# Tutorial on HEPA

*Jason Kelly*

HEPA filters are used in cleanrooms in many different industries, including semiconductor, pharmaceutical medical devices, nuclear, and biotechnology. The main function of a HEPA filter is to provide clean air to the cleanroom. The HEPA filter is constructed with many pleated layers of filter media paper; this design prevents particles from freely passing through the filter as they become trapped and stick onto the filter fibers (Figure 1). There are four mechanisms at work: capture by straining, impaction, interception, and diffusion (Figure 2). Straining/sieving is defined as when a particle is too large and becomes trapped between two filter fibers. Impaction is when a particle of relatively greater mass is unable to follow the curved streamline around the fiber and, as a result of momentum, travels in a straight line into the filter fiber and sticks. Interception occurs when a section of a particle "runs into" a filter fiber. Diffusion capture occurs when particles leave the streamline due to random collisions with the surrounding fluid molecules and strike the fibers, where they again stick.

## LEAK TESTING

ISO 14644-2 outlines the frequency of cleanroom validation according to cleanroom classification. Part of this validation includes leak testing of the HEPA filter. ISO 14644-3 outlines the testing procedure to follow.

## EQUIPMENT REQUIRED

**Aerosol Generator:** used to produce an aerosol upstream of the HEPA filter. A stable test aerosol has particles that have the following distribution:

- More than 20% by mass of particles less than 0.5 μm
- More than 50% by mass of particles less than 0.7 μm

# Filtration

- More than 75% by mass of particles less than 1.0 µm

An annual output test should be carried out to verify that the aerosol meets this distribution.

**Photometer:** used to measure the upstream aerosol concentration and downstream penetration of the HEPA filter by the aerosol; it should be calibrated at least annually.

**Particle Counter:** used to measure the concentrations of particles of different sizes downstream of the HEPA filter; it should be calibrated at least annually.

## AEROSOL GENERATOR OUTPUT TEST

The aerosol generator output test, carried out annually by the supplier, verifies that the aerosol generator is capable of producing a stable distribution. The photometer verifies that the sensor/optics and flow rates are within tolerances. Some new digital photometers now on the market have the ability to verify on "power up" the condition of the sensor/optics and flow rates as part of a self-diagnostics program and, therefore, improves the reliability of the unit continually instead of waiting annually for the calibration and hoping it passes. Photometer operators can be satisfied that the photometer is free from contamination around the sensor/optics, ➤

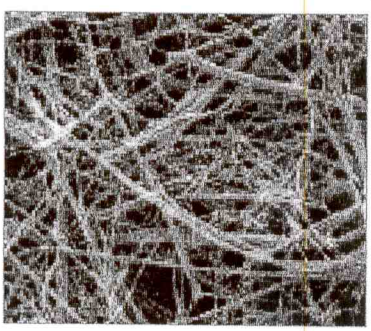

Figure 1: Filter media magnification x500

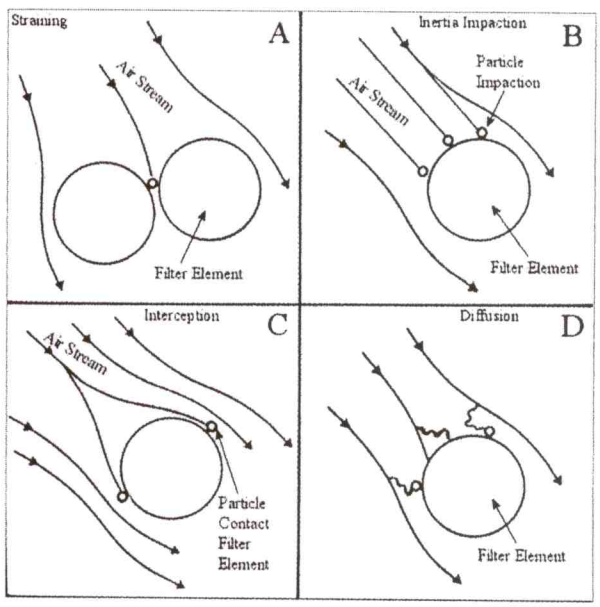


Figure 2: Filter mechanisms at work

the flow path is unobstructed, the unit is performing correctly, and that the results are accurate.

## TEST METHOD

A linear photometer may be used to measure upstream concentrations provided it is calibrated.

This upstream concentration may be used as the 100% reference, enabling percentage penetration downstream to be measured directly. The linear photometer may be used to test filters to 0.01%.

## TEST REQUIREMENTS

Each filter requires an upstream challenge of 20–100 µg/L for best results. One must find the area of the filter and the airflow through the filter before calculating the throughput of the filter. The product of throughput and concentration are required to give the aerosol output required. Alternatively, the aerosol can be adjusted to reference the photometer at 100%.

## TEST PROCEDURE

Disperse the test aerosol upstream of the HEPA filter to produce a uniform challenge concentration in the region of 20–100 µg/L. Using the photometer, measure the upstream challenge concentration.

Maintain this concentration throughout the test. Adjust the aerosol generator such that the challenge concentration at the upstream filter face is at a level such that the photometer can be set and maintained at a stable reading of 100%. The photometer is then set at 100%.

Using the same photometer, scan the entirety of the downstream face and perimeter inclusive of the sealing device with the sampling probe. Hold the probe approx 25 mm away from the area tested and pass over the entire area in slightly overlapping strokes, at a rate of 5 cm/sec. Record the location of any steady, repeatable reading of the photometer that exceeds 0.01% for grades A through D in the relevant class of environmental cleanliness. Refer to ISO 14644-3 section B.6.2.5 for a more detailed procedure.

## GUIDELINES

Care should be taken when generating the upstream aerosol as too much aerosol will over-concentrate the filter and filter replacement will be necessary; use too little aerosol and there may be insufficient aerosol to effectively scan the filter sufficiently. Discuss these scenarios with to reach an agreement regarding the upstream concentration.

Once a leak has been detected, repair of the filter will be necessary, following the manufacturer's procedure regarding the type of repair media and guidelines on resealing the filter and performing tests after the repair. After successful testing, a particle counter positioned under the filter can evaluate the condition of the filter and can be used as a back up to the photometer.

### References


- ISO 14644-3
- ISO 14644-2
- IEST-RP-CC034
- IEST-RP-CC007



***Jason Kelly** is the Director of OptiCal Sciences, Ireland Ltd. and has been working in the semiconductor and pharmaceutical/medical device cleanroom industry for the last ten years. He can be reached at www.optical-sciences.ie.*