Chemical Process Safety
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Lecture 15
Industrial Hygiene: Control

Welcome to this module of industrial hygiene. So, up till now we have studied about the identification and evaluation tools. In this particular module, we will discuss the various methodologies applicable for different type of toxic hazard, evaluation of toxic hazards etc.

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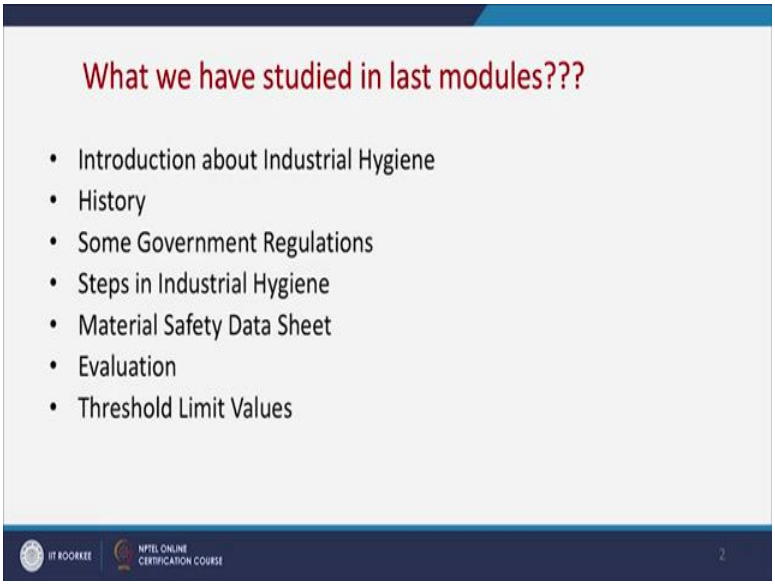

So, just have a look that what we have studied in the last modules. We have gone through, that what is industrial hygiene? What was the history? There are some governmental regulations and abbreviations, what are the steps involved in industrial hygiene? We have gone through the material safety data sheet, perform the evaluation study so that we can analyse that what is the gravity of toxic substance those who are released at the workplace.

We have discussed about the various threshold limit values and other parameters through with which you can assess the gravity of those toxic release at work place. In this particular module, we will discuss and a briefly we have gone through these control methodologies in the last module.

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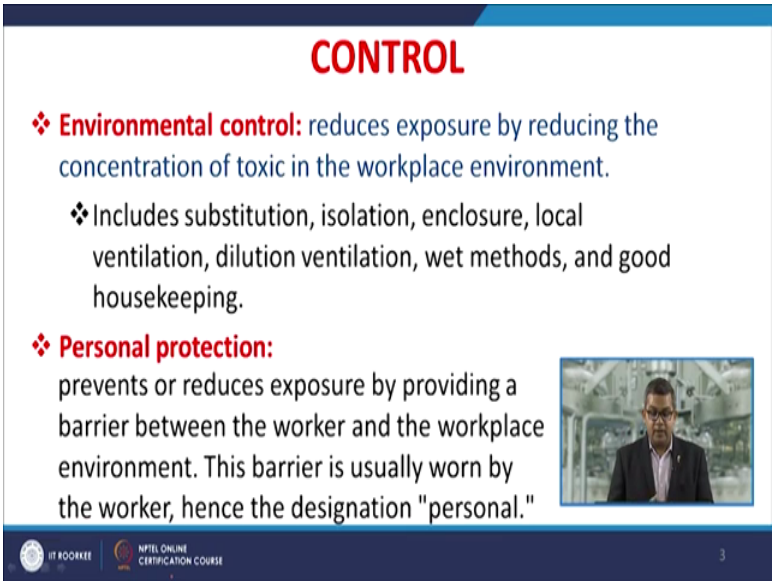

Again I am coming back to the control modules, these control modules are divided into two different aspects. One is the environmental control and second one, is the personal protection. So, environmental control they reduces the exposure by reducing the concentration of toxic in the workplace environment, they include the substitution, isolation which we have gone through in the last module, enclosure, different type of ventilation tools etc.

The personal protective production involves the prevention or reduction of exposure by providing the barrier between the worker and a workplace exposure. This barrier is usually worn by the worker. So, it is designated as a personal word.

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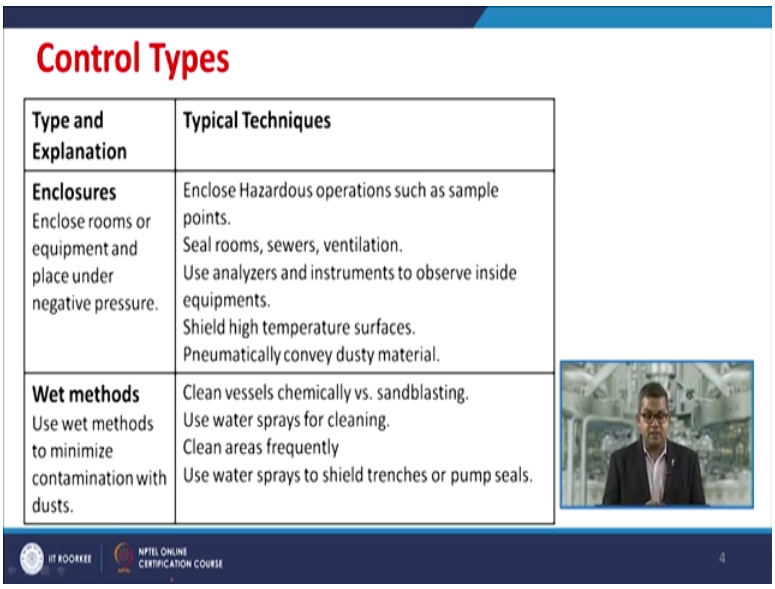

Now, in this particular table we are having the different type of control tools or (controls) control methodology available and what are the typical techniques available for those control methodologies? These are the general examples like we may have a enclosure, that is a enclosed room or equipment and a place under the negative pressure. So, typical techniques they are enclosed hazardous operation such as sample point sometimes sealed rooms, sewer, ventilation, you may use the analyzer and instruments to observe inside equipments, shield high temperature surface, pneumatically convey dusty materials etc.

