**Introductory Neuroscience and Neuro Instrumentation**
**Indian Institute of Science, Bengaluru**
**Lecture No. 16**
**Introduction to Cleanroom Protocols and Demonstration of Gowning Procedure**

Hi, welcome to this module. In this module, we will look at the introduction to the cleanroom. Now earlier modules what we have seen an introduction to Fab lab where you kind of I have discussed with you about what are the equipment within the Fab lab and what kind of application we could think of if you already know how to fabricate a device or in another way if you know the fabrication technology.

Now when we talk about cleanroom it is not just the room which is clean, but also there are some standards like how many particles in a cubic area or cubic feet should be there, what are the size of this particle and depending on certain factors the cleanrooms are divided into class 1, class 10, class 100, class 1,000, class 10,000 and so on. So, we will be looking at the cleanroom in this module that is how the cleanroom can be defined.

We will also look at the possible contaminants in the cleanroom. We will look at the protocols of how to enter a cleanroom lab we will be showing you a recorded lecture from my lab which shows how a person or an engineer or scientist when he or she wants to enter the laboratory what kind of protocols one has to follow. So, with this particular thing in mind let us see this particular module.

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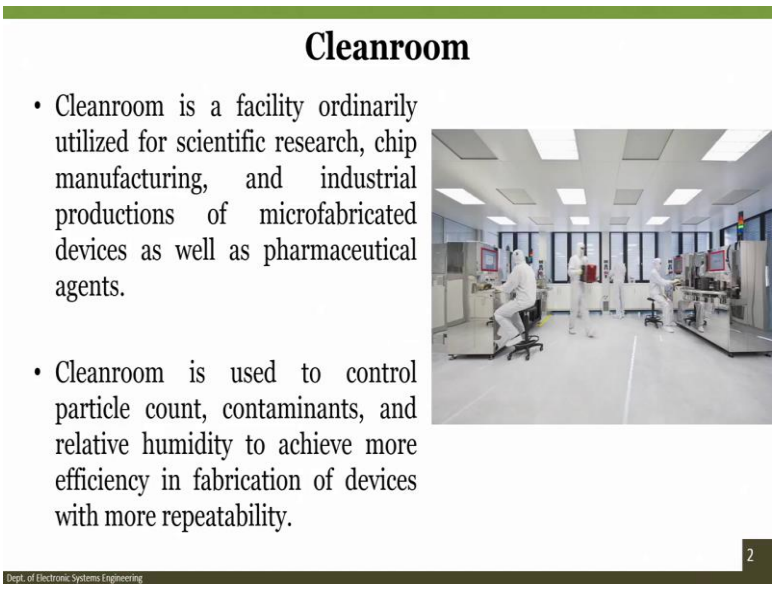

Like I said when we talk about cleanroom facility, cleanroom facility is ordinarily utilized for scientific research, chip manufacturing, and industrial productions of microfabricated devices as well as pharmaceutical agents. You can see a photo of a cleanroom with this class 1,000 cleanroom and like we discussed that a PPEs needs to be in place and needs to be a person has to wear it before working in a cleanroom environment.

So, what is a requirement of cleanroom another requirement of the cleanroom is let us say you fabricate a chip on a silicon wafer and if there is dust on this chip there will be millions of transistors and the size can anywhere from few nanometers to a few micrometers size of this transistors. So, when I say nanometer does not mean the size of the transistor it means the channel length.

But the overall device would be extremely tiny and that is why you have millions of transistor on a small 1 millimeter by 1-millimeter chip, but if a particle size 0.5 microns sits on this particular chip it looks like this that means that 0.5-micron particle would kill a lot of transistors from your silicon chip or on your silicon chip. Same thing when you developed a drug in a pharmacy you need to make sure that the drug is free of any contaminants.

And that is why generally pharmaceutical industries as well as industries related to chip manufacturing like Intel, TI, Qualcomm when they go for fabrication they use a cleanroom environment. Now you must be having a question that why we are required to understand cleanrooms in the introduction of neuroscience. The reason is that we can fabricate electrodes that can be used for measuring EEG signals using the cleanroom facility. And when I say cleanroom facility that means several equipment within the cleanroom including the environment of the cleanroom.

So, that is why it is important to learn the cleanroom, the cleanroom protocol, and the equipment within the cleanroom, and then we will show you how to utilize this equipment for fabricating a patch electrode that can be used for not only measuring EEG, but also to measure EMG signals. So, the cleanroom is used to control particle counts, contaminants, and relative humidity to achieve more efficiency in the fabrication of devices with better repeatability.

