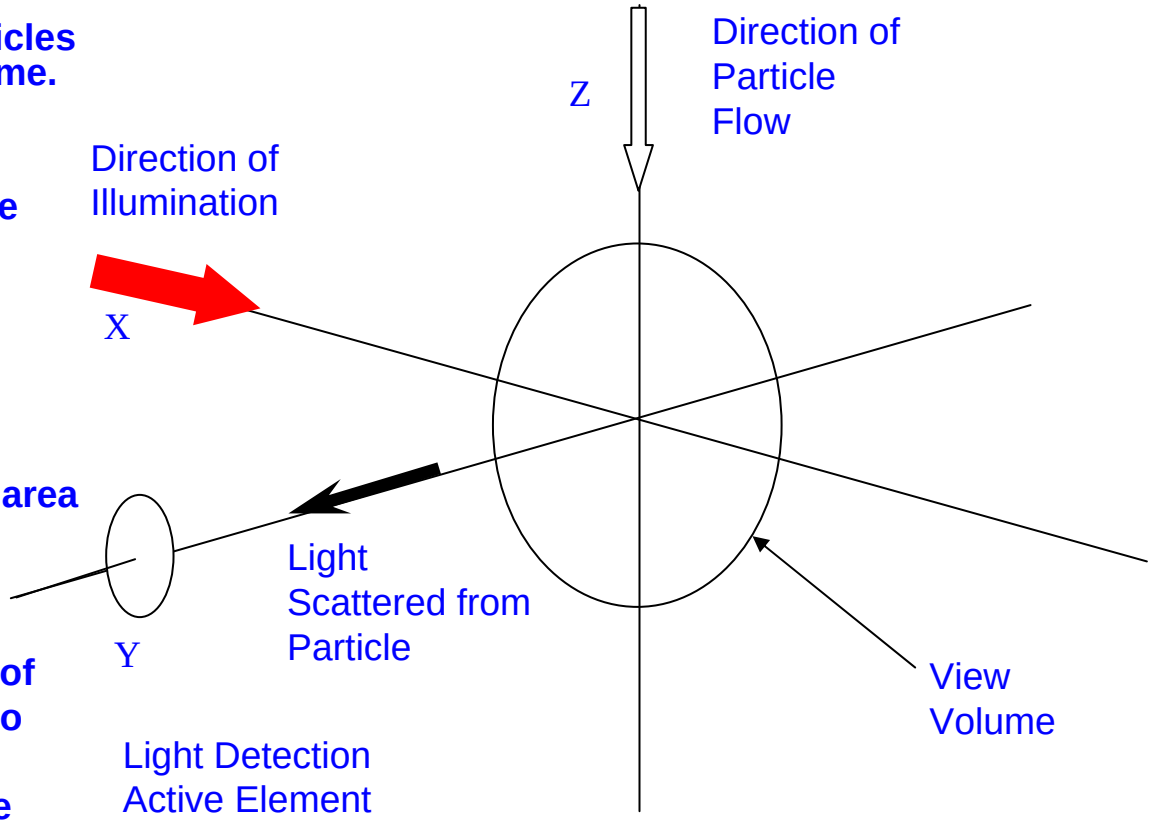
1) **The Sensor**
   The Sensor is the device that detects particles using light scattering techniques

2) **The Sample Delivery System**
   The air sample is delivered to the sensor by some method

3) **The Counting Electronics**
   The particle counts are processed

Particle Counting 101 – Theory of Operation

- ★ **Light source to illuminate the particles as the pass through the view volume.**
- ★ **Detector system is positioned to capture the scattered light from the particle as it passes through the view volume.**

