

LIGHTING DESIGN – CLEANROOMS

WHAT, WHO, WHERE, HOW, WHY?

A DEMANDING ENVIRONMENT

- What is a Cleanroom?
- What do you have to be aware of when designing a Cleanroom?
- What is Particulate Matter?
- What is a Hepa Filter?
- What does the Classification system (Class 10, etc.) mean?
- What is Federal Standard 209E?
- What is the objective to using a Cleanroom?
- What is the key to cleanliness?
- What kinds of activities take place in a Cleanroom?
- Who are the players in the business?
- Who decides what class of room will be used?
- Who does the design and specification of the room?
- Who determines the requirements of a class? Of a Cleanroom?

WHAT IS A CLEANROOM AND HOW DO THEY OPERATE?

A cleanroom is a defined area of space in which the air has to be so pure that even invisible particles twenty times smaller than the eye can see have to be screened out. This is achieved through the creation of a shell including the floor, ceiling, walls and egress which is completely sealed off from the rest of the environment. The air in this shell or cleanroom is then regulated by high powered, advanced design H.V.A.C. (heating, ventilating, air conditioning) system. Air is exchanged as often as sixty times an hour, compared to six in the average office space. Everything in a cleanroom, including humidity, temperature, air-flow and balance is monitored and work together to create and maintain this cleanliness level. Equipment is constructed of non-shedding components and adds to the overall cleanliness of the room. All people who occupy the space wear special clothing designed to prevent particulation (shedding of any kind) and, in many instances, they pass through an air shower to further remove any microscopic particles. Semiconductor manufacturing is moving into the SUB-HALF-MICRON era. That means ONE HALF OF ONE MILLIONTH OF A METER! Particles of a few hundredths of a micron in size are like meteors in this environment and might cause circuit faults and product failure. This might bring one to ask: How clean is clean? **The average surgical operating room is three times dirtier than the dirtiest cleanroom.**

The need for this level of cleanliness arose over thirty years ago when NASA created white rooms which were designed to screen out dust during process of communication systems for aerospace. In the time since, almost every area of high tech manufacturing, as well as biotechnological research, animal containment and the fields of medicine and pharmaceuticals has begun to realize the benefit of cleanroom operation.

OBJECTIVES OF OPERATION IN A CLEANROOM:

- To maximize productivity: If the environment is not as clean as it needs to be, production cannot be achieved.
- To reduce rejection: When product failure begins, the room has a leak and contamination is entering from an undiagnosed source.
- To achieve unbiased experimentation: In a laboratory setting, airborne contamination can hamper test findings.
- To prevent contamination: In a micro setting, biological contamination can promote infection or worse.
- To increase product shelf life: Especially in food and beverage production.

Thus, if you ask who monitors the cleanliness levels in a cleanroom, the answer becomes apparent: the owners do. Product failure, biased test results, faulty research findings, shortened shelf life and bio-contamination can cost owners millions of dollars and create adverse publicity – problems owners will work very hard to prevent. As owners spend millions of dollars to create these high-tech environments, they know that their investments will pay for themselves in product yield, increased shelf life, reduced contamination risks and accurate research findings. When these standards of operation decline, so do profits. So, who decides how clean a room must be? The Federal Standards Bureau determined a classification system (Federal Standard 209E) for NASA. It determined that in order to achieve the goals of cleanroom operation, the number and size of potentially damaging particles would have to be regulated. Cleanrooms are designed to provide a CONTAMINANT FREE environment because any form of particulate matter – dust, spore, virus, bacteria, or mold – can

- Who monitors the continued class rating of the original Cleanroom?
- Who is affected when a Cleanroom fails to operate at its class rating?
- Who uses Cleanrooms?
- Where are the largest Cleanroom markets?
- Where did the Cleanroom start?
- How does lighting differ in a Cleanroom?
- How does lighting differ in a Cleanroom?
- How does a lighting fixture have the potential to destroy a Cleanroom's class ratings?
- How big are Cleanrooms?
- How do Cleanrooms achieve the standards necessary for class ratings?
- How clean are Cleanrooms?
- How big are the particles allowed to be?
- Why is it so important that a Cleanroom maintain its class rating?
- Why do companies use Cleanrooms?

destroy the productivity of the cleanroom. Cleanrooms are classified according to the number and size of particles found in a given cubic foot of space once the room becomes operational. The number of particles will determine the class of the room. Thus, a Class 1 room will allow ONE micron-sized particle per cubic foot. A Class 100 will allow one hundred particles, and so on, to Class 100,000.