There are certain wet methods, used wet methods to minimize the contamination with dust. The typical technique involved are clean vessel chemically versus sandblasting, use water sprays for cleaning so that the dust may get deposited, clean area frequently good housekeeping, use water spray to shield the trenches or pump seals.

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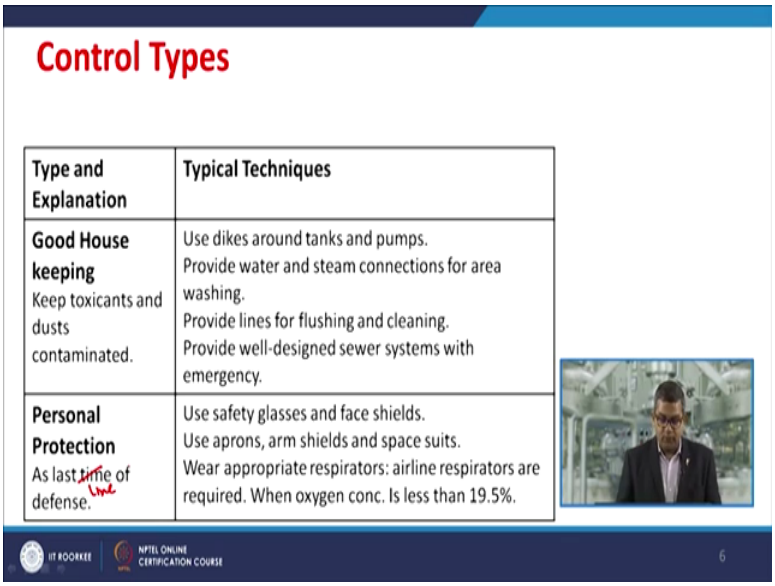

Another is the local ventilation, this contains the exhaust of hazardous substance we will discuss these local and a dilution ventilation in due course of time in this particular module. The typical techniques are used properly designed hoods, use hoods for charging and discharging, you may use the ventilation at drumming section, use local exhaust at sample points, you may keep exhaust system under negative pressure etc.

The dilution ventilation, the design ventilation system to control the low toxic level so that I mean this is with the help of certain diluents may be inert or may be air. So, design locker rooms with the good ventilation and a special area or enclosure for contaminated clothing,

design ventilation to isolate operation from rooms and offices, design filter press rooms with directional ventilation.

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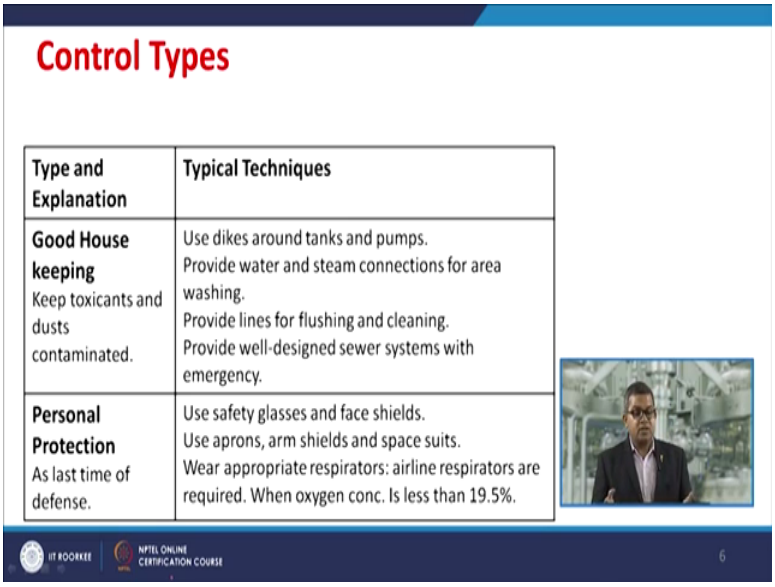

You may go for a good housekeeping, so keep toxicant and dust contaminated away from your workplace, you may use dikes around the tanks and pumps, provide water and steam connection for area washing, provide lines for flushing and cleaning, you may provide well-designed sewer system with emergency.

You may use the personal protection, this is the last line of defence. Use safety glasses and free shields, use aprons, arm shields, and space suits, wear appropriate respirators, airline respirators they are required, so when oxygen concentration is less than 19.5 percent, 19.5 percent is called IDLH immediate death when the oxygen concentration is below this particular concentration, this is the last not time this is the last line of defence.