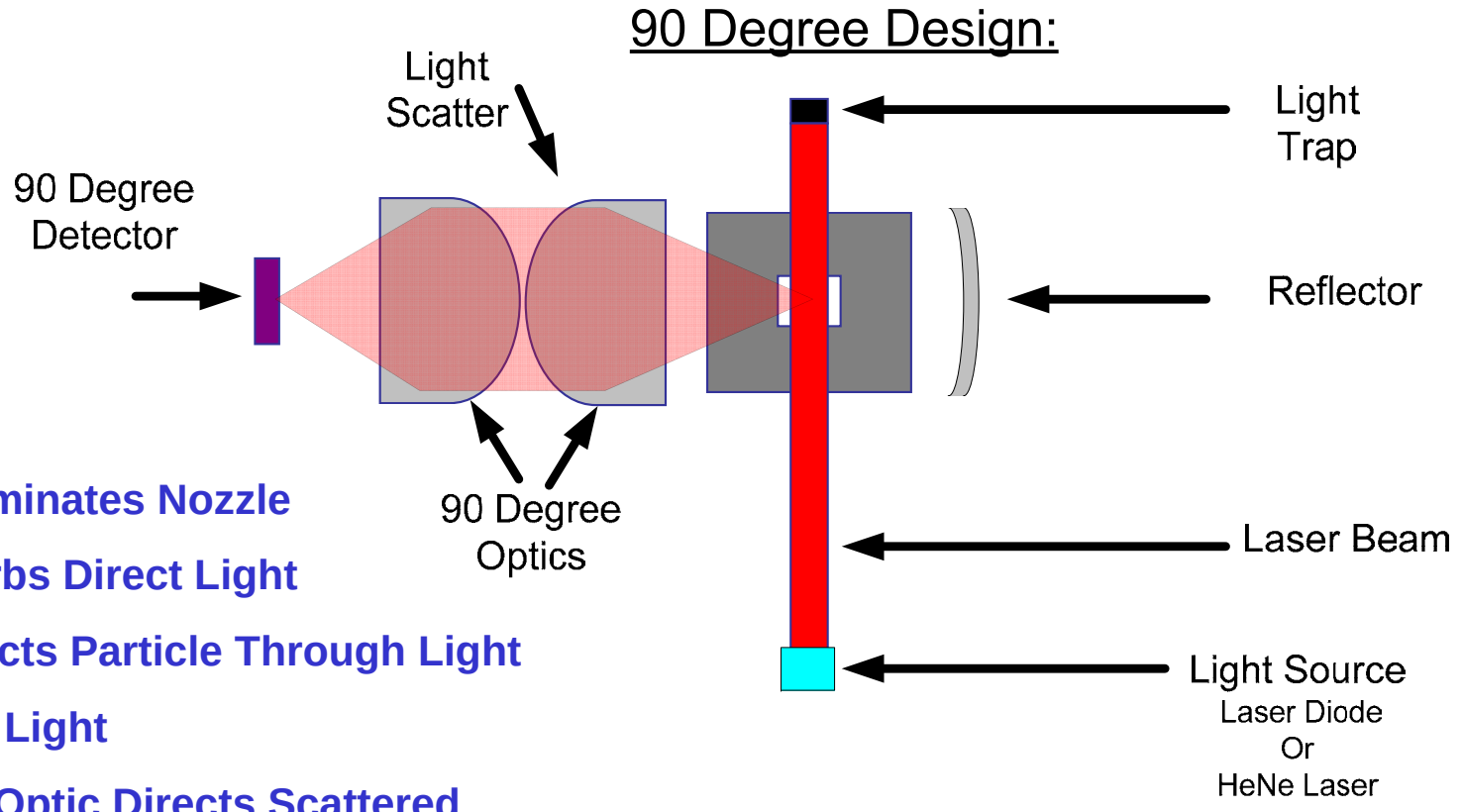


The light striking the detector's active area is used to define the existence of the particle.

Based on the signal strength, the size of the particle is determined. The ability to accurately count and size particles is based on the signal strength above the background noise of the system. The greater the signal to noise ratio, the smaller the particle that can be detected and sized.

FIG. 1 – Simple Particle Detector

Particle Counting 101 – Theory of Operation

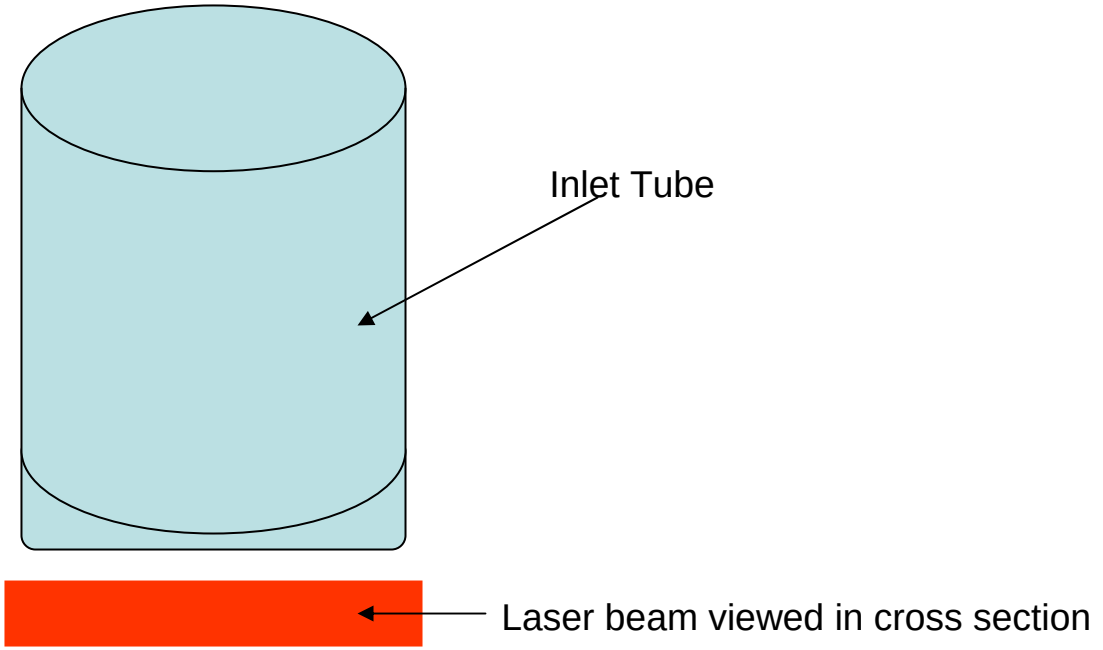


- ★ Light Source Illuminates Nozzle
- ★ Light Trap Absorbs Direct Light
- ★ Flow Nozzle Directs Particle Through Light
- ★ Particle Scatters Light
- ★ Light Collection Optic Directs Scattered Light onto the Detector
- ★ Detector Outputs Voltage Pulse

Particle Counting 101 – View Volume

Sensor View Volume

The View Volume is the area where the air stream and the laser beam intersect. The View Volume is the width of the inlet Tube and ± 1mm high.