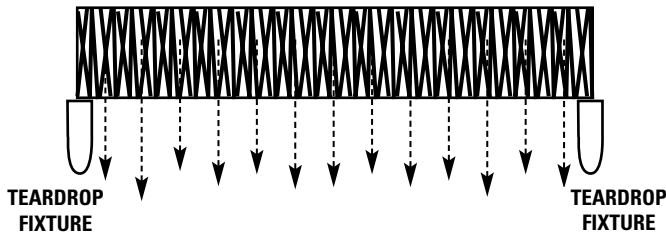
In order to achieve a Class 1 Class 10 level, laminar air flow is incorporated into the design of the cleanroom. Laminar flow moves all air in a vertical or horizontal pattern. With vertical laminar flow, the entire ceiling system consists of High Efficiency Particulate Air (HEPA) filters or Ultra Low Penetration Air (ULPA) filters that screen out 99.995% to 99.999% of the particles. All incoming, purified air moves in a vertical pattern through the ceiling, down to a raised, ducted floor and back up through the outer walls. With horizontal laminar flow, the same principle works in a horizontal pattern with filtered walls. Laminar flow is highly used in the semiconductor and electronics industries where wafer chips and circuit boards are so tiny that one micron of dust can destroy production. As the process in the cleanroom grows less critical, greater quantities of the invisible particles may be present without risk. Thus, the class of cleanroom is higher.

The major governing factor in designing a cleanroom is awareness of the activity in it. The process conducted in the cleanroom will determine all materials, type of airflow, component materials, and temperature. For example, certain cleaning solutions or food and beverage process areas will necessitate the use of a least 304 stainless steel on all exposed areas. Working in a photosensitive processing room may require the screening out of certain nanometers of light. Cleaning techniques might require that components be able to withstand high impingement hosedown spray. Each cleanroom process involves different design parameters based on the activity to be performed in the clean space. Even more challenging for the designer is that many times the activity remains classified.

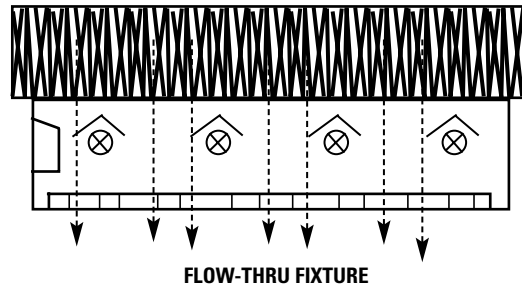
The international standard ISO 14644-1 has superseded the General Services Administration (GSA) standard FED-STD-209E to determine the amount of acceptable particulates for a cleanroom. The new ISO standard uses new designations, a metric measure of air volume and adds 3 additional classes. Both standards will be in use for about 5 years.

ISO 14644-1	STD 209E	STD 209E
ISO Class	English	Metric
1	—	—
2	—	—
3	1	M1.5
4	10	M2.5
5	100	M3.5
6	1,000	M4.5
7	10,000	M5.5
8	100,000	M6.5
9	—	—

HEPA FILTER



HEPA FILTER



A cleanroom's purchase and design will be conducted in a number of ways. Most Fortune 500 companies are exploring the use of cleanrooms in some form of their business. As outlined in the accompanying chart, most forms of technology already employ these rooms in their daily operations. Many of the larger companies will employ architectural and engineering firms to design and specify the cleanroom and all of its components. Other companies will purchase soft-wall and hard-wall, portable cleanrooms which can be transported from one sight to another. When designed the A&E way, sales forces who represent the component manufacturers will call on the architect and engineer to have their products specified. In many instances, owners are large enough to have their own design staff who will specify everything and then hire a cleanroom contractor for construction. Additionally, cleanroom manufacturers are companies who will design, purchase O.E.M. components and fabricate everything from portable, soft wall, hard wall and stick built, to permanent fixed cleanrooms. There are a number of players in the area. Manufacturer's representatives will sell everything from garments to lighting fixtures. Others will specialize in an area of the cleanroom, such as the ceiling system which would typically consist of a "T" grid system (1 1/2" to 2" in width), HEPA or ULPA filters, blowers and lighting fixtures in a 2'x4' grid configuration. Most often, room class is Federal Standard driven and owner enforced.

WHO USES CLEANROOMS?

