

# *Application Note*

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***Multi-point Monitoring  
in Minienvironments***

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# Multi-point Monitoring in Minienvironments

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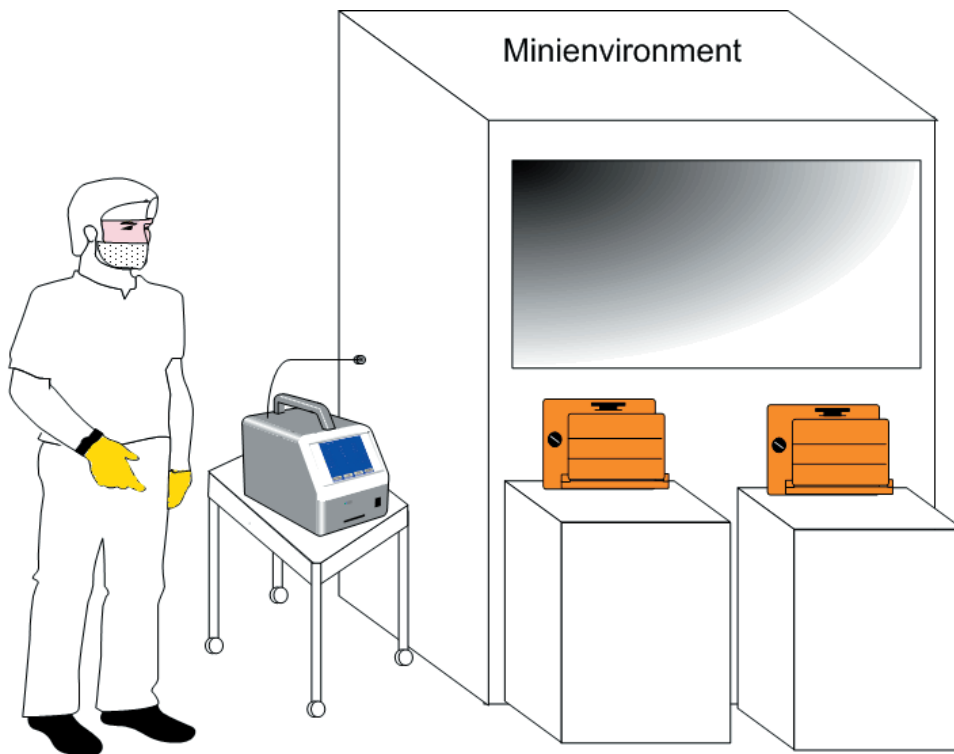
## Abstract

Minienvironments and isolation technology have become commonplace in semiconductor and other high technology manufacturing industries. The use of minienvironments and the associated automation allows for greater levels of control as well as improved process cleanliness.

Minienvironments come in many sizes and shapes. Traditional minienvironments were built around the process tool after the tool was installed. Modern minienvironments are integrated as part of the process equipment. Design of the tool, airflow patterns and pressurization are important considerations in maintaining the cleanliness classification at which the tool is designed to operate.

The use of particle counters to monitor, test and characterize minienvironments has been an established practice in cleanroom manufacturing. The particle counter is used in conjunction with other equipment such as pressure differential indicators, air velocity sensors, and temperature/relative humidity probes. A traditional portable particle counter is often deployed as the main tool to accomplish the testing, characterization and fine-

**Figure 1**



tuning process (see Figure 1). This generally is the same particle counter used to test and monitor the main cleanroom. Characterization is required to assure the tool is performing to the required cleanliness. Routine monitoring is also needed as an audit to assure that nothing has changed.

## Continuous Monitoring for Continuous Manufacturing

The time between audits is a reflection on the risk of product exposure to harmful contamination. For example, if a tool undergoes an audit for particle counts once per week, if something were to happen one hour after the particle count test was performed, the tool could run for up to 167 hours with high levels of particles. This situation could have a serious effect on product yields. This risk factor is forcing some manufacturers to integrate continuous particle counting as a means of monitoring their minienvironments