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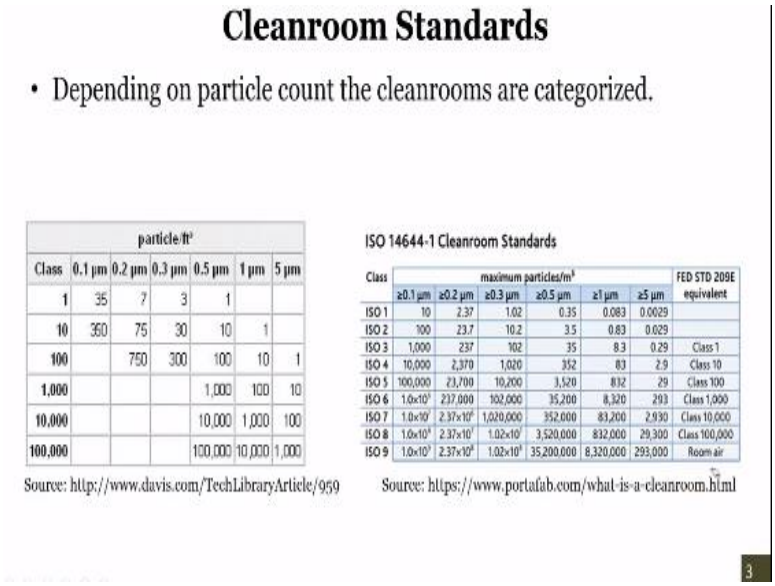


Depending on the particle count that cleanrooms are categorized into several classes as I said from class 1 to class 10,000. If you talk about class 1 then particle per cubic feet there would be 0.1 microns 35 particles 0.2 microns 7, 0.3 microns 3, 0.5 microns 1 and 1 micron and 5-micron particle would be none. Same thing if you go for class 10, class 100, class 1,000 that means in cubic feet particle per cubic feet that means it is extremely clean.

Also generally when a chip manufacturing I will show you one of the videos that are a robotic arm and robotic system that does the process that entire thing is covered but to control those particular semi-automatic systems we require a Fab engineer. So, it is more like for the personal rather than for the equipment because the equipment is within that casing where already the environment is maintained.

So, if you see class 10, class 100, class 1,000 then the number of particles would change in 1,000, 10,000, and 100,000 these particles would present so we have not written anything it will be there, but 0.5 microns, 1 micron, and 5-micron particle will be in this particular values. You may be able to understand that how many particles are there generally in an environment if you open your window in the morning.

And if there is sunlight coming entering a window you will be able to see a lot of particles floating. So, generally, that is what are the particles. Anyway, the point is we can also classify the cleanroom based on the ISO standards. So, according to ISO cleanroom standard cleanroom are classified right from ISO 1 to ISO 9. Again class 1 falls in ISO 3 and class

100,000 falls in ISO 8 while general room air is ISO 9. So, these are the standards this is just for your information.

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Now how this cleanroom environment is maintained. So, there is a filter called High Efficiency Particulate Air or HEPA. So, HEPA filter or High Efficiency Particulate Air filter is one of the most important components as it absorbs particles at the air inlet of the cleanroom. These supplies filtered air throughout a cleanroom to maintain temperature, pressure, and humidity with circulating airflow.

Additionally, along with HEPA filters cleanroom also has air showers and this is implemented between the cleanroom and outside environment at the entrance. So, let us say the person standing here when he enters the cleanroom if there is an air shower here then it will help to maintain the environment from outside to the inside of the cleanroom. Air shower bombards the person with a flow of filtered air to dislodge particles and foreign objects from hair, skin, and clothing.

So, the point is anything on your clothes or if the hair is there or any dust on the skin is there this bombardment of the air shower will help to filter that or dislodge that particular particle.

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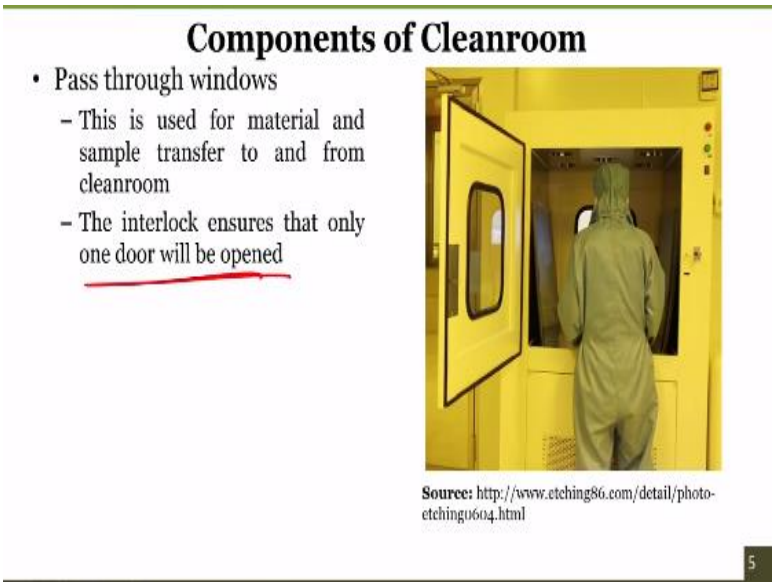


Then there are pass-through windows so that means that a person does not have to come inside, but can pass the device or footraces or any other component through this particular pass-through window. So, there is a person this person is inside the cleanroom while there is another person outside the cleanroom and these pass-through windows are used in a way that first lets us say this window is closed, this window is closed.

