Standards for clean room maintenance

Introduction

Clean rooms are rooms that are designed specifically to manufacturing or scientific research. It is a room in which level of pollutants such dust, microbes and chemical vapours are kept low. Clean rooms are specified to have a controlled level of contaminants which is the number of particles per cubic meter. Clean rooms are used in industries where small particles such as bacteria, can affect the product that is being produced by the manufacturer. It is a confined area where supplies are made to minimise contamination and control temperature, humidity, and pressure. To eliminate contamination in the air, workers are given the appropriate equipment to use to prevent the scattering of contamination that came from the workers' clothing. Other than Proper Protective Equipment that is provided to the workers, High Efficiency Particulate Air (HEPA) filter is the main constituent that is used to trap particles that are 0. 3 micron or larger in size. All the air brought to the clean room passes through HEPA filters, and in incidents where demanding cleanliness performance is obliged, Ultra Low Particulate Air (ULPA) filters are used. They go in and out of the clean rooms through airlocks, air shower or gowning rooms.

Clean room technology is divided into three areas, design and construction, clean room testing and monitoring, and cleanroom operations. The standard of the design to be used must be considered, the layout and construction materials must be implemented, and ways the services should be granted to the cleanroom. The cleanroom must be inspected to guarantee it conforms to the design after its installed. During the life of the cleanroom it must be observed to determine that it reaches the specific requirements. The clean

room must be controlled to ensure manufactured products are not contaminated which includes the entry of people materials, and the gowning selection. Cleanroom disciplines and the cleaning of the room are all rightly carried out. There are many technologies that are used to “ disinfect and sanitise” clean rooms, such as the:

- Isolator technology: are used in industries from 2010 onwards as it is said to provide the best level of protection, as it has a separated environment to prevent contamination during production. Although isolators can prevent contamination, it is still possible to have microbes present in isolators as the FDA had stated that good manufacturing practice such as aseptic procedures has not been done properly.

- Restricted Access Barrier Systems or RABS: are like Isolators but this technology protects products from contamination as it consists of physical and aerodynamic barrier. RABS also differ from isolators as it contains screen barriers and High Efficiency Particulate Air (HEPA) filters.

There is a standard in situ that has recently been published and being followed for clean rooms. The standards are prepared by experts who had worked in many fields. The standards is a set of guidelines that has undergone a five-year review and some sections are currently still being written. Some of the clean room standards that are currently being followed are found in the table in Appendix 2.

Content & Analysis

A cleanrooms function is to prevent contamination of a product. A products chances of approval are based on its standard of safety and quality. New complex technologies require better cleanroom standards. Temperature, humidity, pressure, and cleanness all affect air quality. ULPA or HEPA air filters change air multiple times per hour help clean the air.

Cleanrooms are distinguished by the way air is ventilated. These are unidirectional flow and turbulently ventilated cleanrooms. The unidirectional cleanroom gives better cleanliness due to its use of more air. In a turbulently ventilated cleanroom, air moves around in a random, turbulent way. There is between 10 and 100 air changes per hour and only between 2% and 10% of the air is fresh. The cleanliness of a turbulently ventilated cleanroom can be found using the equation: Number of particles generated / min Air volume supplied (m^3 / min)

. The number and placement of air suppliers is important to ensure good air mixing. Airflow must always flow from the cleanroom to less clean areas by having the cleanroom have higher pressure than the adjacent areas. Airflow can be tested using smoke. Unidirectional airflow can either be vertical or horizontal and speed is usually between 0. 3 and 0. 5 m/s. In the vertical airflow, air is supplied from a bank of filters in the roof. It exits through the floor, is mixed with fresh air and recycled. If there are any obstacles in the cleanroom, airflow can turn into turbulent airflow. In a horizontal airflow, the air flows across the room and returned through the air filters which gives increased contamination risk. A ballroom cleanroom is very large floor area and a high ceiling.