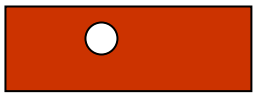


Most Aerosol Particle Counters are “Volumetric” or “Full Stream” Meaning 100% or the View Volume is Covered by the Laser.

Particle Counting 101 – Concentration Limits / Coincidence Error

If particle counter is used in environments where the concentrations of particles are too high, more than one particle at a time can enter the view volume. This results in coincidence errors.

Sensor View Volume



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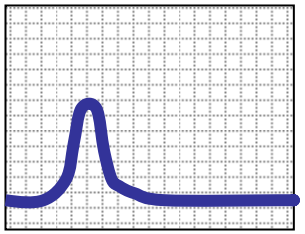
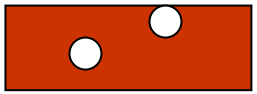


Normal

This example shows one 0.5µm particle in the view volume and its output pulse.

Sensor View Volume



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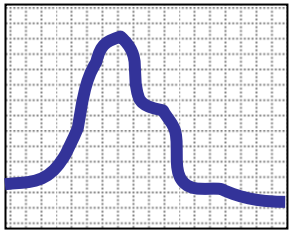


High Concentration Exceeding Concentration Limit

This example shows two 0.5µm particles in the view volume at the same time. The counter would report a size larger than 0.5µ and only one count.

Particle Counting 101 - Isokinetic Sampling

- ★ Webster's dictionary describes "iso" as denoting equality, similarity, uniformity. Kinetic is defined as, pertaining to, or due to motion

- ★ Isokinetic sampling is an equal or uniform sampling of particles and gases in motion

- ★ Isokinetic sampling is achieved when the velocity of gas entering the sampling nozzle (Isokinetic Probe) is exactly equal to the velocity of the approaching gas stream

Particle Counting 101 - Isokinetic Sampling Probes

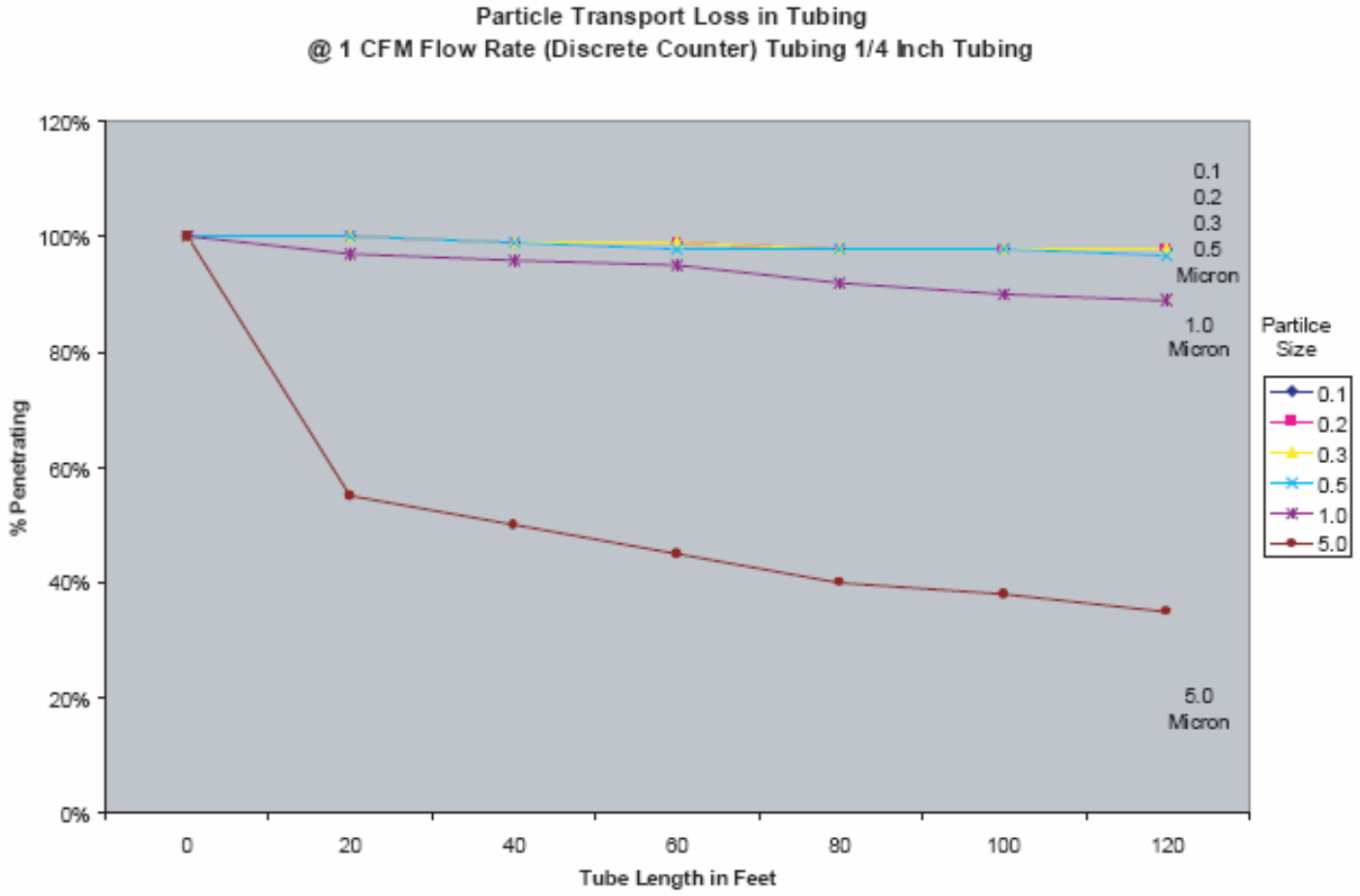
- ★ Isokinetic Sampling Probes vary in size and diameter according to the flow rate of the particle counter.
- ★ Designed for Air Velocity of 100 feet / Minute (1.67 feet / second)