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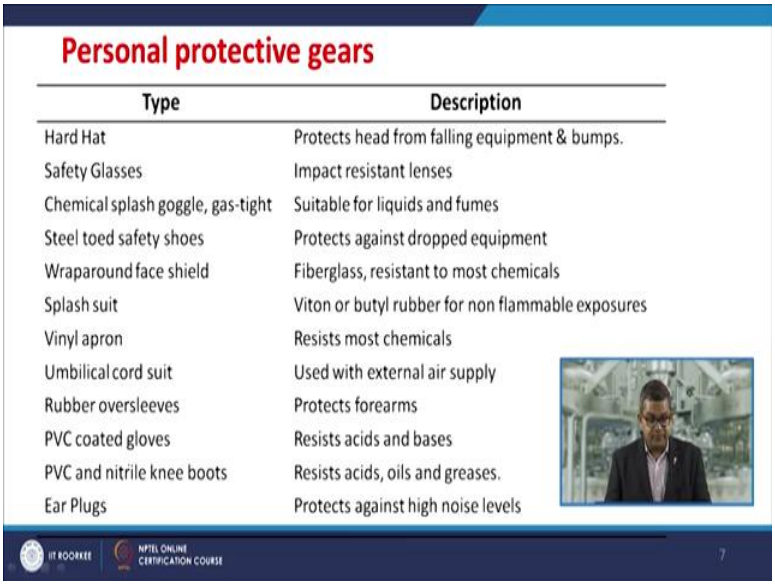

Based on the gravity of the toxic substance various protective gears are available like hard hats, usually protect head from falling equipments and bumps. Safety glasses, usually the impact resistant lenses, chemical splash goggle, gas-tights etc suitable for liquid and fumes, steel toed safety shoes protect against dropped equipment, wraparound face shields like this this protect usually made of fiberglass and resistant to most of the chemicals.

Splash suits, Viton or butyl rubber for non-flammable exposures, Vinyl apron resist most chemicals, umbilical cord suits used with the external air supply, rubber over sleeves these usually protects forearms, PVC coated gloves resist acid and bases, PVC and nitrile knee boots they resist acid, oil and greases, ear plugs protect against the high noise level. So, basically these are the barrier from toxic substances to yourself.

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Now, we will discuss something about the respirator because this is you can say the last line of defence or it provides the barrier, remember these respirators to be used very carefully.

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And you can see in this particular figure that this prevents the contamination of toxic vapours through inhalation to the body system and these respirators are of so many (times) types you can see there are a couple of in this particular figure.

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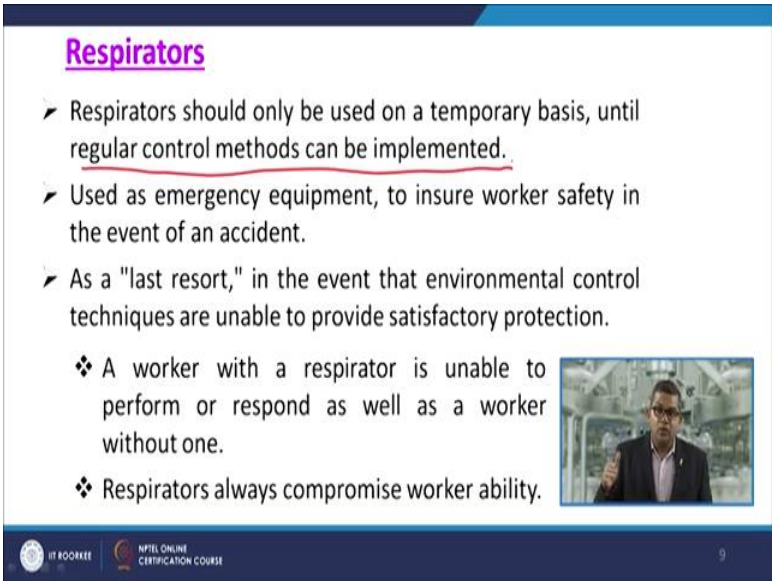

Now, there are certain advantages and certain disadvantages associated with the Respirators because and we are going to discuss all those things in the subsequent slides. And respirators should only be used on temporary basis until regular control methods can be implemented. So, whenever you are using the respirators then definitely the level of contamination or level of exposure is on the higher side and it crosses all the workers or the person those who are in and around, they are overexposed

So, it should be used as a temporary basis because ultimate attempts should be there to control the emission of that particular toxic substance, used as emergency equipment to ensure worker safety in the event of accident. This is the last resort in the event of the environmental control techniques are unable to provide a satisfactory protection because the human life is first.

So, one major disadvantage associated with the use of the respirator is that a worker with a respirator is unable to perform or respond as well as a worker without one. So, respirator always compromise workers ability, so that is why we must emphasize that you must implement the regular control methods, so that the normal condition or the toxic substance released can be lower compared to the acceptable limit.

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There are various types of respirators or a covering available as on date. Now, this one is like quarter mask, this is filled this one, this is the half mask filled at the nose etc, this is the full face piece sometimes the toxic substance they are irritating to the skin also, so are itching they were they may impart itching to eyes, so you can use the full face piece. There are mouthpiece and nose clamps not very common, but mostly people are using.

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Sometimes the toxic substance is extremely reactive. So, there are different types of loose-fitting coverings, these are the part in part this may be the part and parcel of full suit, full bodysuit or full face suit. So, this one is the hood, sometimes the helmet being used for the protection, these are the loose-fitting face pieces and this is the full body suit. So, based on

your requirement you can use because ultimately the efficiency of worker is always challenged whenever you are using this type of respirators.