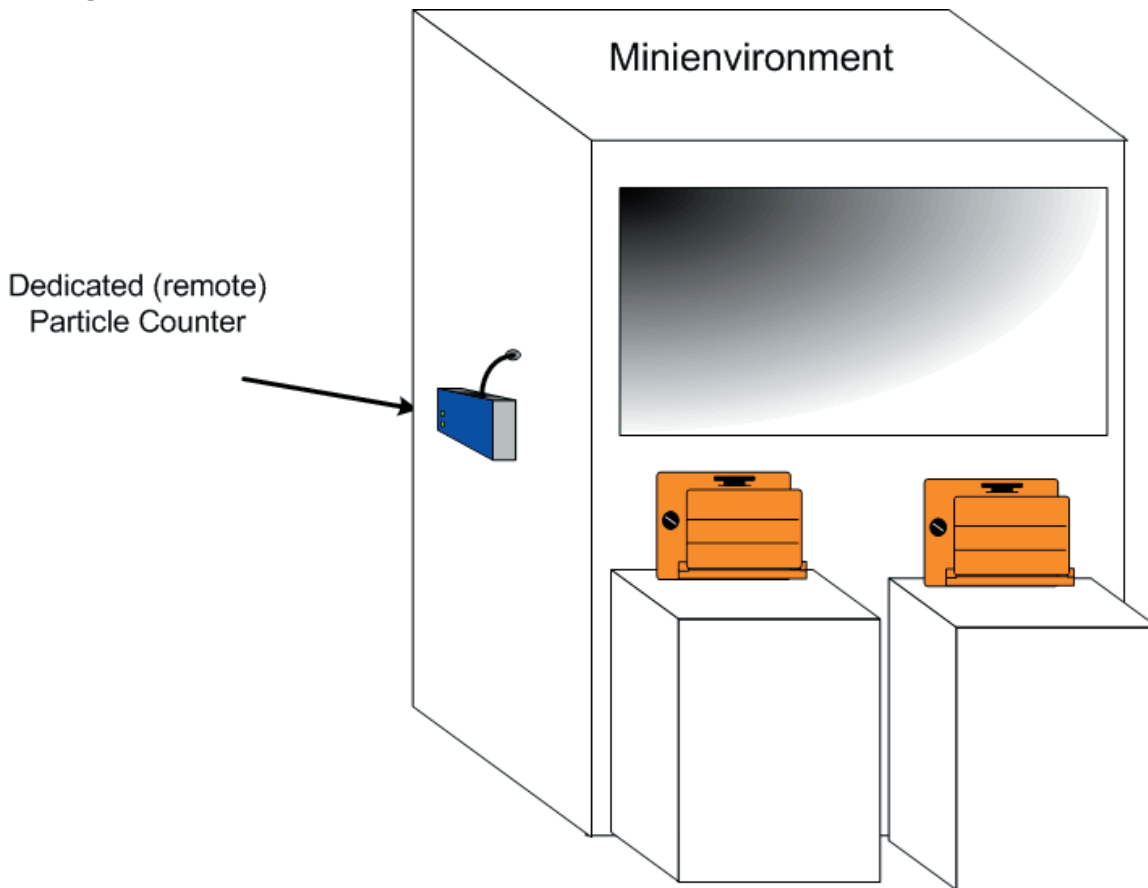
## Continuous Particle Monitoring Methods

With the advent of several methods for continuously monitoring particle counts, several options exist.

### A. Dedicated Particle Counter:

This is typically a remote particle counter. A remote particle counter is an instrument without many of the features and user interface of a portable instrument. Its data is recorded and displayed via some type of external system or computer. The dedicated particle counter is attached to the minienvironment either internally or externally with the sample probe located at a specific location inside the minienvironment (see Figure 2).

