



## A Basic Introduction to Clean Rooms

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A cleanroom is a controlled environment where products are manufactured. It is a room in which the concentration of airborne particles is controlled to specified limits. Eliminating sub-micron airborne contamination is really a process of control. These contaminants are generated by people, process, facilities and equipment. They must be continually removed from the air. The level to which these particles need to be removed depends upon the standards required. The most frequently used standard is the Federal Standard 209E. The 209E is a document that establishes standard classes of air cleanliness for airborne particulate levels in cleanrooms and clean zones. Strict rules and procedures are followed to prevent contamination of the product.

The only way to control contamination is to control the total environment. Air flow rates and direction, pressurization, temperature, humidity and specialized filtration all need to be tightly controlled. And the sources of these particles need to be controlled or eliminated whenever possible. There is more to a clean room than air filters. Cleanrooms are planned and manufactured using strict protocol and methods. They are frequently found in electronics, pharmaceutical, biopharmaceutical, medical device industries and other critical manufacturing environments.

It only takes a quick monitor of the air in a cleanroom compared to a typical office building to see the difference. Typical office building air contains from 500,000 to 1,000,000 particles (0.5 microns or larger) per cubic foot of air. A Class 100 cleanroom is designed to never allow more than 100 particles (0.5 microns or larger) per cubic foot of air. Class 1000 and Class 10,000 cleanrooms are designed to limit particles to 1000 and 10,000 respectively.

A human hair is about 75-100 microns in diameter. A particle 200 times smaller (0.5 micron) than the human hair can cause major disaster in a cleanroom. Contamination can lead to expensive downtime and increased production costs. In fact, the billion dollar NASA Hubble Space Telescope was damaged and did not perform as designed because of a particle smaller than 0.5 microns.

Once a cleanroom is built it must be maintained and cleaned to the same high standards. This handbook has been prepared to give professional cleaning staff information about how to clean the cleanroom.

## What is Contamination?

Contamination is a process or act that causes materials or surfaces to be soiled with contaminating substances. There are two broad categories of surface contaminants: film type and particulates. These contaminants can produce a “killer defect” in a miniature circuit. Film contaminants of only 10 nm (nanometers) can drastically reduce coating adhesion on a wafer or chip. It is widely accepted that particles of 0.5 microns or larger are the target. However, some industries are now targeting smaller particles.

A partial list of contaminants is found below. Any of these can be the source for killing a circuit. Preventing these contaminants from entering the cleanroom environment is the objective. It requires a commitment by everyone entering the cleanroom to make it happen. Professional cleaning personnel need to be aware of the importance of controlling contaminants. Strict procedures should be followed whenever entering or cleaning a cleanroom. Compromise is not acceptable when cleaning in a cleanroom.

## Sources of Contamination

This is a partial list of some of the commonly known contaminants that can cause problems in some cleanroom environments. It has been found that many of these contaminants are generated from five basic sources. The facilities, people, tools, fluids and the product being manufactured can all contribute to contamination. Review this list to gain a better understanding of where contamination originates.

### 1. Facilities

Walls, floors and ceilings

Paint and coatings

Construction material (sheet rock, saw dust etc.)

Air conditioning debris

Room air and vapors

Spills and leaks

### 2. People

Skin flakes and oil

Cosmetics and perfume

Spittle

Clothing debris (lint, fibers etc.)

Hair

### **3. Tool Generated**

Friction and wear particles

Lubricants and emissions

Vibrations

Brooms, mops and dusters

### **4. Fluids**

Particulates floating in air

Bacteria, organics and moisture

Floor finishes or coatings

Cleaning chemicals

Plasticizers (outgasses)

Deionized water

### **5. Product generated**

Silicon chips

Quartz flakes

Cleanroom debris

Aluminum particles

## **Key Elements of Contamination Control**

We will look at several areas of concern to get a better idea of the overall picture of contamination control. These are the things that need to be considered when providing an effective contamination control program.

**HEPA (High Efficiency Particulate Air Filter)** - These filters are extremely important for maintaining contamination control. They filter particles as small as 0.3 microns with a 99.97% minimum particle-collective efficiency.

**CLEANROOM ARCHITECTURE** - Cleanrooms are designed to achieve and maintain a airflow in which essentially the entire body of air within a confined area moves with uniform

velocity along parallel flow lines. This air flow is called laminar flow. The more restriction of air flow the more turbulence. Turbulence can cause particle movement.

**FILTRATION** - In addition to the HEPA filters commonly used in cleanrooms, there are a number of other filtration mechanisms used to remove particles from gases and liquids. These filters are essential for providing effective contamination control.