High Efficiency Particulate Air (HEPA) filters give an efficiency of 99. 97%. The Ultra-Low Penetration Air (ULPA) filter gives an efficiency of 99. 999%. For ISO class 4 cleanrooms and lower, ULPA filters are required. HEPA filters are suitable for all others. Filters are made either deep-pleated or mini-pleated. With deep-pleated, rolls of filter paper are folded back and forth beside each other with 15-30cm gaps. And aluminium foil sheet is used as a separator and attached to a frame. An aluminium sheet is not used in mini-pleated filters and allows 3 times more pleats than the other method. Filters should be replaced if air pressure reaches 3 times the regular amount in the room. Filters are designed to remove particles of 2 µm and the filtration medium is made up of glass fibres. ULPA filters use a higher proportion of these than HEPA filters. As particles move through the filter, they bump into the fibres. Four ways of retaining particles are diffusion, impaction, interception and screening. In diffusion, particles move randomly which may or may not be captured by the fibres. In impaction, particles with enough momentum can leave the gas stream and hit a fibre. Interception is when a particle hits a fibre as it passes and is captured. Screening is when particles are caught between the gaps in the fibres.

The Methods for cleaning a cleanroom include wet or dry vacuuming, wet wiping, and swabbing. Dry vacuuming involves a jet of air that can removes the particles from the surface. Water has a high viscosity and increases the number of particles that can be collected if using wet vacuuming. Wet wiping allows particles to float off surfaces, and a mop is required to remove any excess. Dry brushes should never be used as they contain millions of particles. Dry vacuuming is popular as it is cheap and needs no extra

materials, however wet-vacuuming is more efficient. When mopping and using a disinfectant, the 2 or 3-bucket system is put in place as the waters contamination could reduce the disinfectants effectiveness. One bucket is filled with the disinfectant, the second bucket is for removing waste water and the third is filled with clean water. A swab can be used to remove dirt from small hard to reach areas within machines and other areas

The ideal cleaning solution for a cleanroom would be one that is non-toxic, non-flammable, fast-drying, and leaves no contamination. No one solution has all these properties and multiple solutions must be used in conjunction for full cleanliness. Alcohol is suitable for use as it is good for removing bacteria and leave no residue.

Areas that are interacted with more often will need to be more thoroughly cleaned due to contamination from personnel. Horizontal surfaces will also require more attention than vertical surfaces due to how gravity settles particles. Cleaning crews should start by dry vacuuming to remove large contaminants first. Cleaning should also be started furthest from the door and gradually move toward the exit to prevent recontamination. Cleaning staff should be given the same clothing and gloves as production personnel and air-conditioning should always be on. The most effective cleaning methods should be used in the areas that require the least number of particles, this is known as the critical area. The least effective methods should be used in the more general areas. Cleaning should always be done slowly and methodically. The cleanliness of a cleanroom can be tested using certain methods. This testing gives info and can be used to determine how a cleanroom gets contaminated and how quickly it does so. A UV light can be

shined on surfaces to reveal fluorescent particles. Tape can be applied to a surface and then particles stuck to the underside can be counted under a microscope. A damp black wipe could be drawn over the surface and it might be possible to view any particles that came up.

Cleanroom standards are produced by the International Organization for Standardization (ISO). There is also The Federal Standard and the Pharmaceutical standards, but these are not as widely used. The ISO standards are written by experts nominated from countries all over the world. ISO 14644-1 gives the cleanroom classification method which is based on the equation = 10 N x [0 . 1 D] 2 . 08

. Cn is concentration of particles in the air, N is the classification number and D is the particle size. ISO Class 1, which is the cleanest required classification requires no more than 2 0. 2µm sized particles and no more than 10 0. 1µm particles and none larger than that. The standard mentions that cleanrooms have different amounts of particles at different levels of production and classification should be carried out at all states. The states are as built, where there is no equipment, At-rest where there is equipment but no productions and operational, where work is being done by personnel. ISO 14644-1 includes a method for specifying a cleanroom using particles outside the size range Ultrafine (<0. 1µm) particles are important in the semiconductor industry and macroparticles (> 5µm) are of use in other industries. ISO 14644 mentions the classification of air cleanliness which gives limits on airborne particles in different standard cleanrooms and methods of testing this. It then mentions info on testing and monitoring a cleanroom to ensure it conforms with ISO standard 14644-1. It then

describes methods for testing the cleanroom, followed by information on how a cleanroom should be designed and constructed, then general advice on running a cleanroom. A list of the terms used in the ISO standards is given and is followed by information on clean air devices. The final section gives info on gaseous contamination. ISO 14698 involves info on biocontamination control. The first section gives information on establishing methods for measuring micro-organisms. The second section gives information interpreting results gotten from measuring micro-organisms.