And the window that you can see here is opened then the person will keep whatever components are there then this particular window is closed and this one is open and anywhere within the cleanroom will take the component from the box or pass-through window. After taking that particular box he will or she will close the window. This is an easy way because then the person who outside does not have to wear the entire PPE.

PPE stands for Personal Protective Equipment or personal protective equipment and it consists of from your gown, shoe cover, hair cover, gloves then we have the wear protection, we have the glasses so this consists of all this stuff. Like I said the interlock ensures that only one door will be opened at a time.

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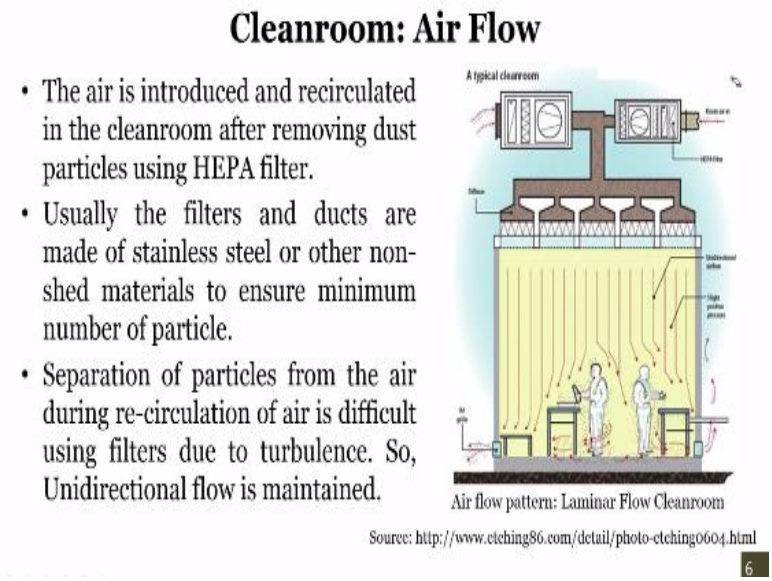


So, how the airflow occurs in a cleanroom? You can say that a typical cleanroom is there, there is a room air in, there is a HEPA filter as typical cleanroom this is how the infrastructure is and you can see that there is a slight positive pressure and there is a unidirectional flow and this goes out of the cleanroom. So, the air is introduced and re-circulated in the cleanroom after removing dust particles using HEPA filters.

Usually, this filter and ducts are made up of stainless steel or other non-shed material to ensure a minimum number of particles. Separation of the particles from the air during re-circulation of air is difficult using filters due to turbulence so unidirectional flow is maintained.

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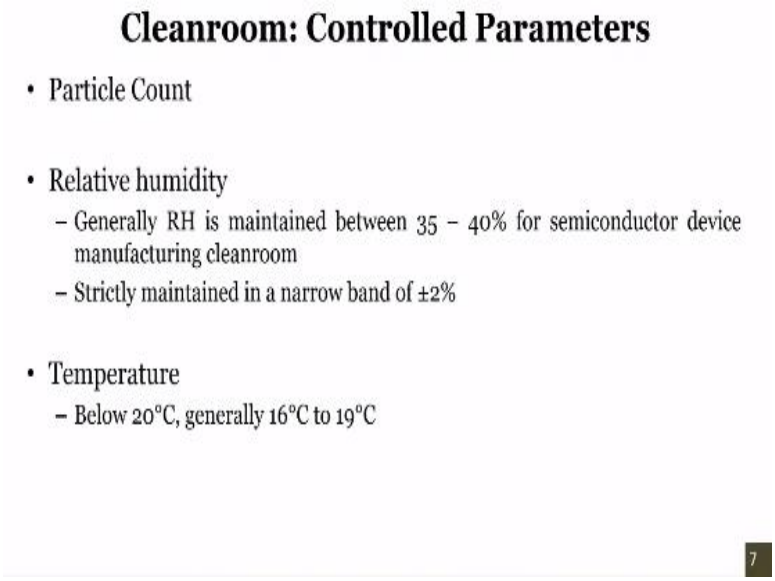


So, what are the control parameters number of particles, relative humidity generally it is between 35 and 40 and it is maintained with a very narrow band of ± 2 percentage. The temperature is below 20 degrees and generally, it is between 16 and 19 degrees centigrade.

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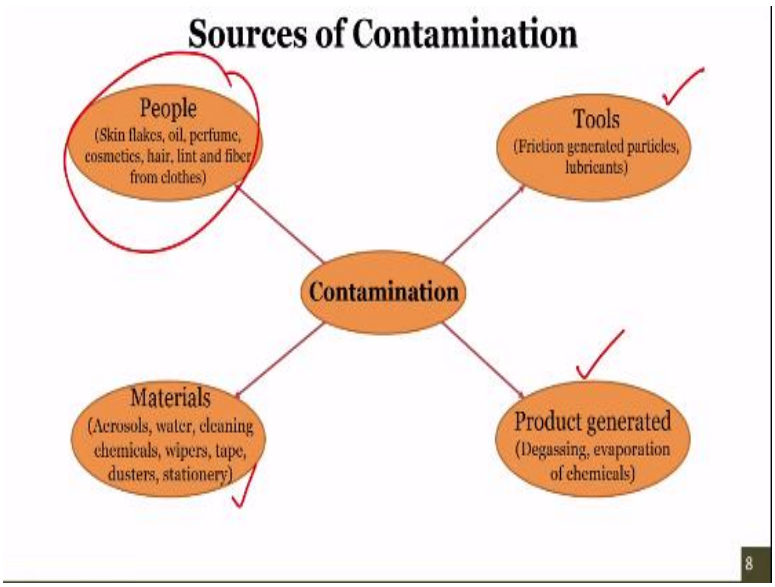