**CLEANING** - Cleaning is an essential element of contamination control. Decisions need to be made about the details of cleanroom maintenance and cleaning. Applications and procedures need to be written and agreed upon by cleanroom management and contractors (if used). There are many problems associated with cleaning. Managers need to answer the following questions before proceeding with any cleanroom cleaning program:

1. What is clean?
2. How is clean measured?
3. What cleaning materials can be used in the cleanroom?
4. When can the cleanroom be cleaned?
5. How frequent does it need to be cleaned?

**CLEANROOM GARMENTS** - The requirements for cleanroom garments will vary from location to location. It is important to know the local garment requirements of the cleanroom management. Gloves, face masks and head covers are standard in nearly every cleanroom environment. Smocks are being used more and more. Jump suits are required in very clean environments.

**HUMANS IN CLEANROOMS** - There are both physical and psychological concerns when humans are present in cleanrooms. Physical behavior like fast motion and horseplay can increase contamination. Psychological concerns like room temperature, humidity, claustrophobia, odors and workplace attitude are important. Below are several ways people produce contamination:

1. **Body Regenerative Processes**-- Skin flakes, oils, perspiration and hair.
2. **Behavior**-- Rate of movement, sneezing and coughing.
3. **Attitude**-- Work habits and communication between workers.

People are a major source of contamination in the cleanroom. Look at the people activities listed below. Notice the number of particles produced per minute during these activities.

PEOPLE ACTIVITY	PARTICLES/MINUTE (0.3 microns and larger)
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Motionless (Standing or Seated)	100,000
Walking about 2 mph	5,000,000
Walking about 3.5 mph	7,000,000
Walking about 5 mph	10,000,000
Horseplay	100,000,000

**COMMODITIES** - Care is taken when selecting and using commodity items in cleanrooms. Wipers, cleanroom paper and pencils and other supplies that service the cleanroom should be carefully screened and selected. Review of the local cleanroom requirements for approving and taking these items into the cleanroom are essential. In fact, many cleanroom managers will have approval lists of these types of items.

**COSMETICS** - Many cosmetics contain sodium, magnesium, silicon, calcium, potassium or iron. These chemicals can create damaging particles. Cleanroom managers may ban or restrict cosmetics in the cleanroom. This is usually dependent upon the threat to the product being made in the cleanroom. A recent mirror on a space telescope was fogged up from the cologne that was present in the cleanroom.

**MEASUREMENT AND INSTRUMENTATION** - Some important measurements related to contamination control are particle count, air flow & velocity, humidity, temperature and surface cleanliness. Cleanroom managers usually have specific standards and/or instruments to measure these factors.

**ELECTROSTATIC DISCHARGE (ESD)** - When two surfaces rub together an electrical charge can be created. Moving air creates a charge. People touching surfaces or walking across the floor can create a triboelectric charge. Special care is taken to use ESD protective materials to prevent damage from ESD. Cleaning managers should work with their personnel to understand where these conditions may be present and how to prevent them.

## Cleaning Procedures for Clean Rooms

What follows are some recommended procedures for cleaning cleanrooms. It is important to emphasize that these procedures are guidelines and not standards or rules. The procedures listed here are routine cleaning tasks. Local cleanroom cleaning procedures may supercede the ones listed here. It is important for cleaning managers to review all cleaning procedures to be used in a cleanroom with the cleanroom management. A detailed cleaning schedule should be prepared for every cleanroom. Here are some procedures to be completed when cleaning a Class 10,000 cleanroom:

### Cleaning Procedures for a Class 10,000 Cleanroom

Housekeeping maintenance of the cleanroom and restricted areas is essential to assure quality. Cleaning of a cleanroom should be performed on a daily basis. Improper cleaning of

the cleanroom can lead to contamination and a loss in end user product quality. Proper selection of equipment and materials is important for proper cleaning. Only products that have proven cleanroom performance records should be considered for use in cleanrooms. These products should be listed and all vendors should be informed about the strict policies of how products are qualified. All procedures should be strictly enforced. Below are some examples of how to organize the cleaning to be done in a cleanroom. These are NOT schedules or exact procedures. They are guidelines for preparing work procedures and schedules. Local requirements must be included in any cleaning program.

### List of Some of Equipment and Supplies Needed to Clean the Cleanroom

(All supplies must meet the Class 10,000 minimum requirements)

1. Cleaning and disinfecting solutions
2. Cleanroom mops
3. Cleanroom vacuum cleaner (if allowed)
4. Cleanroom wipers
5. Cleanroom mop bucket and wringer

### List of Cleaning Tasks to be Completed in the Cleanroom

(Frequency may vary depending upon local requirements)

1. Cleaning of all work surfaces in the controlled environment.
2. Vacuuming (if allowed) of the floors and work surfaces.
3. Emptying of appropriate trash and waste.
4. Cleaning of the doors, door frames and lockers in the area and gowning areas using the approved cleaning solution.
5. Mop gowning and cleanroom floors.