Conclusion & Recommendation

In conclusion, Cleanrooms have certain criteria that need to be met to be classified in different ways. Different classifications are needed depending on how complex the manufactured product is. For example, a semiconductor manufacturing cleanroom requires an ISO Class 1 cleanroom. HEPA filters were useful until the 1980s and still are today for lower ISO class cleanrooms but ULPA filters are superior and are much more efficient which is why they are used in most ISO class cleanrooms.

In terms of airflow, both turbulently ventilated and unidirectional airflow both have their merits, but unidirectional is the better airflow. Turbulently ventilated airflow is too random and can cause increased risk of contamination. As for unidirectional airflow, vertical airflow is better than horizontal airflow in most situations. There is an increased contamination risk with horizontal airflow. The way the cleanroom is designed is also important in keeping it sterile. Cleanrooms have round corners to prevent dirt from

accumulating and making the corners easier to clean, decreasing the possibility of products being contaminated.

When it comes to cleaning the cleanroom, all methods should be used in conjunction with one another, however, the standout method would be wet vacuuming as it removes a higher number of particles from surfaces than dry vacuuming, which should be used for larger particles and as preparation for the rest of the cleaning. The best disinfectant to use by far would be pure alcohol as it is good for removing bacteria and leave no residue.

Between the ISO standard, The Federal Standard and Pharmaceutical standard, ISO is the mostly widely used and is the most extensive, descriptive and cohesive standard. The biggest source of contamination in a cleanroom is the production personnel themselves that is why the practice of wearing masks and gloves and full cleanroom suit is so important.

A limitation in the filters is the amount of filter paper that can be fit into the filter frame. The frames could be made bigger but then there is a weight and space issue. As time goes on filter technology will become more advanced and efficient.

As of right now, the standard for cleaning the cleanrooms is probably the best cleaning methods that will be found, there may be technology in the future that will allow for easier sterilisation and cleaning but in the present, a mop and bucket and a vacuum, is the best way to sterilise a room, and it does get the job done to an acceptable degree.

HEPA filters were state of the art in the 1980s, ULPA filters took over from that, it is more than likely that some new filter will become the standard within the next few years, capable of filtering more air than an ULPA filter at a fraction of the cost, and if this new filter does become popular, the ISO classification system will have to change to accommodate the new higher efficiency.

APPENDIX

1

APPENDIX

2

Table 1 showing the clean room standards that are currently being used.

ISO 14644-1: 1999 – Part 1: Classification of air cleanliness – this standard had replaced the Federal Standard

209E. This standard classifies the size of the particle. Particles that are less than 0. 1 microns and

ISO 14644-5: 2005 – Part 5: Operations – has a specific

requirement for operations on a clean room. It states that Annex A is required to undergo risk assessment	
ISO 14644-8: 2006 – Part 8: Classification of airborne	

molecular contaminat ion – this standard state that airborne contaminat ion is classified in means of the concentrati on of the chemicals that are found in the industry. It was later decided that chemical contaminat ion should be included in the

standard

(European Pharmaceutical Review, 2018.)

References

- W. Whyte. (2001). Cleanroom Technology. *Fundamentals of Design, Testing and Operation* [online], (312). Available from: https://phongsach. files. wordpress. com/2010/04/clean_room_technology_whyte_2001. pdf[accessed 17 th October, 2018].
- Kitain, M. (2010). Cleanrooms in Pharmaceutical Production. Bachelor's thesis Building Services [online], (39). Available from: https://www. theseus. fi/bitstream/handle/10024/13196/Kitain_Mikhail. pdf[accessed 17 th October, 2018].
- CLEAN AIR TECHNOLOGY, INC. (2018). *What is a cleanroom?* [online]. Available from: https://www. cleanairtechnology. com/cleanroom-classifications-class. php[accessed 17 th October, 2018].
- European Pharmaceutical Review. (2018). *Cleanroom Standards* [online]. Available from: https://www. europeanpharmaceuticalreview. com/article/2430/cleanroom-standards/[accessed 17 th October, 2018].