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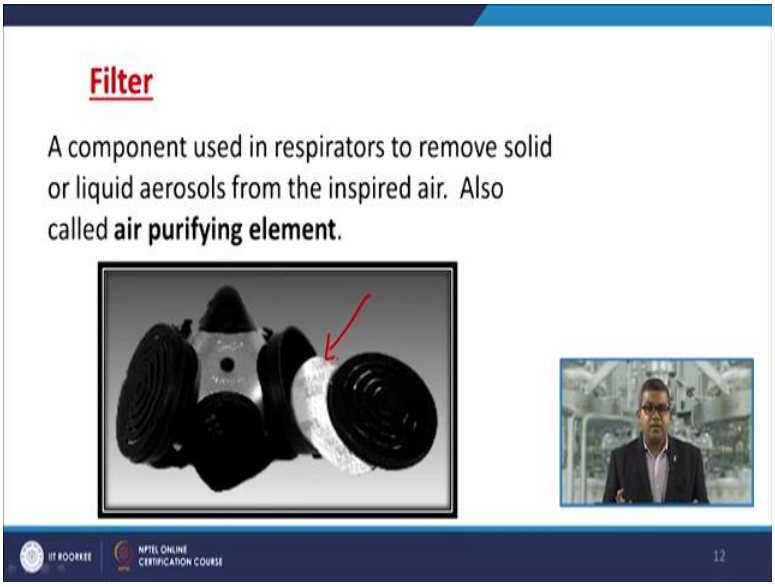

Sometimes, these respirators they are filled with certain type of attachments like filter, chemical canisters, chemical cartridge etc. So, this is purely based on the toxic substance released at the workplace. Now, usual way is to use the filter because whenever the suspended particles on the higher side, so it is advisable to use filter along with the respirator. So, a component what is the (respirator) filter? A component used in the respirator to remove solid or liquid aerosols from the inspired air this is called also called the purifying element.

So, you can see this one, the white or light coloured thing is filter, these are very common so whenever you are crossing the traffic or if the particulate matter is on the higher side then you may find the people are using this type of filter along with the respirators.

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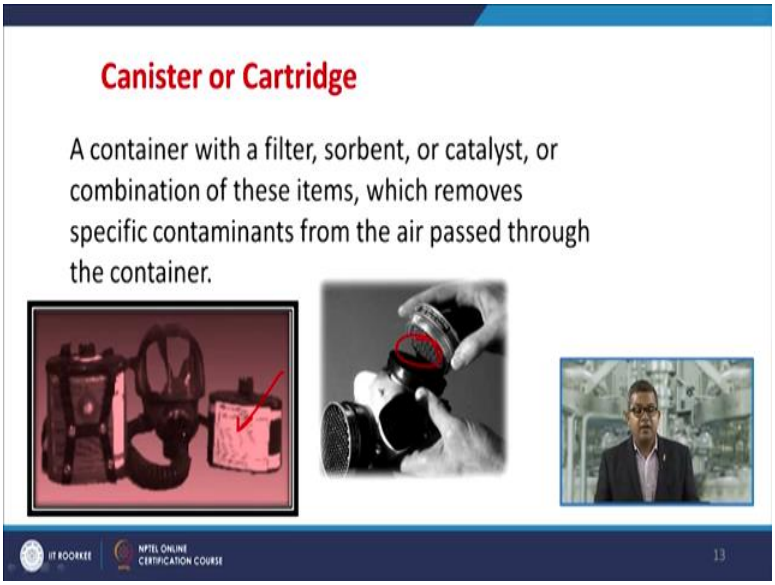

There are certain canisters or cartridges, they are situated in between like this or the canister is attached to this one. So, basic purpose of this chemical based canister or cartridge is to have (an adsorbing) or absorbing ability of toxic substance and sometimes a filter fails to provide the adequate safety or adequate protection then these canisters being used or the cartridges being used to neutralize the effect of that toxic substance.

So, usually a canister or cartridge a container with a filter, sorbent or catalyst or combination of these items, which remove the specific contamination and from the air passed through the container.

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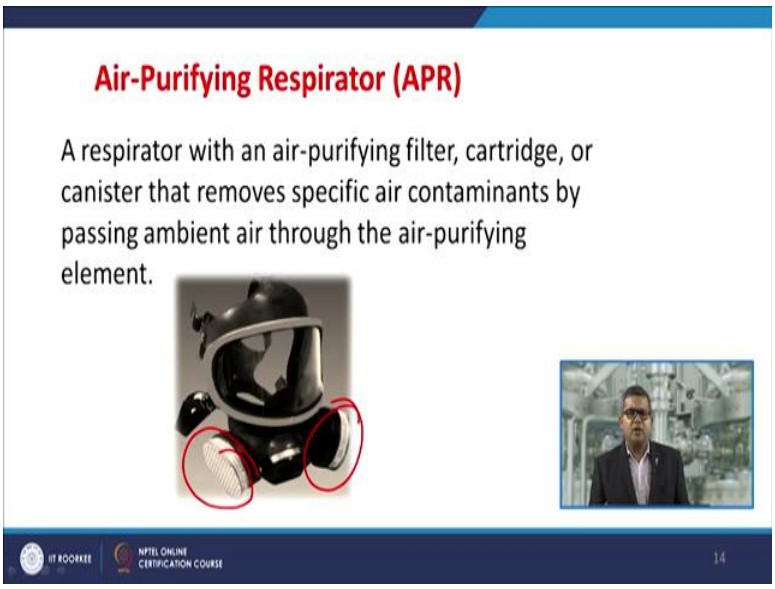

There are certain air purifying respirators like this you can see that these are the air purifying devices. So, a respirator with an air purifying filter, cartridge or canister that removes the specific air contaminants by passing ambient air through the air purifying element it may be a chemical it may not be it may be some physical device.

