TECHNICAL PAPER

# Lighthouse Active Air Sampler Technology and d50

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# Lighthouse Active Air Sampler technology and d50

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Air Sampler impaction technology has been around for decades. However the d50 is a little know aspect of air sampler technology design and it plays a critical role in air sample capture.

Aerosol Impaction is the process in which particles are removed from an air stream by forcing the gases to make a sharp bend. Particles above a certain size possess so much momentum that they cannot follow the air stream and strike a collection surface such as a media plate which is available for later analysis of composition after an incubation period.

It is one of the most fundamental selection CRITERIA in an Air Sampler is the resolution of the Air Sampler which can be equated to the D50 cutoff point. We all know with a particle counter it must count 0.5um and 5.0um particles as a minimum. The same holds true for an Air Sampler and its ability to capture particle sizes of interest especially when single rod bacteria diameters are as low as 0.3um in diameter its becomes such a critical factor to select an air sample with the right D50 (Resolution) and ability to collect the smallest particle size physically possible.

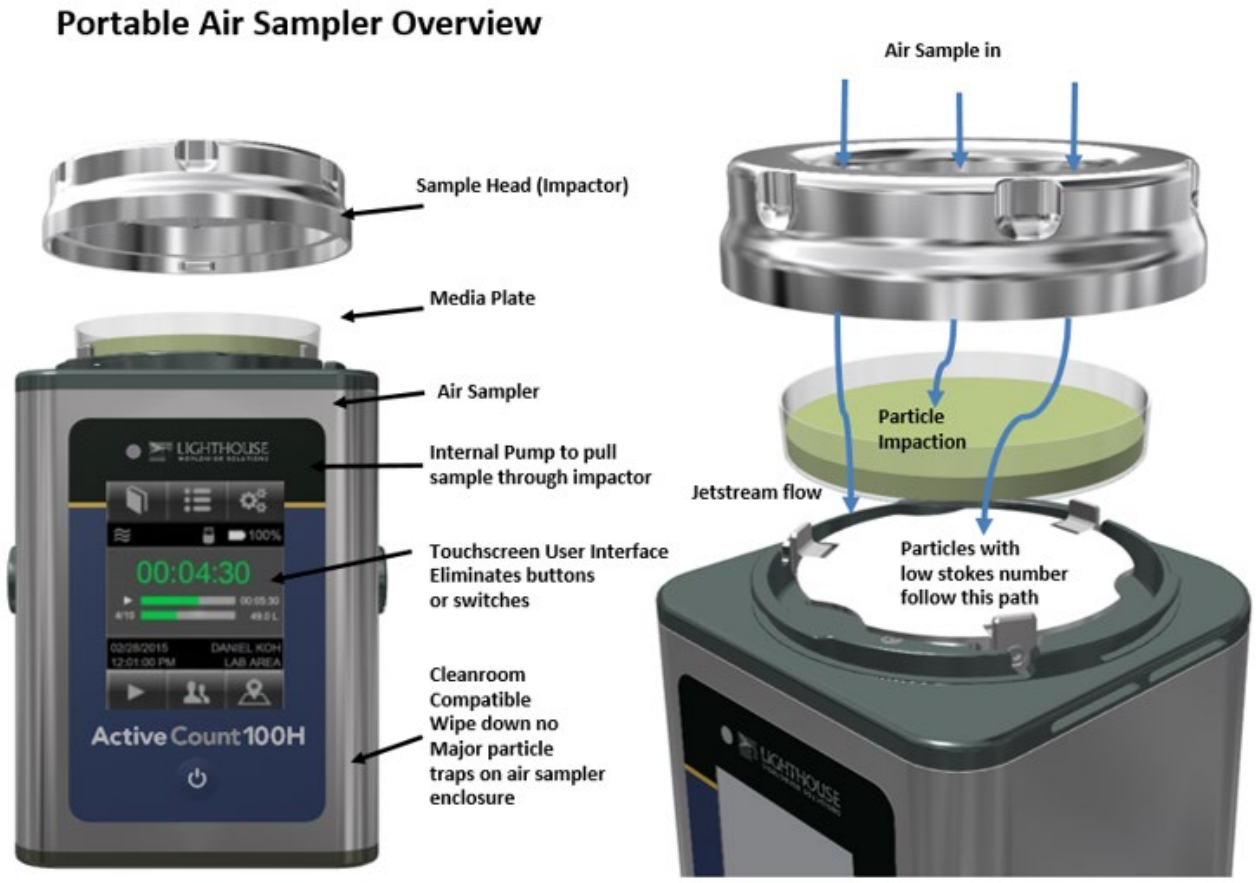


**Fig 1 Air Sampler Impactor Overview**

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## What are physical and biological efficiencies?

