

# AEROTRAK 9001 CLEANROOM CONDENSATION PARTICLE COUNTER CPC WORKING FLUIDS

APPLICATION NOTE CC-126 (US)

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## Introduction

Cleanrooms are controlled environments that are designed to reduce/eliminate contamination to levels appropriate for accomplishing contamination-sensitive activities. Within cleanrooms, mini environments are used to provide ultra-clean environments for manufacturing processes that are particularly sensitive to contamination. In the electronics industry, as manufacturing geometries continue to decrease, increasingly smaller particles affect yield and need to be monitored.

Maintaining an ultra-clean environment is essential to maintain high yields with today's nanoscale manufacturing geometries. While monitoring particle concentrations will help ensure that these environments stay ultra-clean, it is critical that the instruments used are not a source of contamination themselves.

Condensation Particle Counters (CPCs) are designed to count nanoscale particles that are invisible to traditional airborne particle counters. They work by condensing vapor onto the particles, growing them to a size that is easily detectable. The vapor is produced from the instrument's working fluid. When the vapor surrounding the particles reaches a specific degree of supersaturation, the vapor begins to condense on the particles.



There are several different types of working fluids used in CPCs. Some are potential sources of contamination and should be avoided. Others are already present in cleanroom processes and are not a source of contamination. Only ultra-pure/de-ionized water-based CPCs, like the AeroTrak® 9001 Cleanroom CPC, keeps possible sources of contamination out of the cleanroom, while providing 24/7 continuous operation with minimal maintenance.

This application note will compare types of working fluids as they relate to their use in monitoring nanoscale particles in ultra-clean environments, while supporting 24/7 operations with minimal maintenance.

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## Organic Compound-Based Working Fluids

Organic compound-based working fluids used in commercial CPCs include n-butyl alcohol (butanol), isopropyl alcohol, and glycerin (1, 2, 3-propanetriol; glycerol). All three of these chemicals are part of the hydroxyl functional group (-OH), which is alcohol. Most are banned for use within the cleanroom with the exception of isopropyl alcohol, which is used solely for surface cleaning and not during the manufacturing process.

### n-Butyl Alcohol (Butanol)

- Formula: C<sub>4</sub>H<sub>10</sub>O
- Hazardous chemical
  - Fire: highly flammable
  - Explosive: above 29°C explosive vapor/air mixtures may be formed
- Chemical/particulate contamination
  - Toxicity: classified as a VOC (volatile organic compound)
  - Vaporous state may have a harmful effect on the products, processes or equipment in the cleanroom and ultra-clean environments
- Not readily available in the cleanroom
  - Sourced from chemical supplier
- 24/7 continuous operation
  - Butanol-based CPCs can operate over long time periods with minimal maintenance
- Additional information
  - Butanol is not typically used in cleanrooms
  - Storage: requires safe containment
  - Problematic if other gas analyzers are in used in close proximity
  - Primarily used with general purpose/research CPCs
    - Measuring high particle concentration environment
    - Long-term monitoring applications

## **Glycerin (1, 2, 3-Propanetriol; Glycerol) Sugar Alcohol**

- Formula:  $C_3H_8O_3$  or  $CH_2OH-CHOH-CH_2OH$
- Hazardous chemical
  - Oil/syrupy-based organic compound
  - Fire: combustible, gives off irritating or toxic fumes or gas in a fire
    - Heating will produce corrosive fumes of “acrolein”
  - Tri-hydroxyl “sugar alcohol” that is an intermediate in carbohydrate and lipid metabolism
- Chemical/particulate contamination
  - Toxicity: classified as a VOC (volatile organic compound) by some sources even though it has a boiling point of  $290^{\circ}C$
  - Vaporous state may have a harmful effect on the products, processes or equipment in the cleanroom and ultra-clean environments
- Not readily available in the cleanroom
  - Sourced from chemical supplier
- 24/7 continuous operation
  - Can operate over long periods of time
- Additional information
  - Storage- requires safe containment
  - Oil/syrupy-based chemical deposits residue on surfaces and other objects on contact
    - Not normally used in electronics manufacturing cleanrooms
    - Cross-contaminations concerns
    - Used as a solvent in the pharmaceutical industry or as an artificial sweetener
  - Problematic if other gas analyzers are in used in close proximity