Particle Counting 101 - Particle Loss During Transport in Tubing

★ Various factors impact the efficiency of particle transport in tubing:

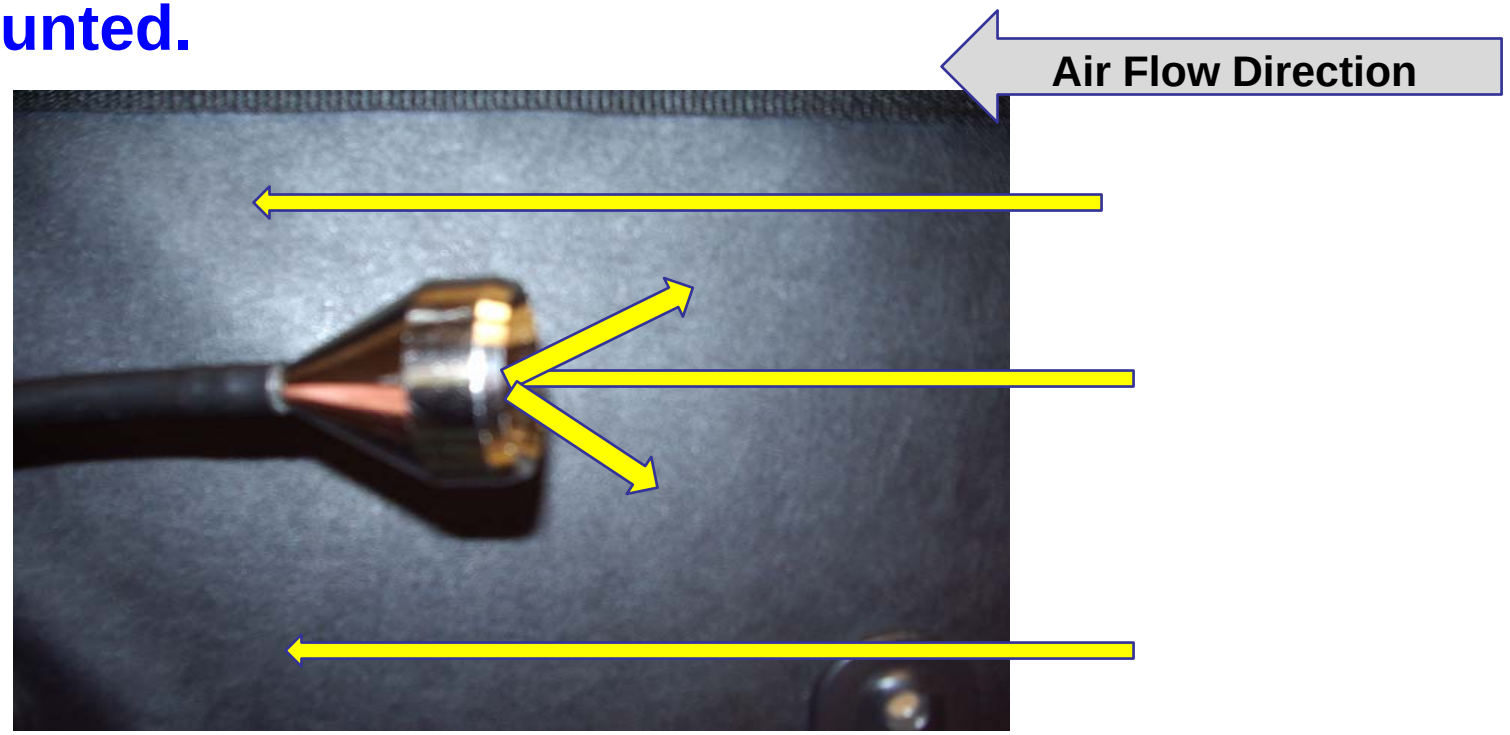
- ★Sample Air Velocity
- ★Tubing Length
- ★Tubing Material
- ★The Number of Tubing Bends
- ★The Radius of the above mentioned Tubing Bends
- ★Tubing Diameter

Particle Counting 101 - Particle Loss During Transport in Tubing



Particle Counting 101 - Particle "Washout"

★ If the air velocity in the ductwork is higher than the sample flow rate of the particle counter, particulates may be redirected from the Isokinetic Probe, and not be counted.