In order to understand air sampler impaction technology we need an overview on microbial air sampler design criteria which is strongly influenced by the physical and biological efficiencies. Biological efficiency is strongly influenced by the air sampler's physical efficiency. The overall collection efficiency of microbial air samplers is considered by both physical and biological efficiency. ISO 14698 Annex B "Guidance on validating air samplers" provides the criteria on physical and biological efficiencies and on selecting an appropriate microbial air sampler. The Lighthouse range of microbial air sampler portable units and impaction heads used in automated systems have been designed to meet the guidance set forth in ISO 14698.

### Physical Efficiency

An air sampler's physical efficiency determines the ability to capture particles suspended in an air sample. Physical Efficiency is the ability of the air sampler to collect various sizes of particles. This efficiency is the same whether the particle is a micro-organism, carries a microorganism, or is an inanimate particle. The d50 determines at what lower size range the particles can be captured.

### Biological Efficiency

Is the ability of the air sampler to successfully capture the particles suspended in an air sample so they will cultivate on a media plate. Biological efficiency is determined by testing the air sampler in a series of controlled tests normally conducted by reputable independent organization. The air sampler is tested against a known standard instrument.

## What is the d50 cutoff point?

Aerosol Impaction Air Samplers that have a "sharp cutoff" approach the ideal step-function efficiency curve, in which all particles that are larger than the designs cutoff diameter (aerodynamic size) strike a collection surface or media plate and all particles smaller than the cutoff diameter pass through. When operated at the design flow rate, all particles larger than the cutoff diameter will possess enough momentum to separate from the nominal flow and collide with the collection surface or media plate.

The d50 cutoff point/size for an Aerosol Air Sampler is the size at which 50% of the particles will impact the collection surface or media plate while 50% stay in the nominal air flow and are not collected; the d50 cutoff size is one of the fundamental metrics for evaluating and selecting an Air Sampler, and can be thought of as the resolution of the device. The d50 size of an Air Sampler is analogous to the 50% channel on a particle counter, and is a measure of the smallest particle size that can be physically captured by the Air Sampler.

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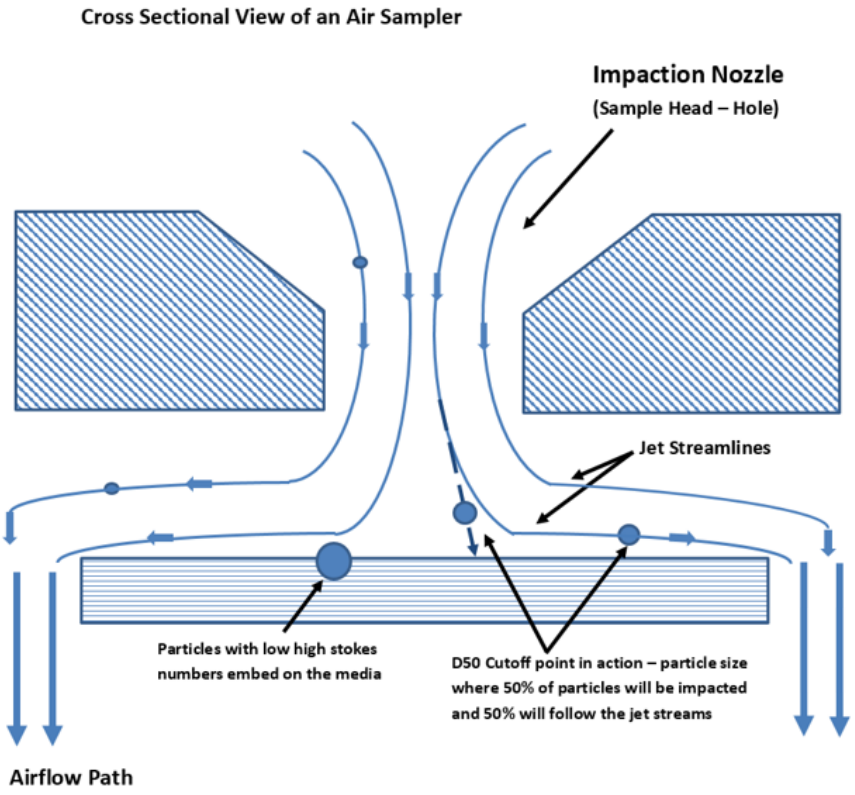