So, what are the sources of contamination? The sources of contaminations, in general, can be divided into 4 types, tools that are fabrication generated particles lubricants or friction generated particles lubricants. The second one is a product generated that is degassing, evaporation of chemicals. The third one is material which is aerosols, water cleaning chemicals, wipers, tapes, dusters, stationary this all causes contamination.

And final and the most important contamination is through the personal working inside the cleanroom. These are from the skin, flakes, oil, perfume, cosmetics, hair, lint and fiber from clothes, and so on. To reduce this generally, the PPE can be taken care of it. However, it is advised not to use any cosmetics particularly when you are working with a cleanroom. Perfume is we should not wear any perfume and if you are wearing the PPE then probably the contamination because of the personal work in the cleanroom would be less.

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So, these are the following items that are not permissible inside the cleanroom. Normal paper, pencil and fabrics from natural fibers. Wearer wet, dirty and dusty clothes and loose clothes and dangling jewellery. You see this is a very loose cloth the reason for not wearing a loose cloth and to wear a proper fitting cloth is that your cloth will not get entangled while working in a cleanroom.

Dusty cloth for sure because of the dust that can fall it is not allowed. Stationary and paper will also leave the fiber that causes the contamination in the cleanroom then wet clothes are not allowed. Jewellery is not allowed because while you operate the system if the jewellery comes and entangles it may any cause any kind of incident or accident. So, we need to stick to the protocol and that is why I have recorded a lecture where we show you how to enter a cleanroom.

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Now if you see the gowning procedure like I said if there are face masks, hairnets, gowns, cleanroom shoes, gloves.

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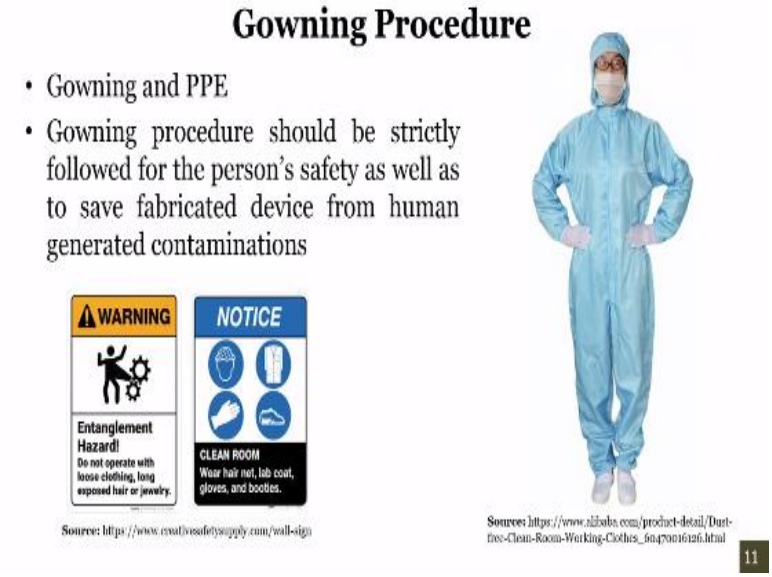


So, gowning and PPE. So, the gowning procedure should be strictly followed for the person's safety as well as to save the fabricated device from human-generated contaminants. Also if you see that if you have loose clothes there is an entanglement hazard is there. So, you need to wear a hairnet, lab coat, gloves, and booties or shoe cover inside the cleanroom.

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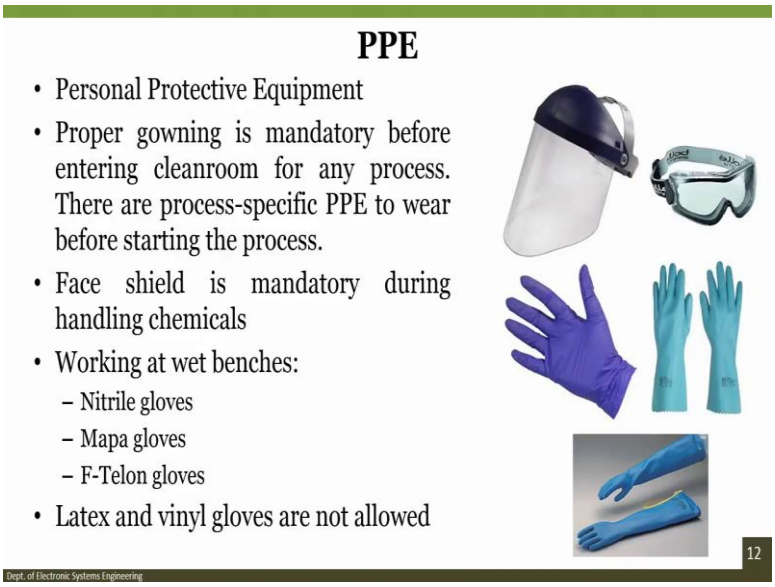