Figure 2

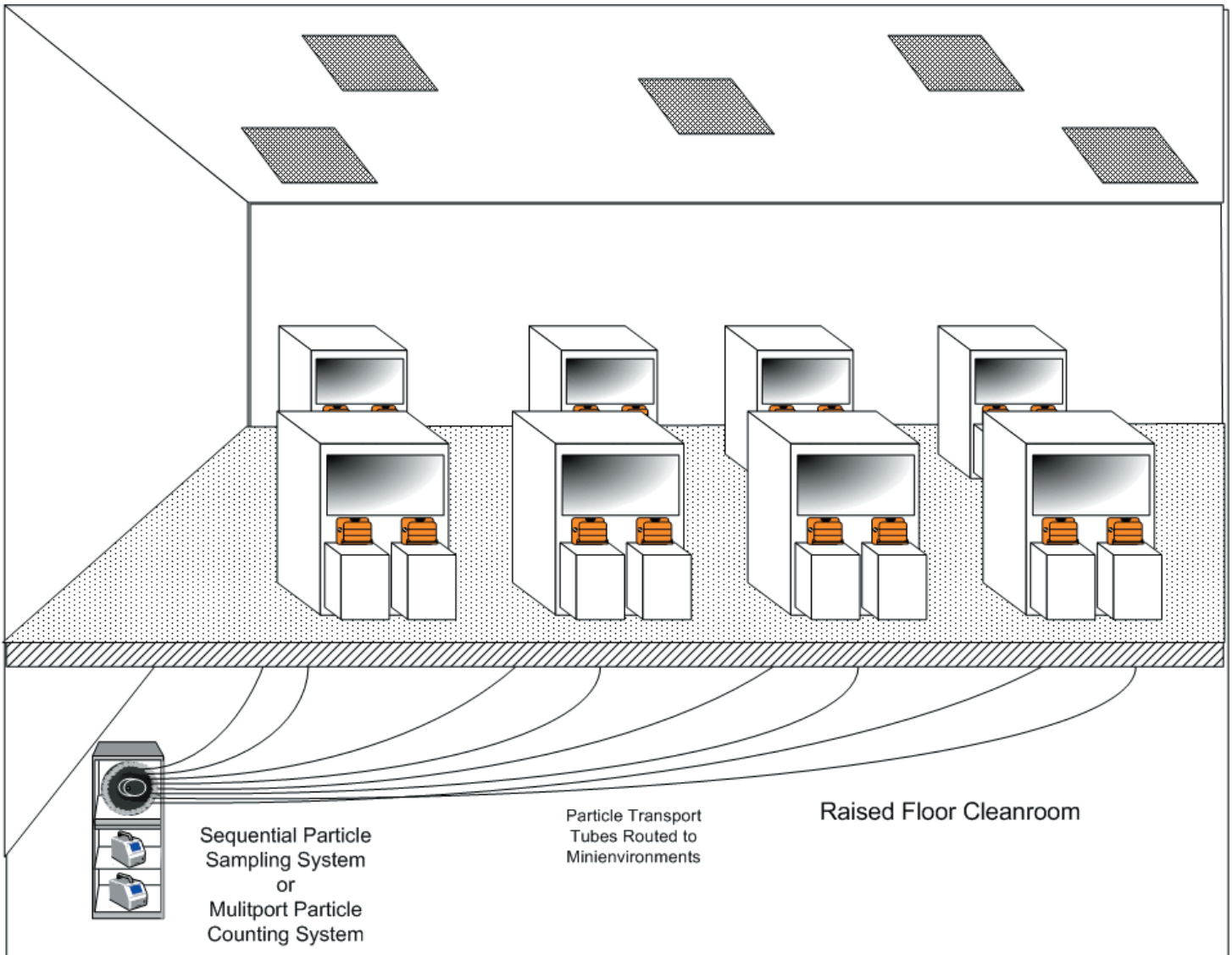


### B. Sequential Sampling System (attached to a particle counter):

This method is sometimes referred to as a Manifold Particle Counting System or a Multiport Sampling System (see Figure 3). It is an aerosol sampling system designed to allow a single particle counter to sample many different locations in sequence. The particle counter is placed in a fixed location attached to the multiport sampling system. Tubes are routed to various locations in the cleanroom or to various minienvironments. Air is drawn continuously through all tubes via an external blower. The internal mechanism inside the multiport sampling system allows for the routing of the sample stream from one tube to connect to the particle counter. This allows the particle counter to sample from one specific tube at a time.

Typically, sample times reflect the sampling of one cubic foot of air (one minute for 1.0 CFM particle counters). After the sample of a specific tube is complete, the multiport sampling system will select a different sample stream. Multiport sampling systems typically can connect a maximum of 12, 24, 30 or 32 sample locations to a particle counter. The frequency of sampling is dependent on the number of sample locations. If you have 12 tubes and each tube is sampled for one minute with a 10 second hold time between samples, it will take 14 minutes to sample from the same location once again. For 32 locations, it will take greater than 40 minutes to sample from the same location again.

