Airflow Management of Biological Safety Cabinets

Case Study

Introduction

In a laboratory environment safety of the operator is extremely important. Biological Safety Cabinet is the primary means of containment developed for working safely with infectious micro-organisms. BSCs are designed to provide personnel, environmental and product protection when appropriate practices and procedures are followed. Three kinds of biological safety cabinets, designated as Class I, II and III have been developed to meet varying research and clinical needs. High efficiency particulate air (HEPA) filters or ultra-low penetration air (ULPA) filters are used in the exhaust and/or supply systems of biological safety cabinets.

The airflow within the work area in a BSC is designed to be laminar at a speed of 50 to 120 feet per minute. The air in the work area should not escape into the room causing contaminants to reach the operator. Therefore there is a constant airflow from the room into the BSC.

Managing such complex airflow pattern requires precise measurement of airflow at least at two points: One at the down flow from the filter and one at the exhaust path to guarantee constant air removal from room to BSC to exhaust.

Two airflow sensors are used for such an application as shown in Figure 2. These two sensors can guarantee constant laminar flow and adequate air exchange.

Airflow sensing methods

Airflow can be measured in two ways: Direct airflow sensing or indirect method using Pitot tube through pressure measurement.

Direct Airflow Measurement:
When using a direct airflow sensor two factors to be considered are measurement range and accuracy specifications. In a BSC application the airflow in the cabinet is between 50 to 120 fpm (0.25 – 0.6 m/s). The sensor designed for this range should be used for best results. Consider a sensor with 1000fpm range and accuracy specification of 2% full scale or 10fpm. When this sensor measures 50fpm the tolerance could be up to 20fpm (2% of full scale). This means that the real measurement tolerance at 50fpm is 40%. An airflow sensor with measurement range of 50 – 150fpm (0.25-0.75 m/s), operating temperature range of 15-35°C and accuracy of 5% can address most BSC applications.

Indirect Airflow Measurement using Pitot tube:
Pitot tube is used to pick up pressure difference caused by airflow into a tube. This pressure measurement is converted to airflow using a relation:

Airflow, $V = (2\,\Delta P/\rho)^{1/2}$;

Where, ΔP=Stagnation pressure – Static pressure across Pitot

ρ = Air density

As shown by the equation, at lower airflow levels the pressure gets extremely low that a sensor to achieve appropriate accuracy may be hard to find.

Airflow Measurement in BSC

There are two primary factors that need to be monitored in a BSC:

- Down draft air velocity and
- Air exchange rate.

Low down draft velocity ensures that the flow in the chamber is laminar. The flow range is between 50-120 fpm. A sensor placed directly below the HEPA filter (S1) enables ensuring laminar airflow by speed controlling the exhaust fan. Since the airflow at S1 is low, a direct airflow measurement method is necessary.

Appropriate gross air movement through the BSC is monitored through S2, placed in exhaust path. The volume of airflow is calculated by multiplying linear velocity by area of the exhaust duct. Since the flow pattern is not of concern and the duct velocity may be high, direct or indirect measurement methods may be used.

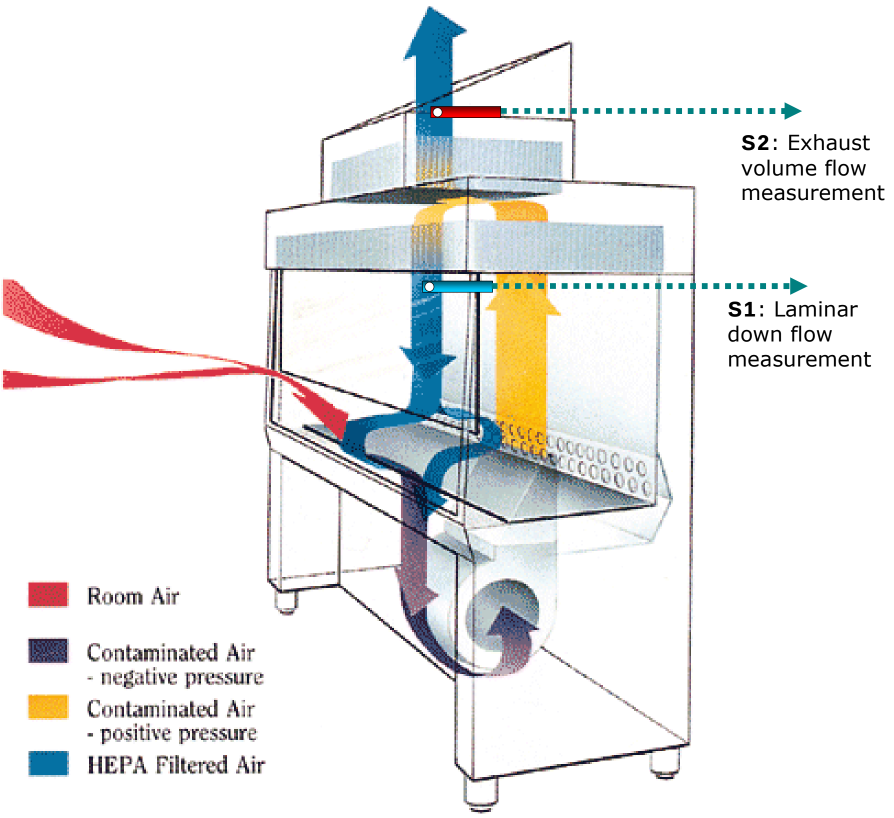

Figure 2. Airflow path in a BSC and ideal locations for sensing airflow.

DegreeC offers direct airflow sensors to world's leading BSC manufacturers such as NuAire, Lab Conco, Esco and Baker. DegreeC's has years of experience in intelligent fan control, sensing technology and airflow engineering for airflow and thermal management.