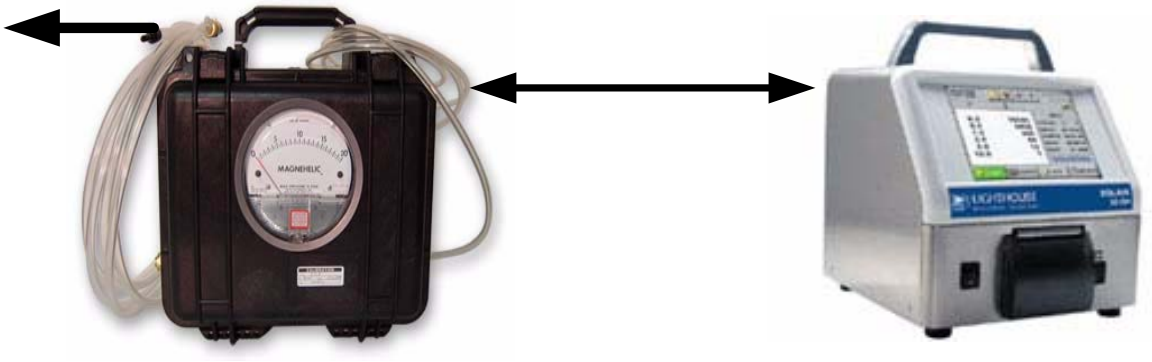


Particle Counting 101 - Aerosol Dilutors

- ★ Aerosol Dilutors are required when the concentration of the particulates in the air is greater than the Concentration Limit of the Particle Counter.
- ★ The Dilutor mixes a known quantity (ratio) of clean air with the aerosol sample.
- ★ Ratios range from 100 / 1 to 1000 / 1