Generally, any company who wishes to achieve the previously outlined objectives uses cleanrooms. Specifically, those companies who cannot afford product failure or biased research because of airborne contamination use them as well. For example, Kodak, Mitsubishi, BASF, Campbell Soup, AT&T, Searle, Eli Lilly, Allied Signal, Boeing, Texas Instrument, Kellogg, Baxter Travenol, Abbott Laboratories, Beatrice Foods, Motorola, Sony, Sandia all use cleanrooms, and the list goes on, including hospitals, universities, research facilities, dairies and medical device manufacturers. Cleanrooms and the need for contamination control have entered nearly every segment of the market. They are the future. They're here to stay, and they're getting even cleaner.

Once a room has passed its Class rating and becomes active, the owner will contract with outside certifying agencies to periodically test the cleanroom to make sure it meets its original rating. Ideally, a corporation will not have to call in one of these organizations because of a problem. Usually when trouble arises, micro-contamination has entered the clean space from a violation of the cleanroom shell that has allowed outside air into the cleanroom. Two of the biggest culprits to this violation are lighting fixtures and HEPA filters.

LIGHTING THE CLEANROOM

In a non-laminar flow cleanroom, recessed lighting fixtures, in a grid or flange configuration, penetrate the ceiling shell. Even surface mounted fixtures, while substantially reducing the size of the opening, still require conduit entry ports. When installed, they must re-seal the shell. This means that the housing, which is exposed to the plenum, must be sealed to prevent contamination during re-lamping and fixture maintenance. During operation, the fixture's door frame must seal to the housing, and the lens medium must seal to the doorframe, thus providing a 3 way seal. Seams, penetrations, and gaps between parts, even if sealed, provide potential storage areas for contamination and also must be reduced to as few as possible. Thus, cleanroom lighting fixtures have to be designed and constructed for cleanroom use, to forbid air passage and prevent contamination. Adequate illumination (80fc on the work surface) from a totally sealed fixture is a must.

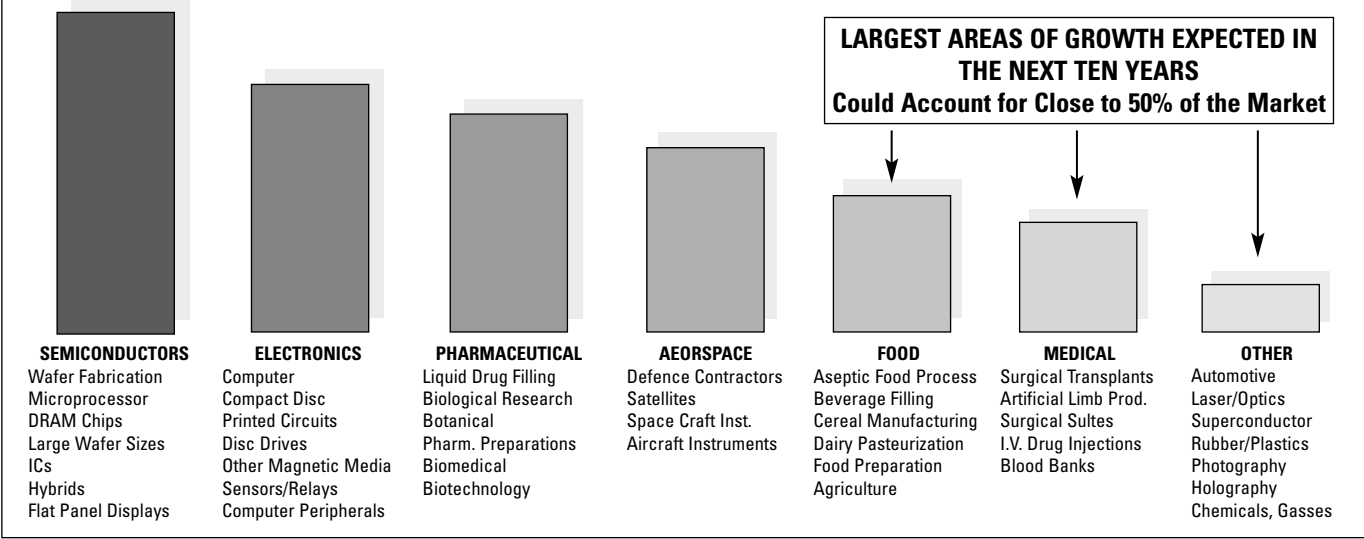
In a laminar flow setting, the entire ceiling system is comprised of HEPA filters. In order to achieve and maintain a Class 10 or cleaner rating, necessary for success in the semiconductor industry, the HEPA filtered air cannot be interrupted with turbulence that will interrupt the vertical or horizontal flow. In these rooms, lighting fixtures come in two varieties. The first is called a teardrop and mounts to the "T" grid. Its lens is shaped like an airfoil and contributes to the laminar flow in the room. The second is called a "flow-through," and mounts under the HEPA filter and allows the clean air to pass through it. Design preferences will determine which of these laminar flow fixtures works best in the setting.