**Figure 3**



**Advantages / Disadvantages of Each Method**

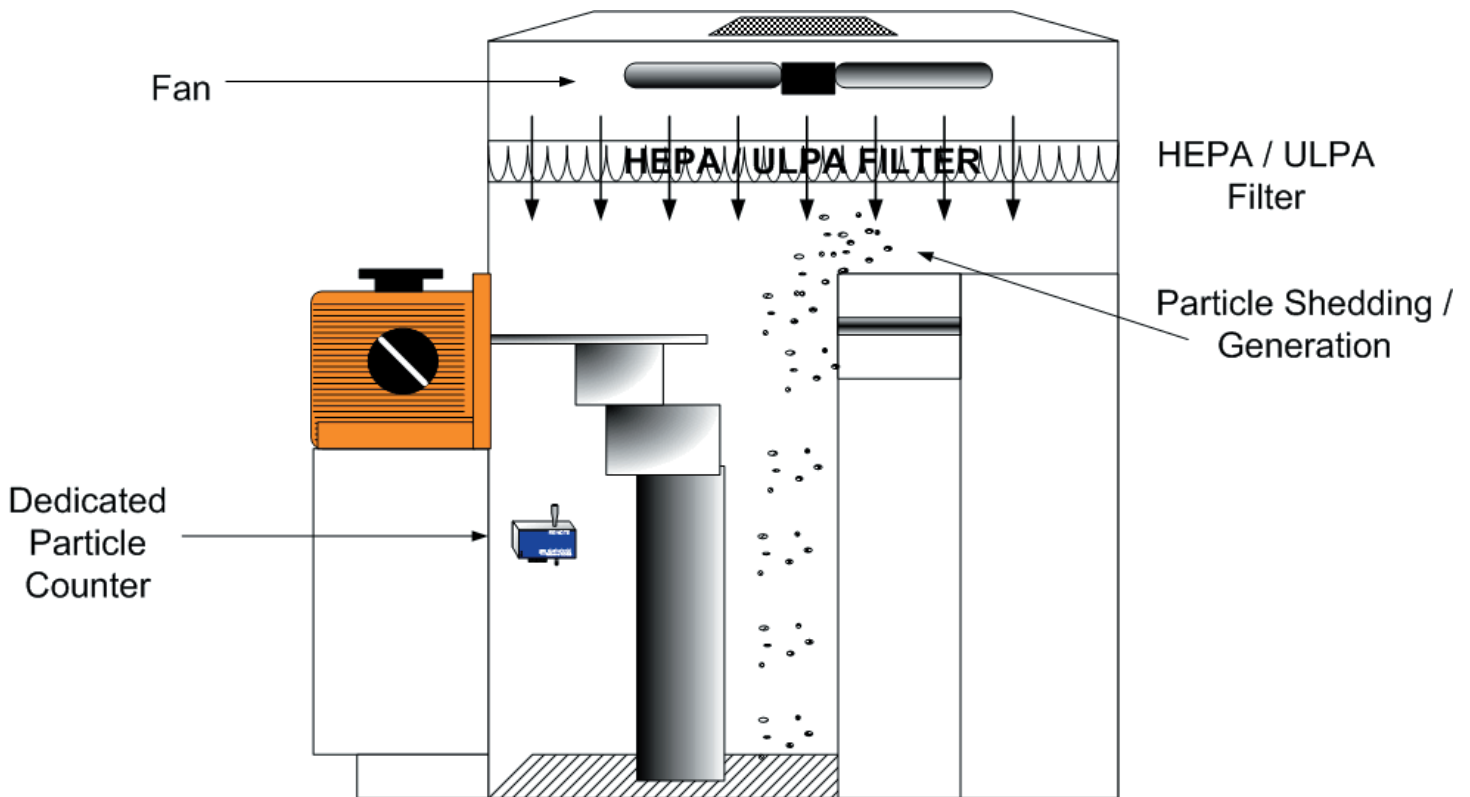
*Advantages of sequencing systems are:*

1. Lower instrument costs: This often allows the selection of more sensitive instruments (e.g. 0.1micron vs. 0.3micron particle counter).
2. Lower calibration costs: With one instrument for 32 locations, only one instrument needs to be calibrated.
3. Lower service costs: Only one instrument needs to be serviced.