**Fig 2 Cross Section view of an Air Sampler Impactor**

It is important to understand that not all Air Samplers have the same d50 cutoff point/size, and it is also helpful to understand the dominant variables that are involved when calculating an Air Sampler's d50. . We all understand that a Particle Counter used widely in Environmental Monitoring programs has a set 50% channel size based on the smallest particle size it can physically detect (with 50% Count efficiency). The same holds true for Air Samplers as they have a limitation on the size of particles that will impact on the media.

**What is the resolution of Lighthouse Air Samplers and how is the d50 calculated?**

The main contributors to an Air Sampler d50 are;

**Impactor Geometry –** number of holes, diameter, flow area,

**Flow Rate –** nominal flow rate and flow through single hole

**Impaction velocity –** jet velocity onto media plate (function of Impactor Geometry and Flow Rate)

**Temperature–** of air/gas being sampled (air/gas viscosity is primarily a function of temperature)

**Particle Density–** assumed to be 1000 kg/m^3

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**Recommended design Criteria to produce the desirable sharp cutoff:**

1. The Reynolds number of the gas flowing through a given jet/nozzle is to be between 500 and 3000

2. The distance between the nozzle and the impaction surface is to be between 1 and 5 nozzle diameters

Lighthouse Air Sampler d50 values have been calculated based on the following formulae and have a d50 between 0.97µm and 1.1 µm meaning that its collection efficiency meets the requirement of ISO 14698 recommendation of at least 1µm. This ensures that the Lighthouse range of air sampler products are ideal for cleanroom and controlled environment applications. This resolution of Lighthouse Air Samplers means that particles at 1um and above will be captured onto the media and thus can be incubated. Lighthouse Air Samplers have the sensitivity to reliably capture viable contamination at sizes expected in cleanroom and controlled environments.