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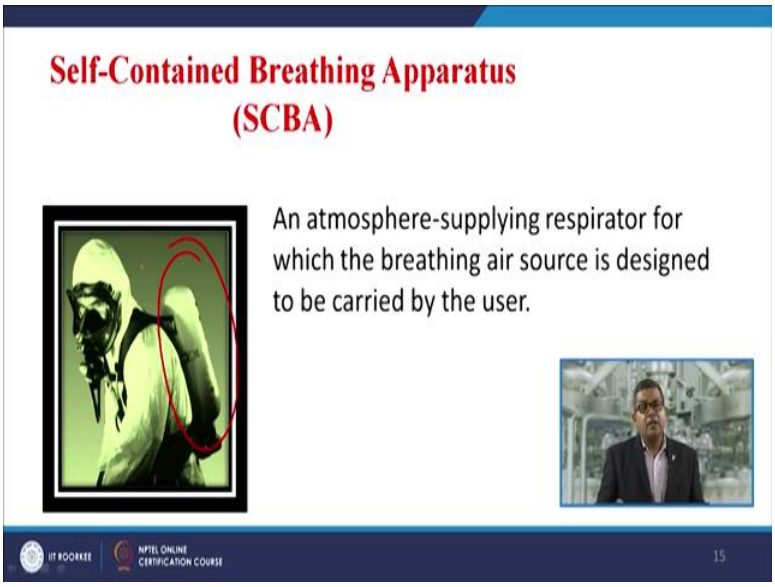

When you are in such a scenario then the toxic the toxicity of any particular chemical is on the higher side then there are certain self-contained breathing apparatus SCBA. Usually this an atmosphere supplying respirator for which the breathing air source is designed to be carried by the user. So you can see that this is the oxygen canister, it is at the real part of the body and this is applicable when the environment is a smoky, when the environment is extremely filled with the toxic substance. So that even there is no and no opportunity to have a purified air with the or your regular respirators they do fail.

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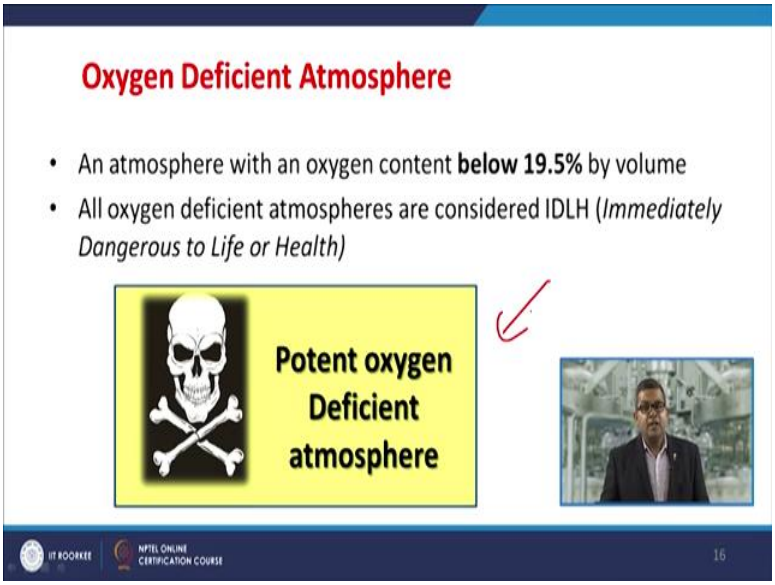

There are certain oxygen deficient environment, so usually in engineering term and atmosphere with the oxygen content below 19.5 percent by volume is termed as oxygen deficient atmosphere. So, all oxygen deficient and atmosphere are considered as (LD) sorry IDLH immediately dangerous to life or health. So it should be well publicized and it is always advisable to use SCBA or SCBA under these circumstances.

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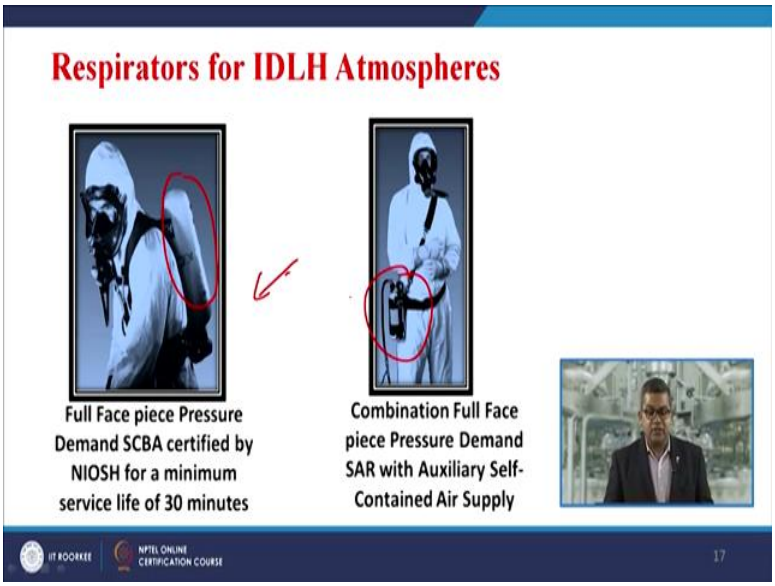

So these are the respirators for IDLH atmosphere, you may use the full face peace pressure, demand SCBA certified by an NIOSH for minimum service life of 30 minutes that is based on the capacity of these cylinders. You may use, you may use a combination of full face

piece pressure demand SAR with auxiliary self-contained air supply apparatus. So, based on your requirement and based on the concentration you may use any one of them.