### Cleaning Procedures for a Class 1000 Cleanroom

Below is a sample of a cleaning program in a Class 1000 Cleanroom. This is only a sample of a program. Local standards and requirements must be followed.

Area	Description of Work	Frequency
101	Change tacky mats	Every 2 hours

102	Wet mop with approved mop, cleaner & DI water	2 times per shift
103	Dust mop (if allowed)	2 times per shift
104	Remove trash, sweep, mop with appropriate cleaner wipe down tables and coffee area, clean walls and recycle cans	1 time per shift
105	Vacuum entry mats, sweep and mop floors	1 time per shift
106	Mop floor with pre-burnish cleaner and tap water	1 time per shift
107	Remove trash. Always wear gloves. Never take waste containers inside cleanrooms.	1 time per shift
108	Wet mop floors	1 time per shift
109	Remove acid and solvent trash	1 time per shift
110	Clean and replenish dispenser in all restrooms	3 times per week
111	Vacuum floor (if allowed)	2 times per week
112	Clean stainless steel pass throughs with s/s cleaner and appropriate wipes	1 time per week

The list above is a sample of some of the common tasks that need to be performed in a Class 1000 cleanroom. The list is not exhaustive. But gives some ideas of how to prepare work schedules and procedures. An assessment of the cleanroom in conjunction with cleanroom management will help define these tasks and frequencies.

### Cleaning Procedures for a Class 100 Cleanroom

<b>Zone</b>	<b>Procedure</b>	<b>Frequency</b>
Zone 1a	Trash removal	Once daily
	Mop walkways	Once a week
	Wipe down horizontal surfaces	Once monthly
Zone 1b	Pull tacky mats	Every 2 hours
Zone 1c	Mop and trash removal	Once daily
	Wipe down walls and trim	Once a week
Zone 1d	Mop and trash removal	Once daily
	Wipe walls and trim	Once a week
Zone 2a	Mop	Twice a shift
	Wipe walls and trim	Once a week

	Vacuum	Once monthly
Zone 2b	Mop and trash removal	Once per shift
Zone 2c	Wipe down walls, windows, doors, trim, showers, passthroughs and fire extinguishers.	Once a week

The list above is a sample of some of the common tasks that need to be performed in a Class 100 cleanroom. The list is not exhaustive. But gives some ideas of how to prepare work schedules and procedures. An assessment of the cleanroom in conjunction with cleanroom management will help define these tasks and frequencies.

## General Cleanroom Regulations

Below is a list of general regulations recommended as a minimum for the successful operation of a cleanroom. All professional cleaning personnel should be aware and follow these regulations at all times.

1. All personal items such as keys, watches, rings, matches, lighters and cigarettes should be stored in the personal locker outside the gowning room.
2. Valuable personal items such as wallets may be permitted in the cleanroom provided they are NEVER removed from beneath the cleanroom garments.
3. NO eating, smoking or gum chewing allowed inside the cleanroom.
4. Only garments approved for the cleanroom should be worn when entering.
5. NO cosmetics shall be worn in the cleanrooms. This includes: rouge, lipstick, eye shadow, eyebrow pencil, mascara, eye liner, false eye lashes, fingernail polish, hair spray, mousse, or the heavy use of aerosols, after shaves and perfumes.
6. Only approved cleanroom paper shall be allowed in the cleanroom.
7. Approved ball point pens shall be the only writing tool used.
8. Use of paper or fabric towels are prohibited. Use of hand dryers equipped with HEPA filters are suggested.
9. Gloves or finger cots should not be allowed to touch any item or surface that has not been thoroughly cleaned.
10. Only approved gloves, finger cots (powder-free), pliers, tweezers should be used to handle product. Finger prints can be a major source of contamination on some products.
11. Solvent contact with the bare skin should be avoided. They can remove skin oils and increase skin flaking.

12. Approved skin lotions or lanolin based soaps are sometimes allowed. These can reduce skin flaking.
13. All tools, containers and fixtures used in the cleaning process should be cleaned to the same degree as the cleanroom surfaces. All of these items are a source of contamination.
14. NO tool should be allowed to rest on the surface of a bench or table. It should be placed on a cleanroom wiper.
15. Only cleanroom approved wipers are allowed to be used. The wipers must be approved for the Class of cleanroom being cleaned.
16. ALL equipment, materials and containers introduced into a sterile facility must be subjected to stringent sterilization prior to entrance.
17. NO ONE who is physically ill, especially with respiratory or stomach disorders, may enter a sterile room. This is a good practice in any cleanroom environment.

### **Personal Actions Typically Prohibited in Cleanrooms**

1. Fast motions such as running, walking fast or horseplay.
2. Sitting or leaning on equipment or work surfaces.
3. Writing on equipment or garments.
4. Removal of items from beneath the cleanroom garments.
5. Wearing the cleanroom garment outside the cleanroom.
6. Wearing torn or soiled garments.