## **Isopropyl Alcohol/Isopropanol (IPA)**

- Formula:  $C_3H_8O$  or  $C_3H_7OH$  or  $CH_3CH_0HCH_3$
- Hazardous chemical
  - Fire: highly flammable
  - Explosive: vapor/air mixtures are explosive
- Chemical/particulate contamination
  - Toxicity: classified as a VOC (volatile organic compound)
  - Vaporous state may have a harmful effect on the products, processes or equipment in the cleanroom and ultra-clean environments
- Readily available in the cleanroom
  - Isopropanol is available for use in the cleanroom for surface cleaning
  - Not used during cleanroom manufacturing process
- Does not enable 24/7 continuous operation
  - Water from the atmosphere readily diffuses into isopropyl alcohol
  - Short-term use only
- Additional information
  - Used in handheld CPC instruments
  - Primarily designed for point of source identification
  - Storage- requires safe containment

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## Water-Based Working Fluids

Water-based working fluids used in cleanroom CPCs are ultra-pure/de-ionized and distilled water. In contrast to CPCs that use alcohol, water is considered a clean working fluid that is cleanroom friendly, readily available, and easier to handle. Using water as a working fluid, eliminates the potential of introducing unwanted chemical contaminants into the cleanroom manufacturing process. The performance of a water-based CPC is based on the quality of water used as a working fluid.

When using distilled water, the liquid purity is not tightly controlled or free of particulates. The impurities in the water will build up on the wicks that bring the working fluid in contact with the sample flow, and eventually cause the wick material to become ineffective. As a result, distilled water is not conducive to 24/7 operation and requires frequent maintenance to ensure proper operation.

Ultra-pure/de-ionized water is produced under a strict purification process and used throughout the cleanroom as part of the wafer cleaning procedure. The use of ultra-pure/de-ionized water as a working fluid eliminates the chances of particulate contamination affecting wick performance, enabling it to be used for 24/7 operation in ultra-clean manufacturing environments without any interruptions.

### Ultra-Pure/De-Ionized Water

- Non-hazardous chemical
- Free of chemical/particulate contamination
  - No impurities in the water
- Readily available in the cleanroom
  - Ultra-pure and de-ionized water is used throughout the cleanroom manufacturing process
- Enables 24/7 continuous operation
  - Can operate over long time period with minimal maintenance
    - 6-month maintenance cycle
- Additional information
  - Water is produced on-site
    - Strict purification process

### Distilled Water

- Non-hazardous chemical
- Particulate Contamination
  - Particulate contamination from the water
- Readily available in the cleanroom
- Does not enable 24/7 continuous operation
  - Substandard wick performance
    - Impurities build up on the wick
  - Required higher maintenance
    - More frequent wick change out due to impurities in the water
- Additional information
  - Liquid purity not tightly controlled

CPC Working Fluid	Non-Hazardous	Free of Chemical/ Particulate Contamination	Readily Available in the Cleanroom	Enables 24/7 Continuous Operation
Ultra-Pure/De-Ionized Water	✓	✓	✓	✓
Distilled Water	✓		✓	
n-Butyl Alcohol (Butanol)				✓
Glycerin (1,2,3- Propanetriol; Glycerol)				✓
Isopropyl Alcohol (Isopropanol)			✓	

## Conclusion

Even though commercially available CPCs use several different working fluids, some are hazardous or are not conducive to 24/7 operation. Only ultra-pure/de-ionized water-based cleanroom CPCs keep possible sources of contamination out of the cleanroom, while providing 24/7 continuous operation with minimal maintenance. Readily available in the cleanroom manufacturing environment, ultra-pure/de-ionized water is the ideal working fluid for cleanroom CPCs.

The AeroTrak 9001 Cleanroom CPC is the most reliable choice, offering:

- Confident 24/7 operation
- Minimal maintenance
- High flow rates
- Ultra-low false count rates
- No contamination or chemicals introduced into the ultra-clean environment

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