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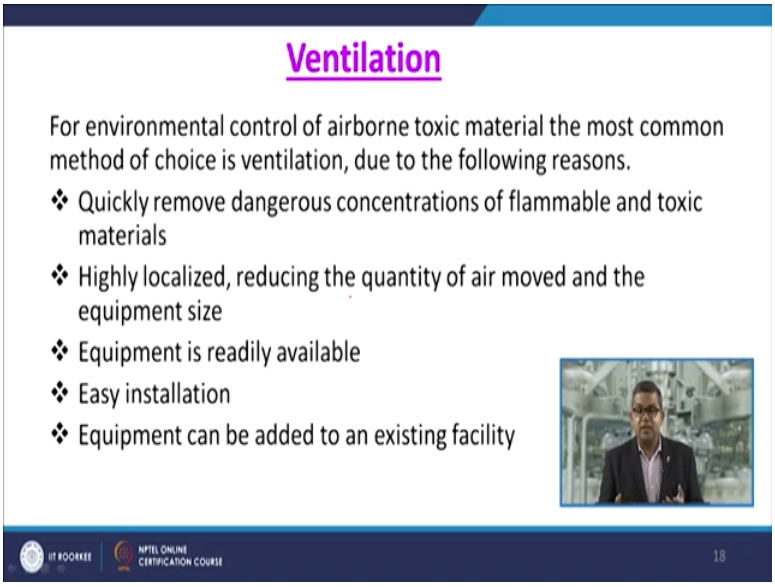

Now, next aspect is the ventilation, usually ventilation is one of the most powerful and most popular tool for decontaminating any workplace, if the workplace is contaminated by the toxic substance. So for environmental control of air bound toxic material, the most common method is the choice is ventilation. Now, ventilation is of so many type, now the ventilation is added benefit, these benefits are can quickly remove the dangerous concentration of flammable and toxic material from workplace. It can be highly localized, reducing the quantity of air moved and equipment size suppose I am working over here, so you can localized, you can direct you can have the directional ventilation tool, so that it can snatch away the toxic substance from the workplace.

So, there is no need to install the costly ventilation equipment throughout your workplace. These equipments, these ventilating equipments they are readily available, it can be even you can find it at your kitchen when the ventilation fan is there or sometimes the (chimney) electrical chimney is there. It is very easy to install any kind of ventilation equipment and equipment these ventilation equipment can be added to the existing facility as smartly as possible.

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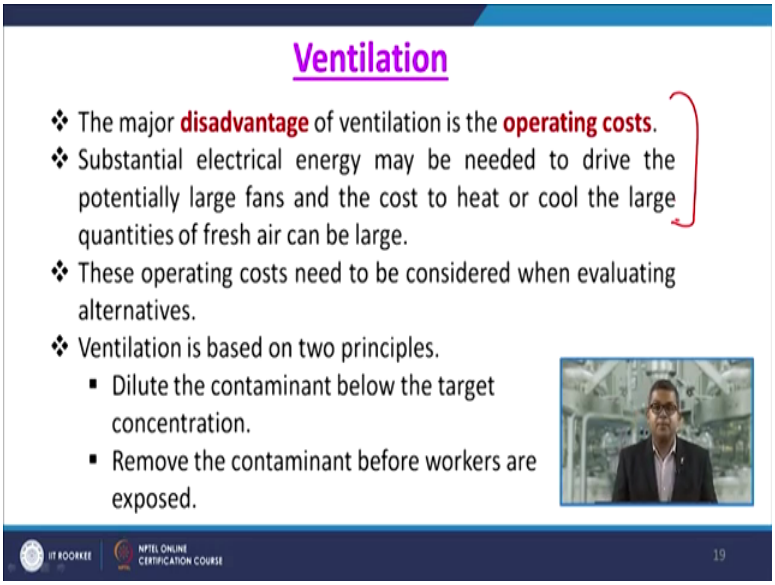

But the one major disadvantage associated with the ventilation and that is the operating cost because they are highly energy consumable, so substantial electrical energy may be required to drive the potentially large fans and the cost to heat or cool the large quantity of fresh air. So, because of these factors they do possess a heavy cost, even if you consider an example of your kitchen whenever you are using ventilation fan or whenever you are using the kitchen chimney then definitely the cost is on the higher side, one is the installation cost and second one is the operating electrical cost. So you cannot overlook (the) these particular factor, but sometimes these the investment to these expenditure is fruitful because your entire working environment is safe.

So, these operating cost need to be considered when you are having when you are evaluating certain alternatives. The best thing is that to minimize the evolution, but if you are not able to find out like if you are cooking something in your kitchen then you cannot avoid the formation of off orders then definitely you are compelled to use these kind of ventilating tools.

Now, ventilation is based on two principles, dilute the contaminants below the target concentration, so (you have) you are having the TLVS with you, so you dilute the contaminants below the target concentration and remove the contaminants before workers are exposed. So, these two are the basic principle on which the ventilation theory runs.