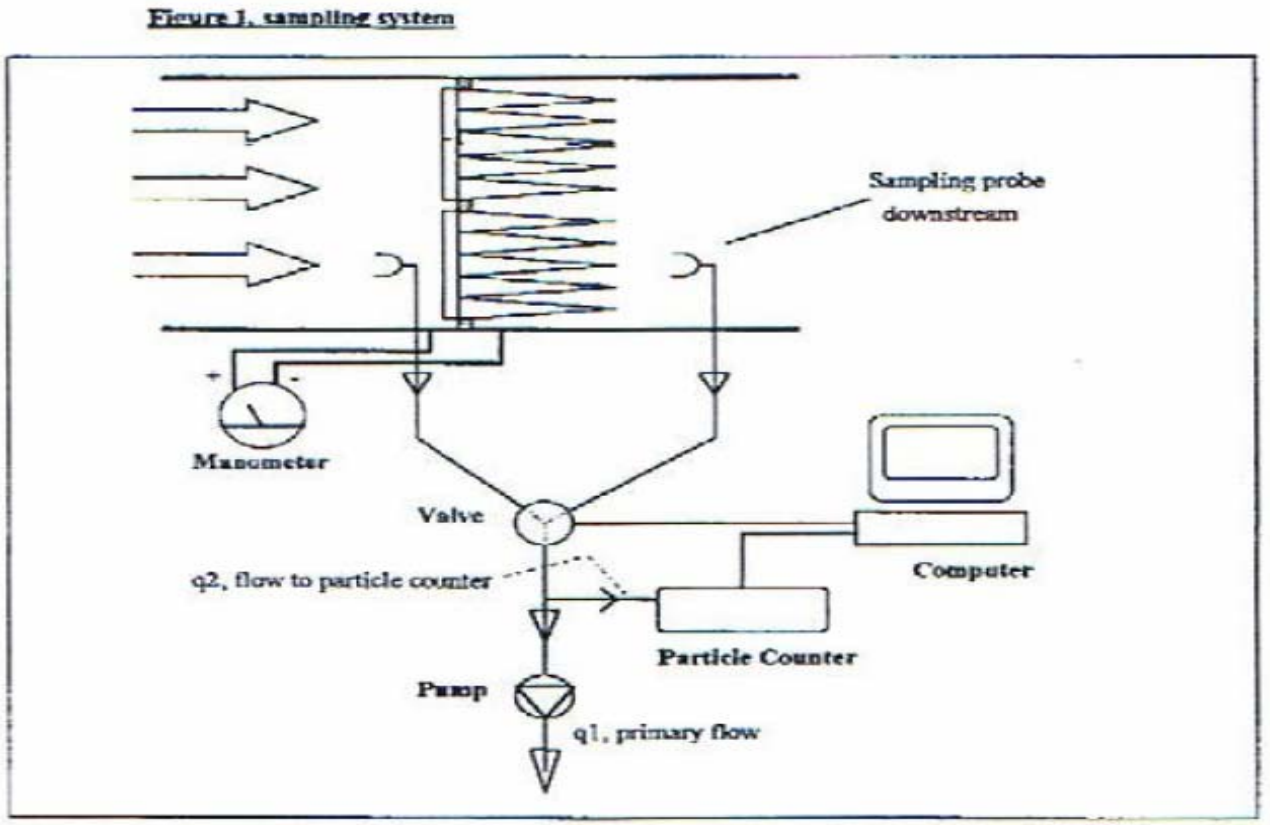
To Isokinetic Probe

To Particle Counter



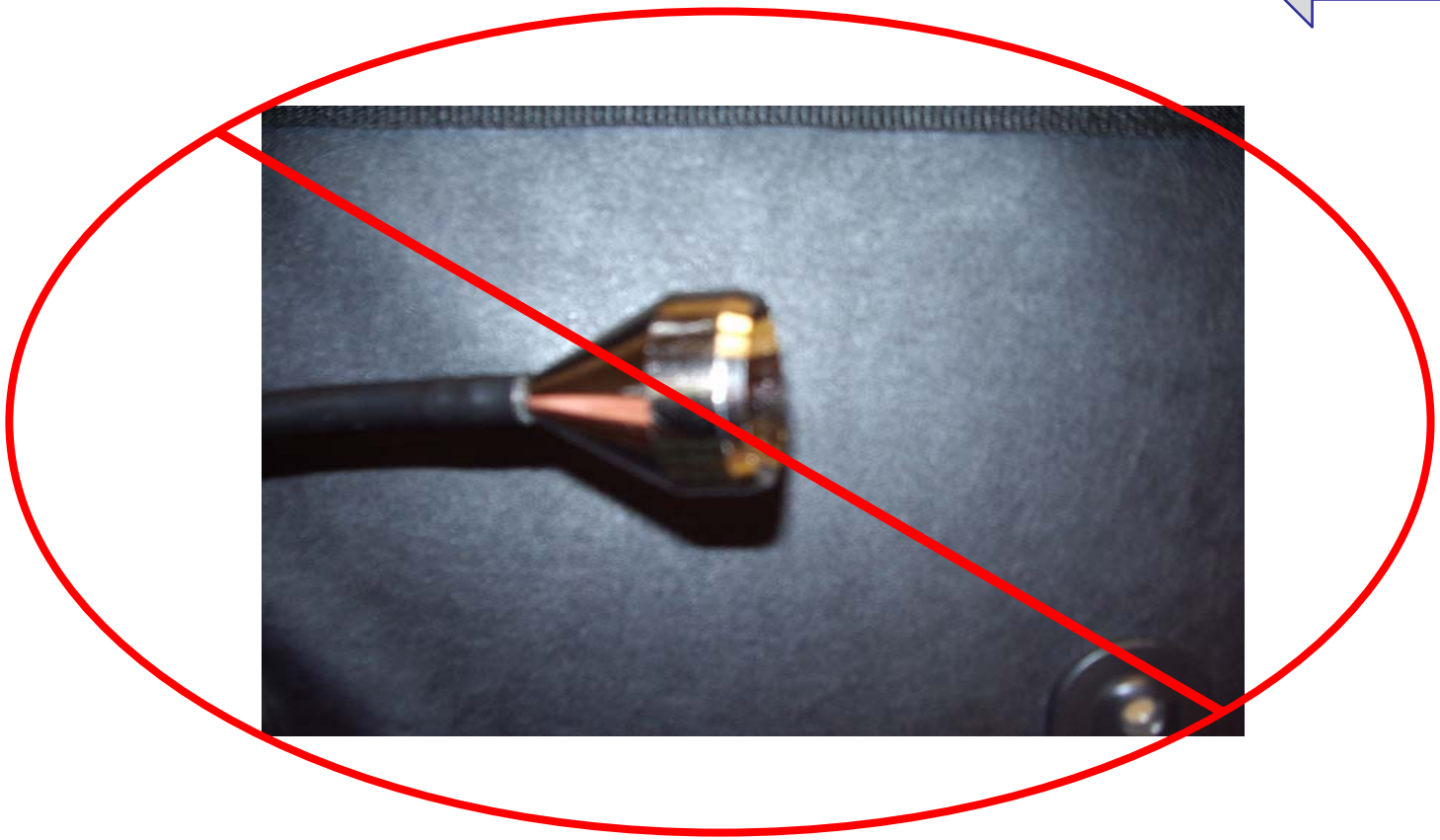
Particle Counting In-Situ – General Diagram