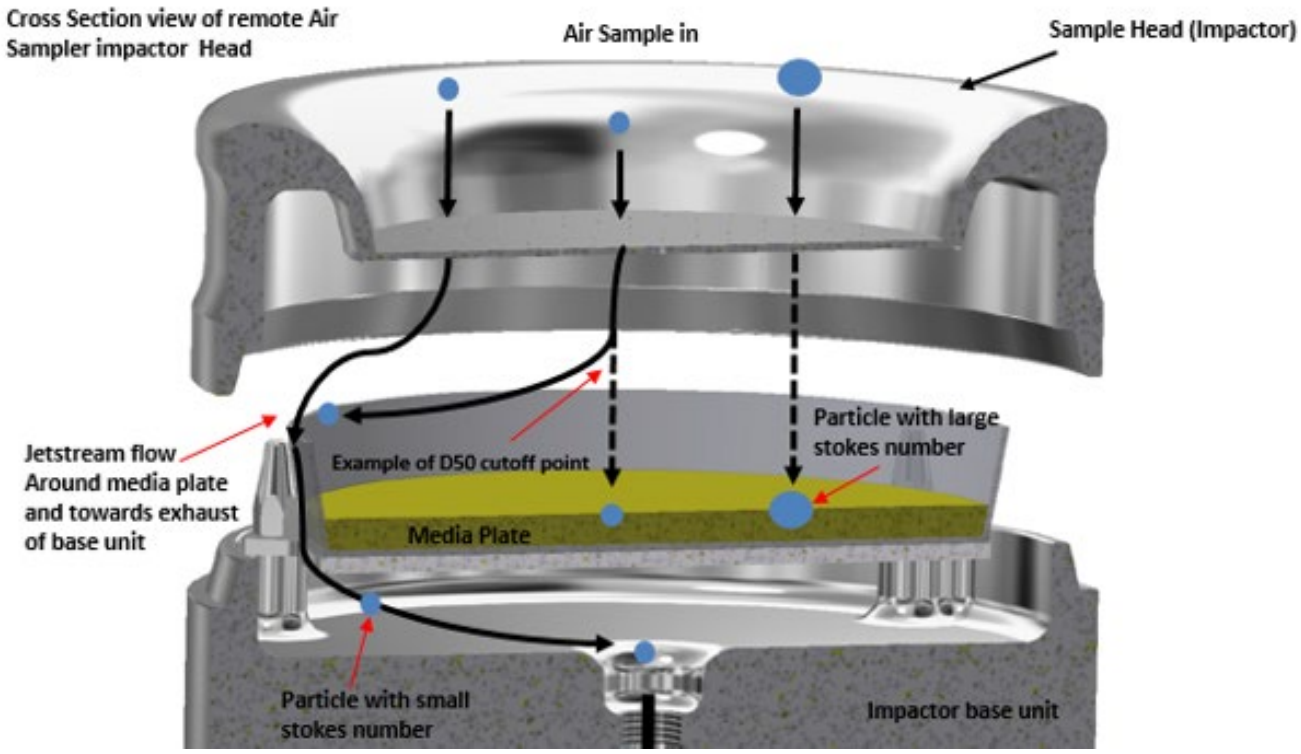


**Fig 3 Cross Section view of a Lighthouse Air Sampler Impactor**

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| Impactor Geometry | US | SI |
|---|---|---|
| # of Holes | 300 | 300 |
| Nominal Hole Diameter, Dj [inch/mm] | 0.0240 | 0.6096 |
| hole - tolerance [inch/mm] | 0.0010 | 0.0254 |
| (- Hole Diameter) [inch/mm] | 0.0230 | 0.5842 |
| hole + tolerance [inch/mm] | 0.0010 | 0.0254 |
| (+ Hole Diameter) [inch/mm] | 0.0250 | 0.6350 |
| Flow Area (- tolerance) [in^2/m^2] | 0.1246 | 0.000080 |
| Flow Area (Nominal) [in^2/m^2] | 0.1357 | 0.000088 |
| Flow Area (+ tolerance) [in^2/m^2] | 0.1473 | 0.000095 |

| Flow Rate | CFM | LPM | m^3/s |
|---|---|---|---|
| Nominal Unit Flow Rate | 3.5300 | 99.9585 | 0.0017 |
| Flow through single hole | 0.0118 | 0.3332 | 0.00000555 |

| Impaction Velocity | ft/s | m/s | % difference |
|---|---|---|---|
| (- hole tolerance) | 67.97 | 20.72 | 8.9 |
| (Nominal) | 62.42 | 19.03 | n/a |
| (+ hole tolerance) | 57.53 | 17.54 | -7.8 |

| Properties of Air at Sea Level | |
|---|---|
| Dynamic Viscosity, η [kg/(m*s) | 0.0000181 |

| Particle Density | [kg/m^3] |
|---|---|
| density, ρ | 1000 |

**Solving For Cutoff Diameter using Equation 1 from Aerosol Science and Technology**

Equation 1:

$$D_{50} = \left[\frac{9\eta W}{\rho_p U_0 C_c}\right]^{1/2} * (Stk_{50})^{0.5}$$

**where:** η is the air viscosity [units]
W is the diameter of the impactor Nozzle
(Stk50)^0.5 is the square root of Stokes number for the collection efficiency of 50%
$\rho_p$ is the particle density
$U_0$ is the jet velocity throught the impactor nozzle
Cc is the Cunningham Correction Factor

| Cunningham Correction Factor | 1.165 |
|---|---|

| Cutoff diameter (d50) | [m] | particle size [µm] |
|---|---|---|
| (- Hole Diameter) | 9.72988E-07 | 0.97 |
| Nominal Hole Diameter, | 1.03713E-06 | 1.04 |
| (+ Hole Diameter) | 1.10262E-06 | 1.10 |

**Fig 2 d50 Calculation and formulae for Lighthouse Air Sampler impactors**

## In Summary

The d50 is similar to the resolution or sensitivity of the Air Sampler. Meaning the smallest particle size it can detect with a 50% collection efficiency. It is calculated based on physical properties of the Air Sampler, its impaction head and other physical properties. ISO 14698 requires Air Samplers to be able to collect particles as low as 1µm and be validated for biological efficiency. Not all Air Samplers have the ability to capture particles as low as 1µm but you can be assured that Lighthouse Air Samplers AC100 and AC100H can with confidence and reliability.



To learn more regarding our Industry award winning Air Samplers click on the link below for the latest tutorial videos. https://www.youtube.com/watch?v=5ht5xpxhSf0

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