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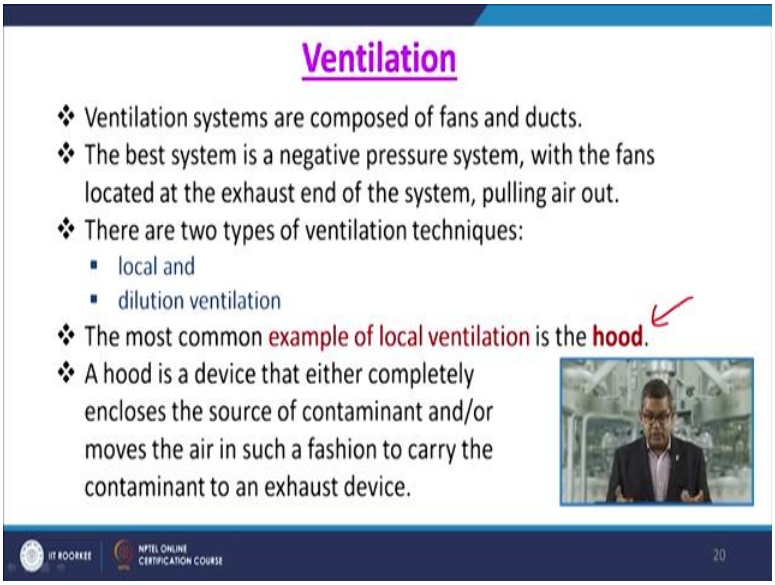

Usually ventilation systems they are composed of fans and ducts. The best system is the negative pressure system with the fans located at the exhaust and of the system pulling air out. Now, based on all the theories applicable technically we can divide the ventilation techniques in two aspects, local and dilution ventilation. The most common example of local ventilation is the hood, we will discuss the hood in subsequent slides.

Now, usually a hood is a device that either completely encloses the source of contaminant and or moves the air in such a fashion to carry the contaminants to an exhaust device.

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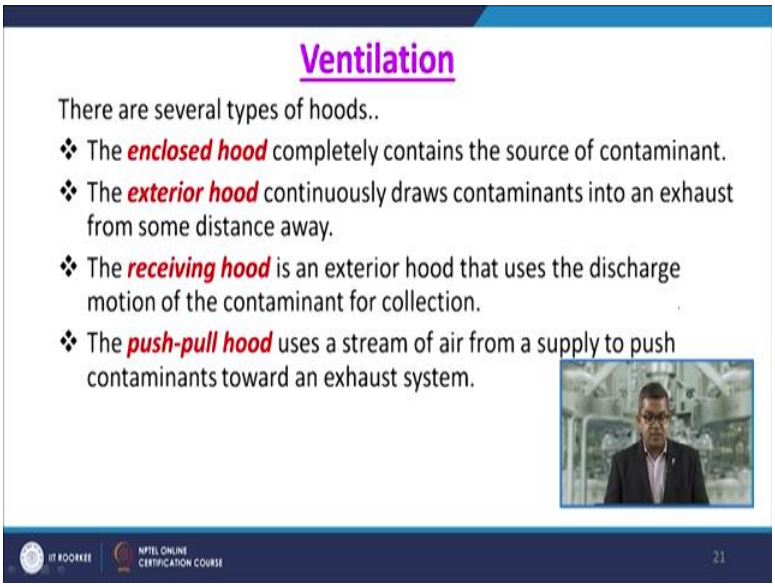

Now based on the requirement there are four different types of hoods. The enclosed hood that completely contains the source of contaminants, now suppose this particular segment is covered with this one, so anything which is running inside is being sucked out by the ventilation tool nothing is coming out, so that is called the enclosed hood I will show the figure.

The exterior hood, the continuously draws the contaminants into an exhaust from some distance away. The receiving hood, this is an exterior type of hood that uses a discharge motion of the contaminant for collection usually utilizes the natural draft of a toxic substance or fumes or a dust etc. The push and pull type of hood, they uses a stream of air from a supply to push contaminants towards the exhaust system.

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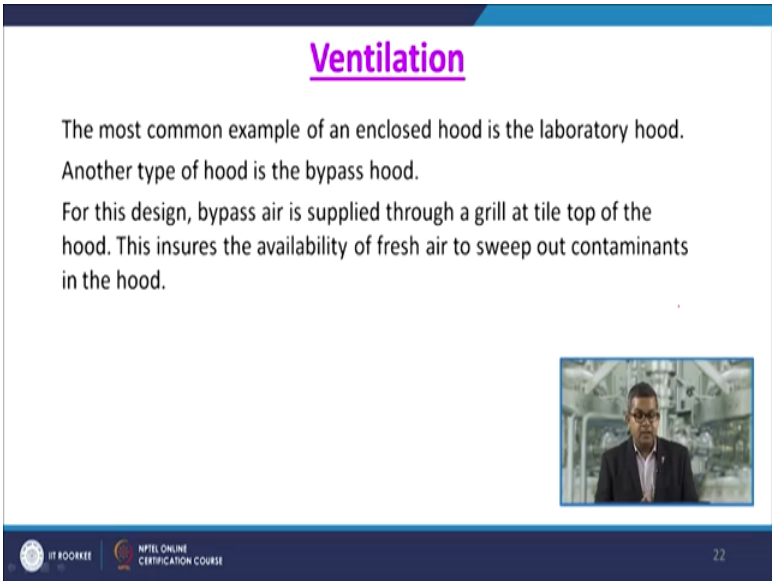

The most common example of an enclosed hood is the laboratory hood. Another type of hood is the bypass hood. Now, for these design, bypass air is supplied through the grill at the tile top of the hood. This ensures the availability of fresh air to sweep out the contaminants in the hood. So, not only it provides a dilution, but also it is performing the push and pull type of activity.