★ Figure 1 – page 6 of Eurovent 4/10



Particle Counting In-Situ – Isokinetic Probe Placement – Improper Angle

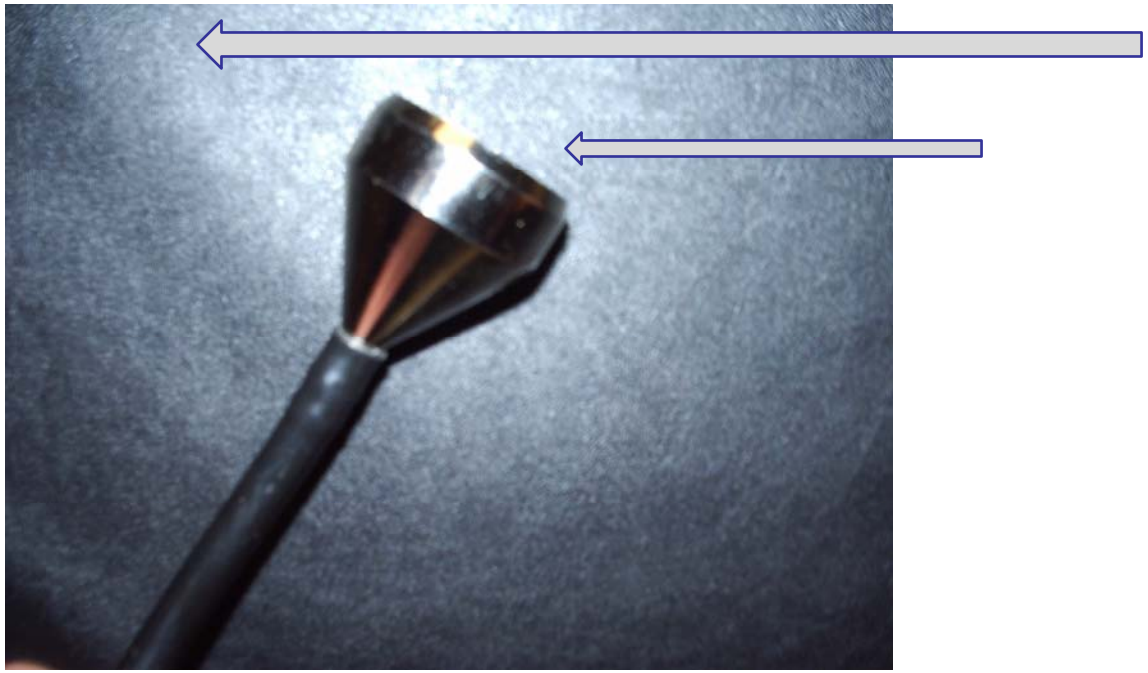
Air Flow Direction



Particle Counting In-Situ – Isokinetic Probe Placement – Proper Angle

Air Flow Direction

The particle counter's pump will "draw" the particles in the airstream into the Isokinetic Probe – eliminating Particle "Washout".

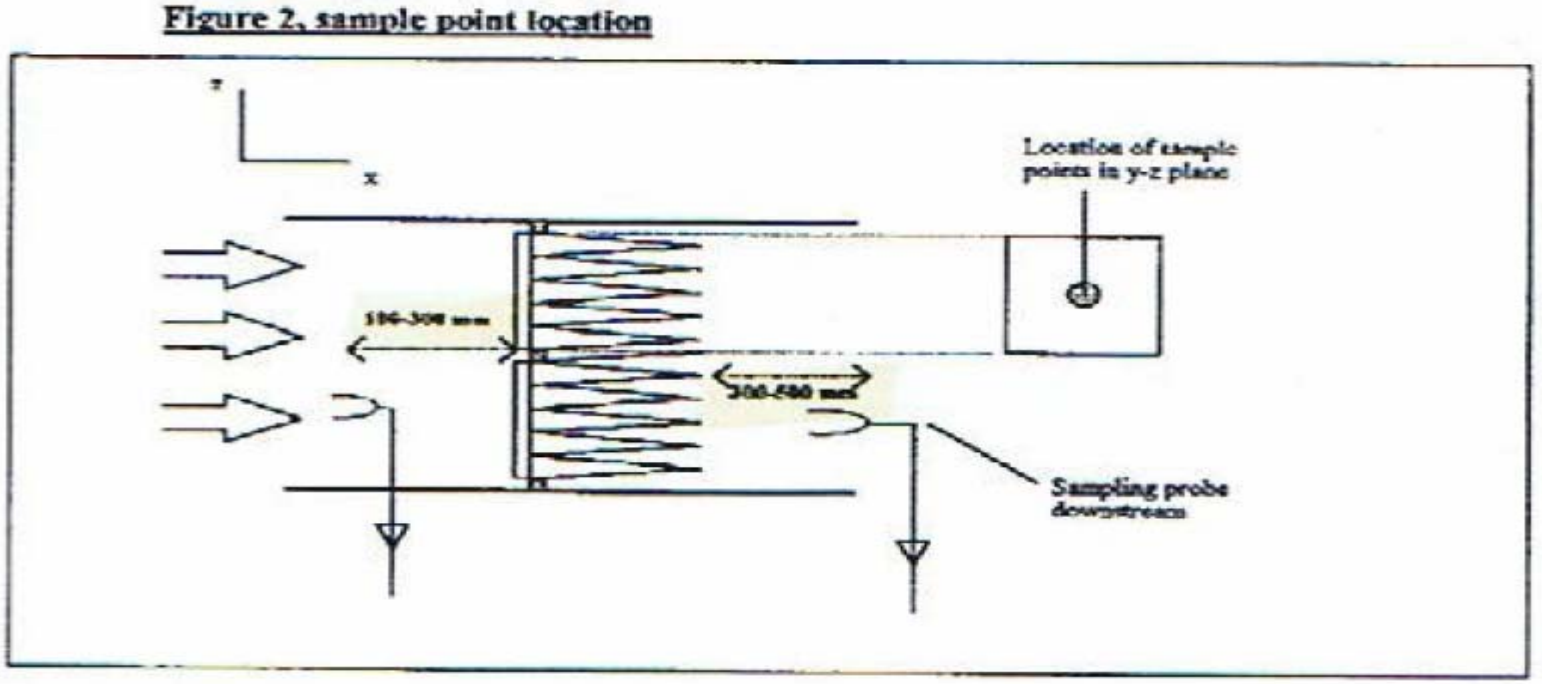


Particle Counting In-Situ – Isokinetic Probe Sample Point Location

- ★ Distances of IsoProbe placement in regards to Filter Bank (section 6.5 paragraph 2 of Eurovent 4/10)
  - ★ Upstream = 100 – 300 mm (4 – 12 inches)
  - ★ Downstream = 300 – 500 mm (12 – 20 inches)
- ★ Each probe should be located towards the center of the ductwork – this is where the highest concentration of particles are found
- ★ Make sure both probes are on the same “y-z” plane – reference Figure 2 of Eurovent 4/10 (page 6)