What is personal protective equipment? So proper gowning is mandatory before entering a cleanroom and there are process-specific PPE to wear before starting the process. The face shield is mandatory during handling chemicals. Generally, we wear glasses, but when we are working with acids on a wet bench. A wet bench is used to create a diaphragm or to edge the silicon or to edge a different kind of metals insulator and semiconductors.

So, Wet bench are of two types the acidic wet bench holds the acids. The second is a wet bench in which you can use solvents. So, it is advisable and in fact, it is mandatory to wear the face shield when you are using the acid bench as well as a solvent bench. So, working on wet benches is nitrile gloves compulsory or mandatory, Mapa gloves are required, F-Telon gloves are required, latex and vinyl gloves are not allowed. So we need to take care of this.

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Wet bench protocols as you can see here during working or accompanying someone at the wet bench is mandatory to wear. Lab shoes clothes toe shoes this is extremely important. Whenever you work in a cleanroom environment you should wear a closed (to) toe shoe. Apron, face shield, appropriate gloves, and the most important thing is you should never touch your eyes or your belongings or with your contaminated gloves.

Everything you considered as hazardous while working in a Fab lab. It is as good as that anything that you touch would cause a problem and that is why if you are wearing gloves if you handle a chemical even it is a solvent can be acetone or ethanol or methanol or IPA, still, it will cause harm if it touches the body. So, forget about acids I am just talking about some solvents, some alcohols that will also affect your body.

And that is why if you have been working inside the cleanroom until you come out until you discard your gloves and your PPEs and you should wash your hand and then only touch your face or your hands or your body anywhere. The point is that until and unless you come out of the cleanroom you should not rub your eyes in particular or touch your face or your hands with your gloves main surface of the hand, not the PPE.

So, you need to also follow the MSDS guidelines, you have to check the hazardous symbols when you are working in the cleanroom. As you can see here there are a lot of symbols like for example gas under pressure, corrosive then serious health hazards even breathing these chemicals will cause a serious health hazard like within VOC with your volatile organic compounds will cause serious lung damage.

Acute toxicity symbol is there and oxidizing explosive hazardous to the environment, flammable you need to understand all these symbols, you need to take care while working in the cleanroom environment. This is what is shown that a person is wearing an apron, face shield, appropriate gloves before using the wet bench which is your acid bench.

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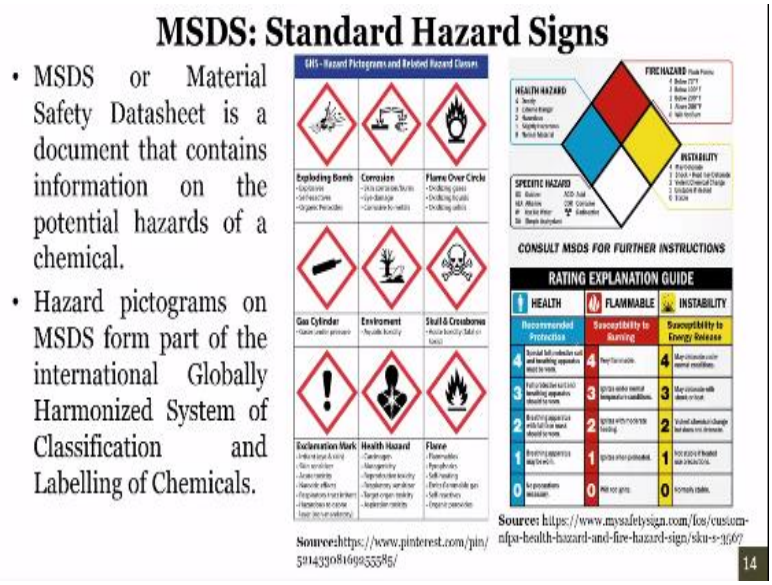


So, the MSDS or material safety data sheet is a document that contains information on the potential hazards of a chemical. Hazard pictograms on MSDS form part of the international globally harmonized system of classification and labeling of chemicals can be seen in this particular slide. You can see that there are several hazards which can be given color for example specific hazard is generally in white.

Instability is in orange color or yellow color, the health hazard is in blue while fire hazard is mostly in red. So, health hazard generally comes as blue color you can see here recommended protection, susceptibility to burning which is a fire hazard that is why is red and instability is susceptibility to energy release is generally given in yellow color. So, for example, if you see health, then an especially full protective suit and breathing apparatus must be worn depending on again the hazardous level.