*Disadvantages of sequencing systems are:*

1. Gaps in data up to 40 minutes: The time between taking samples at the same location is dependent on the number of sample locations.
2. Dependence on a single system for all 32 port particle counts: When the instrument is being calibrated or serviced, no data is collected from any of the locations.
3. Particle transport concerns: In these systems, submicron particles transport well in tubing; however, particles greater than 1.0 micron have lower transport efficiency.

Figure 4



Due to the Unidirectional Air Flow  
The Particle Counter Does not see  
the particles from the particles  
being generated on the other side  
of the robot.

### Disadvantages of Both Systems

A minienvironment typically provides laminar (uni-directional) airflow through the enclosure. A single particle counter or particle sampling location cannot adequately monitor the entire minienvironment (see Figure 4, above). Contamination occurring in one location may not be detected unless it occurs directly upstream of the particle counter. In order to provide the coverage needed for particle monitoring of the entire minienvironment, multiple particle counters may be needed. This adds significant cost to provide particle monitoring.

### A New Solution

In order to sample multiple locations from a single particle counter and correctly identify the source of each sample, a new device has been developed. The MiniManifold allows one particle counter to continuously monitor up to 6 locations in a single minienvironment or process tool and correctly count particles from each location (see figure 5).

**Figure 5**



### **MiniManifold Function**

The MiniManifold consists of a manifold sequencing system with built-in controller and a blower for purge airflow. A particle counter inlet tube is connected to a moving arm that allows the sequencing of the particle counter inlet to the 6 locations. After a sample on one of the six tubes is finished, the arm moves the particle counter inlet tube to the next location.

The controller communicates with the particle counter and can interface to a computer system or process tool via the industry standard Modbus protocol. The controller maintains separate data for each of the six locations. This essentially allows for each of the six locations data to be recorded as if it were a separate particle counter.

The blower is external to the sequencing system and can be remotely installed some distance from the manifold. The blower draws from all 6 locations at the same time. The small manifold utilizes an isokinetic sampling system to prevent particle transport loss in the sampling tubes. This sampling system assures the flow rate is consistent through all tubes all the time, even when the particle counter is accessing the sample tube.

Programming sequences for the MiniManifold can be set up with user defined sample, purge and hold times. Each of the six locations can be configured for separate sample and hold times. In addition to this, unique sample configurations can be created, allowing rapid testing of all or individual locations.

The MiniManifold also has a buffer to store data records. The MiniManifold interfaces with Lighthouse Remote P series particle counters. The P Series has particle sensitivity from 0.2 microns and flow rates of 0.1 CFM. The P series remote particle counter can also interface with external temperature, relative humidity, differential pressure and air velocity sensors.

### **Contamination Concerns for Minienvironments**

**Fan Filter Failure:** FFUs can be damaged or turned off during maintenance. Without proper FFU operation, contamination can easily be deposited on the product surface.

**Excess Contamination Build Up:** Over the course of the tool's life, wear from handling or process related contaminants can accumulate. This excess contamination can be deposited on the products' surfaces.

**Improperly Adjusted FFU Speed:** Often the speed of the fan motor for the FFU is adjustable. Too high a speed can over-pressurize the minienvironment and create turbulent airflow patterns that trap particles within the minienvironment. If the speed is too low, it creates a low pressure differential that can allow particles to enter the minienvironment.