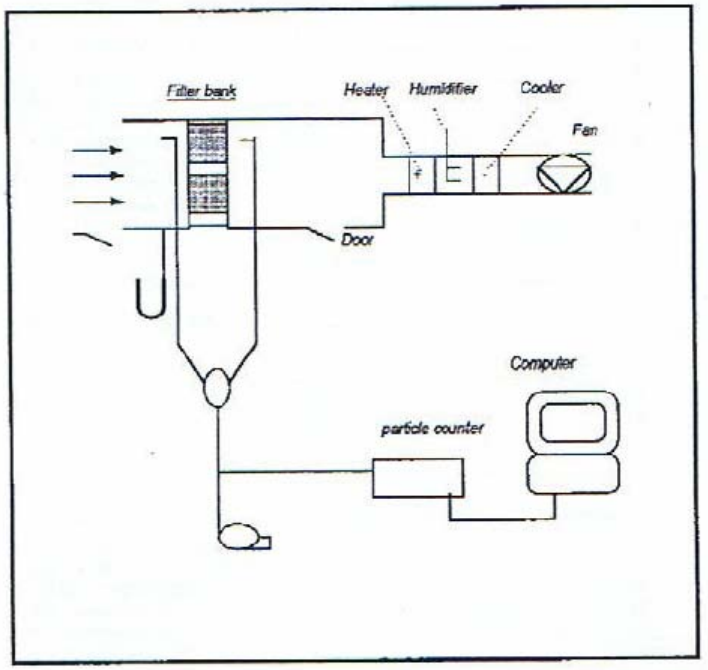
Particle Counting In-Situ – Isokinetic Probe Sample Point Location

★ Figure 2, page 6 of Eurovent 4/10



Particle Counting In-Situ – Tubing

- ★ Tubing on both IsoProbes should be of equal length, diameter, and composition.
- ★ Always compare “apples to apples”!



Particle Counting In-Situ – Concentration Limits

- ★ Section 5 of Eurovent 4/10 – 1996
  - ★ "The aerosol concentration must be within the range of the measuring equipment (particle counter, dilutor) and high enough to produce reasonable statistical accuracy for the result."
- ★ Section 6.5, paragraph 4 of Eurovent 4/10 – 1996
  - ★ "To prevent that the concentration upstream not exceeds the particle counter maximum concentration, a dilutor may be connected to the upstream sample point."

Particle Counting In-Situ – Efficiency Measurement

- ★ Section 6.5, Paragraph 6 of Eurovent 4/10 – 1996
  - ★ "The efficiency measurement is done by a series of minimum 12 counts of minimum 20 seconds conducted successively upstream and downstream of the filter. A purge of at least 20 seconds shall be made (dependent of the length of sampling lines and sample flow) upstream each count, or with a sample upstream or downstream without counting just to equalize the concentration in the transfer lines."
  - ★ What the above is telling us is to purge the sample lines between counts, or cross-contamination may occur within the tubing between the valve and particle counter.

Particle Counter Options

- ★ Hand Held Instruments
- ★ Portable Instruments
- ★ Remote Instruments
- ★ Manifolds

Particle Counter Options – Hand Held

- ★ Cost Effective
- ★ Flow Rate of 0.1 CFM
  - ★ Tubing length restriction of 10 feet maximum
- ★ From 1 – 6 Particle Size Channels available
- ★ Easy to move from location to location (transport)

Particle Counter Options – Portable

- ★ More expensive than Hand Held units
- ★ 1.0 CFM Flow Rate
  - ★ Tubing length up to 100 feet
- ★ From 4 – 8 Particle Size Channels available
- ★ “Portable”, but can weigh up to 25 pounds

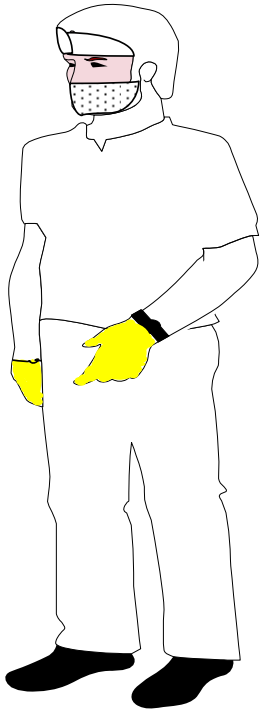
Particle Counter Options – Remote

- ★ Small Footprint
- ★ Real Time Monitoring
  - ★ Can monitor both upstream and downstream at the same time
- ★ For “fixed” installations only
- ★ Requires external vacuum source
  - ★ Adds to overall cost
- ★ 2 – 4 channel sizes available

Particle Counter Options – Manifold

- ★ Requires Particle Counter (added cost)
- ★ Sequential Sampling
  - ★ User Programmable Sequence and Sample Time
  - ★ No need for Valve (between upstream & downstream)
    - ★ Run 2 lengths of tubing directly from Manifold
  - ★ No worries about cross-contamination
    - ★ Continuous Air Flow through all Manifold Ports (slight purge time built in)

Questions?



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