So, it starts from 0, 1, 2, 3, 4 in 0 no precaution is required, but if it is 1 breathing apparatus maybe worn, 2 then you go further the breathing apparatus with a full face mask then 3 full protective suits and breathing apparatus and fourth full protective suit and breathing apparatus must be worn. Same thing if you see flammable at 0 it will not ignite at 1 it ignites when preheated, 2 it ignites when moderate heating, 3 ignites in the normal temperature.

And fourth is extremely flammable. When you go for instability that means at 0 it is normally stable, 1 not stable if heated, 2 violent chemical change, but does not detonate while 3 is may detonate with shock or heat and 4 is may detonate at normal conditions that mean it is instable. So, you need to understand what kind of precaution level you need to take while working in a cleanroom, and like I said there are symbols that you need to follow.

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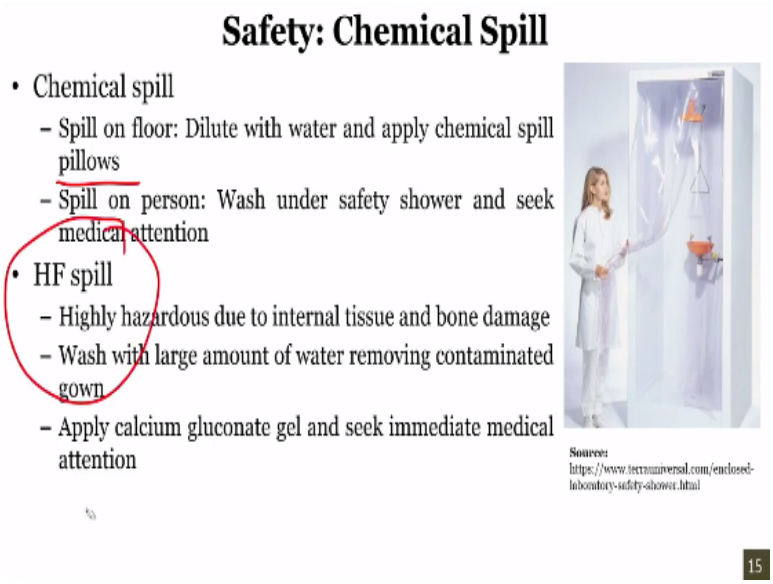


Then you can see here there is a curtain and then this is a shower and this is for the eye splash. So, in case there is a chemical spill, spill on the floor, dilute with water and apply chemical spill pillows. There are chemical spill pillows which you need to use and before that, you need to get trained on how to remove the spill on the floor. Spill on the person if there is a chemical spill on your colleague or on a person who is working in the cleanroom.

Then wash under safety shower and seek medical. This is a safety shower you should wash completely under a safety shower and immediately seek any medical attention then you have HF spill. HF spill is a hydrofluoric acid spill. This is most dangerous and that is why it is highly dangerous to internal tissue and bone damage, wash with a large amount of water removing contaminated gown.

Apply calcium gluconate gel and seek immediate medical attention. So, when you are working with HF be extremely careful and make sure that it does not spill. In case got for a bit it spills, then you need to immediately wash with a large amount of water that particular part which has been exposed to this spill and you should immediately apply calcium gluconate gel which would be there in the cleanroom lab.

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Electrical safety is another point generally we do not consider electrical safety is very important stuff in most of the laboratories. It is important that we put all the possible signatures such as hazardous voltages then there is an electrical hazard then you should keep out of the electrical shocks, severe shock hazard there is hazardous voltage damage and high voltage thing.

Now you can see here this kind of stuff you will see in most of the laboratory avoid do not use wet hand and connect your system. You should not work in an environment when there is a tangling of the wires along with your leg this is a broken code you should never use broken code this is at all not allowed this can cause a tremendous amount of fire and short circuit this is not allowed.

So, in any laboratory, the first thing from the safety point of view is electrical safety. At no point of time, you should be working in a lab that does not follow electrical safety regulations very important. Before you make a device to save humans you should have an environment whether humans are safe. Otherwise, no point of doing all this research and development and making 100 kinds of different cool devices.

If the environment in which you are working is not safe, no point of working at all. So that is why the first is electrical safety, fire safety, health safety, the environment and laboratory safety and then you work in a lab to make devices or components or equipment that can be used for society. So, safety is an extremely important point whether you are making a device

or you are working in an environment and that is why electrical safety comes as a top priority along with other safe environments like fire safety as well as health safety.

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So, another one is safety fire and you should generally have and most of the labs would have fire extinguishers and you should know that there are several kinds of fire extinguishers. For example, there is a water form spill, ABC powder, carbon dioxide, and wet chemical and depending on the fire either it is wood or paper is burning then you can use all of this fire extinguisher except Carbon dioxide because Carbon dioxide will further enhance the flame.

Flammable liquids if it is there because of the fire is there they can use foam spray, ABC powder and carbon dioxide you cannot use wet chemicals and water. Same thing for flammable gases you can use only ABC powder for electrical contact ABC and Carbon dioxide finally for cooking oil and fats if there is a fire then you should only use wet chemical kind of fire extinguisher.