Once again, the activity in the cleanroom will determine component parts of the lighting fixtures. In food processing areas, for example, stainless steel on all exposed parts might be a requirement. In an animal containment facility where cleaning is a daily occurrence, a lighting fixture may have to withstand high impingement hosedown. In photosensitive areas, amber lensing may be needed to screen out certain nanometers of light. In addition to designing a lighting fixture for the cleanroom environment where particulation and outside air passage cannot take place, manufacturers have to be ready and willing to make modifications to existing fixture designs to accommodate the special requirements of this demanding environment.

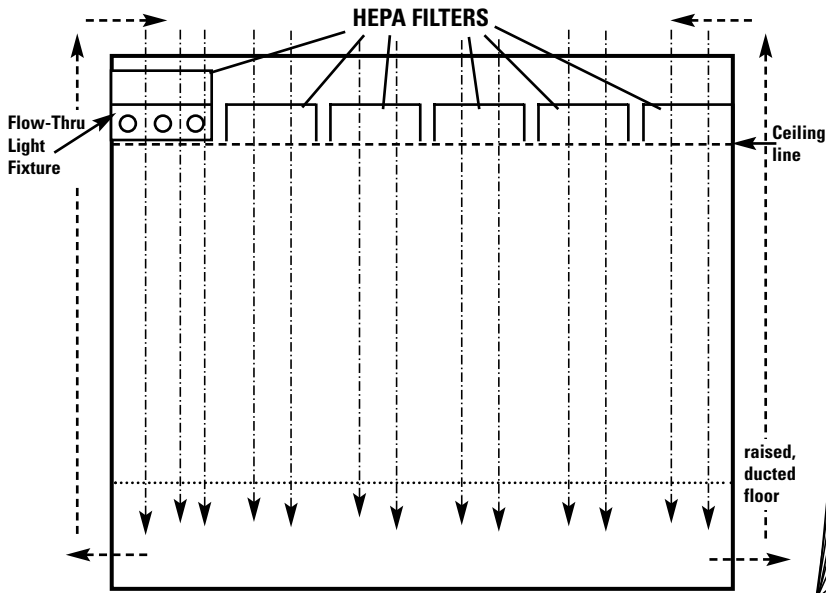
When an architectural or engineering firm designs a cleanroom, components will be specified by manufacturer name and catalog number. Cleanrooms are demanding enough environments that most engineers will not tolerate substitutions and will do a thorough process of choosing what they want during the specification process.

The next time you look at the expiration date on the cream at your local grocery store, you might notice one or more brands with dates longer than two months from now. It's called "ultra-pasteurized," and because it was processed in a cleanroom environment, the shelf life extended from two weeks to two months. As you pop a compact disc into your player, remember that it was probably made in a cleanroom. When you hear headlines of genetic research's latest advancement and the suffering it will eliminate, know that the discovery was made in a cleanroom. If you wonder whether these rooms are just a passing fad, think again. No area of advancement will take place without facilities for the research testing and manufacture of the future; facilities called CLEANROOMS.

A MARKET BREAKDOWN: LARGEST USERS OF CLEANROOMS

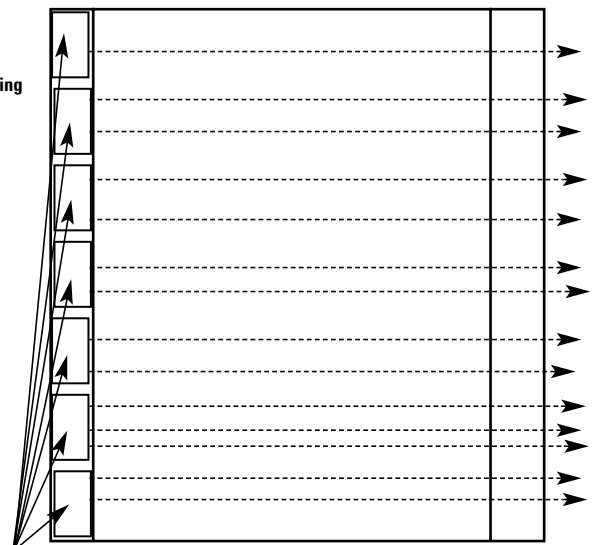


VERTICAL LAMINAR FLOW



OUTER CLEAN ROOM SHELL

HORIZONTAL LAMINAR FLOW



HEPA FILTERED WALLS--AIR MOVES HORIZONTALLY