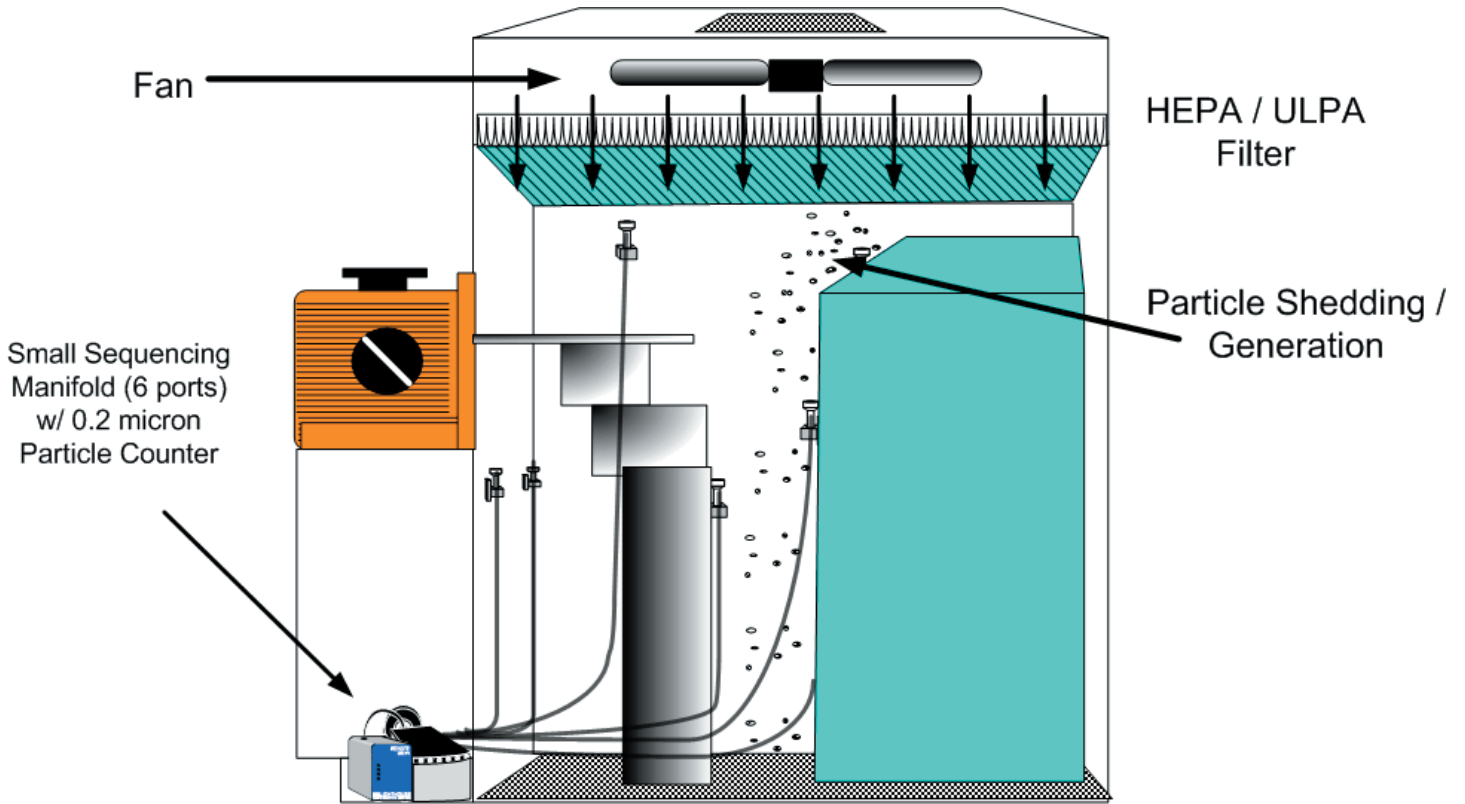
**Minienvironment Integrity Failure:** Seals for the enclosure panels provide the air flow and pressure differential needed for proper operation. If these seals leak or the panels are removed, particle levels can become quite high.

### **APPLICATIONS**

#### **Multi-Point Monitoring**

One application is multi-point monitoring in critical minienvironments that cannot be adequately done by a single particle counter (see figure 6).

Figure 6



Mini-Environment Monitoring  
With Mini-Manifold & Single  
Particle Counter

### Automated Manufacturing Line Monitoring

Monitoring conveyer systems, automated process tools or automated stocking systems are usually difficult or impossible to monitor with a portable particle counter or a single remote sensor.

### CONCLUSION

There are several methods to continuously sample particles in a minienvironment. The MiniManifold allows a single particle counter to monitor up to six locations in a minienvironment or process tool and to record particle data for that specific location. This greatly increases the coverage of a single particle counter inside this type of equipment. With increased coverage, the probability of detecting a contamination event is greater.

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