Anyway, these are just for your understanding in the knowledge it is not really that a part of the syllabus, but it is very important before you understand the cleanroom you should understand all these protocols. So there is a trigger, if there is a fire in the lab you should trigger the alarm, leave the building and reach the nearest gathering point where report to the assembly point that is what a gathering point is.

Do not return to the building until authorized to do so, do not use elevators at any use, use fire extinguisher only if you are trained. So, also always follow the emergency exit sign. So,

let me now show you how the cleanroom protocol is followed by playing a video and that will be the end of the module. So, you see the video and then I will leave you on that particular video. And then we will see another module where we will talk about the silicon wafer and silicon dioxide because oxidized silicon wafer is a substrate that we will be used for designing the EEG electrodes. So, till then you see the video and I will see you in the next class bye.

There are several equipment in the cleanroom class let us say class 1000 or class 100 which use lot of gases and these are harmful gases because these are used for growing silicon also etching silicon and etching several other metals, semiconductors, insulators etch silicon, of course, is a semiconductor. So we not only use gas which we also use chemicals. So, if you do not follow the protocol it is extremely harmful or dangerous for the cleanroom user.

And that is why cleanroom etiquettes are extremely important when to throw the gloves, where to throw the gloves when you start the process, what precautions you need to take so on and so forth. So, we are talking about this particular etiquette in this particular lab class. We would also understand different equipment such as a microscope.

When I talk about microscopes we have metallurgical microscopes which we will be looking at in this particular lab class then we would also look at the incubator. So, what exactly incubator is and what kind of incubators are there. In this particular lab, we will focus on the incubator that is used for cells as well as bacteria. See incubator will it be similar to our equipment which is similar to our body environment.

It will have 95 percent relative humidity, it will have 5 percent carbon dioxide and the temperature is around 37 degrees centigrade. This incubator environment is used for cells so that cells are alive. When we talk about cells it can be cancer cells it can be other body parts cells from other body parts or tissues and we also talk about bacteria because one of the techniques that we will be looking at in this particular course is to develop microphonic chip for capturing bacteria from a biological sample.

We will also talk about cells and tissues and that is why if you want to keep the tissues or cells alive you have to use a media and this entire structure or should be kept in the incubator which will have a similar environment like our body. So, we will be talking about incubators in the lab class. We will be also looking at HEPA filters. So, what are HEPA filters?

HEPA filters are high energy particulate air the teaching assistant we will discuss the kind of HEPA filter. We will be showing you the cleanroom which is a nonconventional cleanroom and then we will also show you the cleanroom which is a conventional cleanroom. So, what are the difference? In nonconventional cleanroom is a cleanroom where you do not have the filters on to a false ceiling instead that you will have the filter that we will be looking at in the lab which is modules.

And then the TA will tell you how it can be used to filter the air within the laboratory. So this will be our lab 2. I will request my teaching assistant to now teach you about the cleanroom etiquette, incubators, metallurgical microscopes, and HEPA filter. Again like always you are free to ask us any questions, any doubts that you have through the NPTEL forum. So, till then you take care, having fun with the lab class, understand it thoroughly, and feel free to ask questions. Thank you.

So now. we have a visiting scholar who wants to use the facility here as you can see he would like to use the cleanroom for his purpose. So, now he would enter the cleanroom so he is professor Shiv Shankar from KLE Technology University a visiting scholar here in DSE

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Now even before he enters the cleanroom let see the procedure that he follows. So, as you can see he has picked up the shoe covers from the container there and he stands over the carpeted area. Just so that you do not contaminate from the external ground so you ensure you stand on a carpeted area which is generally clean compared to the surrounding environment. So, now after wearing the shoe cover he uses the cleanroom.

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As you can see to the right side their laboratory safety protocols which clearly state the mandatory protocols which have to be followed even before entering the cleanroom. So, now he takes the access and enters the cleanroom so now once he got the access like you can see he opens the cleanroom door. So, now you see how he enters the cleanroom and then shuts the door.

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So, the noise what you saw in the cleanroom is the air filter on top we have an air curtain which is going to flow air at around 10 meters per second speed. So, in the rush of air, the influx of air is just to ensure that the particulate count is constrained or restricted to that area

to reduce any sort of contamination or particulate count or dust entering inside the cleanroom. We have this mechanism of flowing high-speed air just at the entrance of the door. Now as soon as you give your fingerprint and open the door the sensor there detects the entrance and then the air curtain gets activated.

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Now that we have seen how our visiting scholar has used the ground there and he has worn. As you can see he is having his shoe covers and the gown and to his right side, there is a hand sanitizer. Again, why is it important to use the hand sanitizer when you are even before you enter the cleanroom. In case you think there could be some sort of dust or particulates on your hand you ensure you use this sanitizer and clean your hands just so that it does not hamper the working of your device.

Also even before you leave this laboratory always use a sanitizer. Again in the coming modules, you will understand how you will be doing the cell and tissue culture and you will be dealing with the sensors so that and once you start working with them your hands get contaminated and just to prevent them from harming yourself and prevent you from any sort of disease you always use the sanitizer, protect your hands and then move out of the lab.

Next, he proceeds towards the bench where we have the hair net, face mask, and gloves. So, as you can see he picks up the face mask always ensuring that the white color thin strip comes on top and so that it fixes right on top of your nose properly. So, that you need not keep on meddling with it while and then it might disturb while you work. So, just that you have to follow the right procedure while you are gowning yourself.

Now that we have worn the face mask let us see how he uses the hairnet and covers the complete head just so that there is no contamination due to hair fall. So, now that we have the hair net on let us see how the gloves are chosen and worn. So, there are three sets of gloves considering you just do the normal work under work station like just study or categorize his devices then he would go with the nitrile gloves of a particular size that fits him right.

Assume you have loose gloves and you move towards your work station then there is always possible that it would really not give the right ductile feedback to your hand and then there could be slippage or any other sort of activity which you do not want to happen inside the cleanroom and it is important for you to notice while you see the videos how he is using the gloves.

And then ensuring that the gloves sit exactly on top of the calf sleeves of his lab coat. So, in case he was moving to a wet bench or any other work station where you are dealing with HF or such harmful acids then what you do is you do not remove these gloves, but just on top of these gloves, you wear the silicon gloves or the Mapa gloves the thick gloves which are chemical resistant.

So, these gloves are not really chemical resistant they are just used to protect the environment from contamination. So, this was the entire gowning procedure that the visiting scholar has followed to use the cleanroom facility here in the lab. Now that we have seen how a cleanroom procedure has to be followed like you have seen how the gowning procedure the sequence of following the procedure becomes very important.

Let me tell you more about cleanroom. So, here when I say class 10,000 cleanroom I told you initially that the particulate count is constrained, restricted to certain numbers and that you could study more about how the ISO standard is and how cleanrooms across the country and nation and worldwide have been classified based on the ISO standards. So, here we have a class 10,000 cleanroom and apart from the particulate count, another important heart of the cleanroom is the HEPA filter.

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So, you can see the big tower here there are four such towers in our laboratory here, so this is the HEPA filter. HEPA stands for High Efficient Particulate Air, HEPA. So, there are different types of filters the EPA, UCLA, HEPA filter again based on the efficiency and again depending on the type of environment and the usage. So, here we have a HEPA filter the main purpose of using this is to reduce the particulate count or controlled environment inside the cleanroom is maintained just because of these filters here.

So, it is going to maintain the temperature, the humidity levels as well as the particulate contamination and then there is a positive pressure module along with the four towers here. So, we have two towers here and the remaining two in the biology section on this side of our lab. So, this is a biology section and as you can see there is a tower on the other end of the biology section.

So, there are 4 such towers here and then there is a positive pressure module on one end. So, what the positive pressure module does is it is going to pump in pressured air. So, why do you need to have an environment which has slightly higher pressure compared to the atmospheric or the outside environment? So, this entire room is slightly at a higher pressure compared to the outside just when you go beyond the door the pressure outside is completely different it is lower compared to this pressure here.

So, we maintain this pressure using these HEPA filters and the purpose of having higher pressure inside this room is just to avoid an influx of air. So, you always know that it is air always flows from a higher concentrate area to a lower pressure area. So, then you maintain a

higher pressure so there is clean air which would go out, but then the contaminated air or the unfiltered air which is outside would not infiltrate into this environment. And that is why we call this as a controlled environment and hence we have the HVAC system. As you can see we have an air curtain just at the beginning at the entrance just to reduce the particulate contaminants which could be affecting the environment inside.

So, how this HEPA filter work is 50 percent of the atmospheric air is taken in and 50 percent of the air which is inside the clean air is always re-circulated within these filters. So, when you are talking about re-circulation what happens is assume I am going to maintain this cleanroom at perfectly clean levels. So, the amount of energy that the entire HVAC system takes the load on the system reduces provided you put your efforts into maintaining the cleanroom by following these procedures reducing the particulate count. So, by following these procedures you could reduce the load on the HVAC system.

Otherwise, what happens is provided you want the particulate count to below. However, you do not follow any of these guidelines. The amount of load that the system takes is higher. So, they have a lifetime and each of their systems have their lifetime and efficiency frequently have to be checked, they have to checked annually for their pressure levels. So, there is no point in them if they do not function properly. And if the room is not maintained at positive pressure there is no point in us having a controlled environment system.

There could be the possibility of having the malfunctioning of your devices or having not maintaining the cleanroom for its purpose. So, to save your devices for better efficiency for a better lifetime of these filters you always do your best to maintain the cleanroom for the given standards. And this was a brief introduction about how we work in the class 10,000 cleanroom, how the gowning procedure is to be followed. Once we have the basic steps in hand then we proceed in our future modules in our next coming modules, what are the different types of equipment that are available in the facility here, why are these types of equipment use, where have they procure from.

How they can be handled and what characterization can be done using the tools and is designated places will be briefed in our future lectures. So, this was about the gowning procedure in a cleanroom. Thank you.