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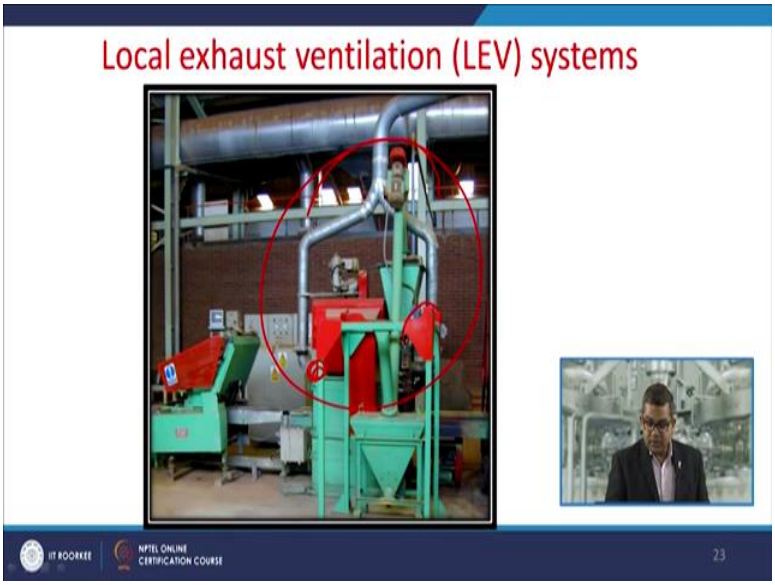

Now, this is the typical industrial local exhaust ventilation system, local exhaust ventilation system you can see, these are the ventilation devices and you may require here the ventilation tool and (some) somewhere here.

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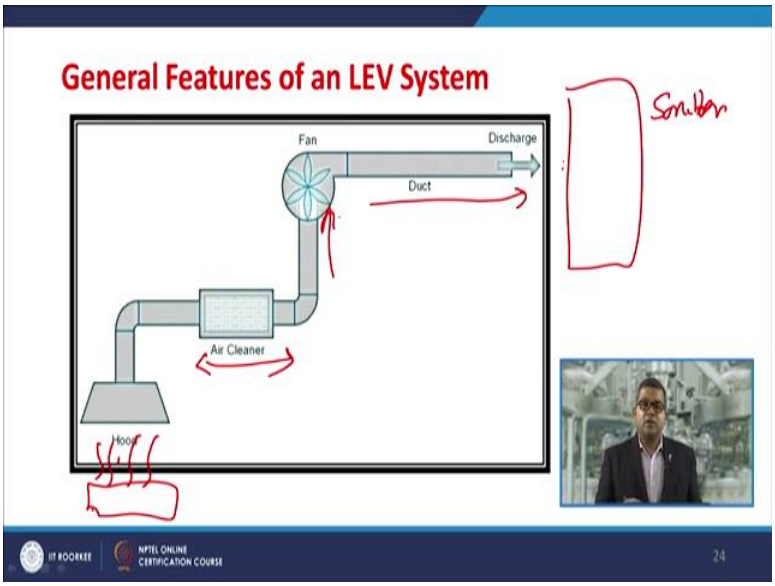

Now, this is the general feature of local ventilation system, this is the hood and some of the contaminants or the fumes may be discharged from this port being collected by the negative pressure through this hood, you may install an air cleaner over here. So, that any kind of suspended particles, any kind of particles can be entrapped and it is composed of fan, so that it can be discharged through duct to the either atmosphere or sometimes if the toxic substances are there then it may be scrubber may be installed at this port. So that the all toxic

vapours or fumes may look and may not go to the atmosphere, otherwise it will create the problem for the nearby people.

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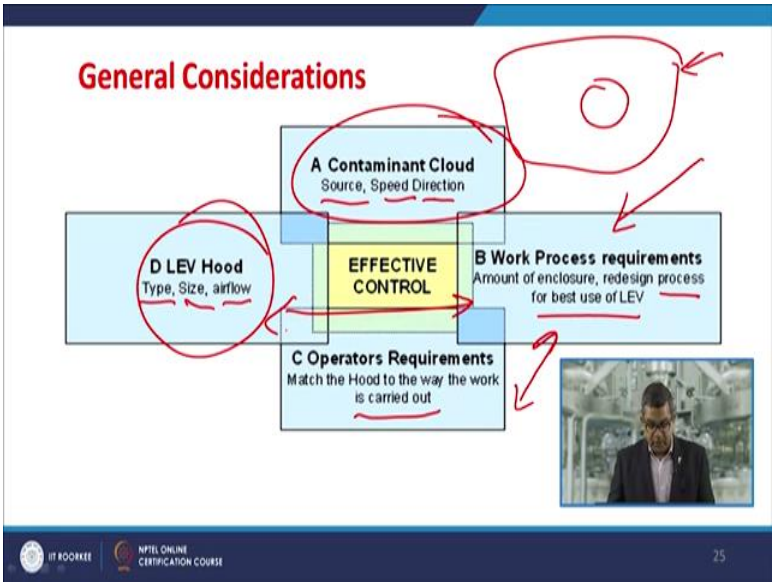

The general consideration of this ventilation is that, you are having a contaminant cloud, you must identify the source where is speed and a direction both the things are important because you must know that what is the evolution rate and in which direction it is going down. See, the Bhopal gas tragedy took place just because of this directional effect. The MIC releases the wind inversion at the time of MIC release is populated towards the population zone. So the direction of the toxic substance release is important.

Then you must analyze that what is your work process requirement, that is how much amount of enclosure you require, sometimes if your working places is small then there is no need to design that things for larger size. The reason is that whenever you are designing for a larger area then definitely the energy consideration would be on the higher side.

So in case if this particular thing fails then again you redesign the process for the best use of local exhaust ventilation. Then you must see that, what is the operator requirement you match the hood to the way the work is carried out there are n number of hoods are available, there are n number of ventilation devices available based on these two principles. So, you must know that what kind of operator is required for your specific local exhaust ventilation system.

Then based on these factor, you may have your local exhaust ventilation hood maybe different type, size and so based on your requirement. So this is the general consideration while selecting for exhaust ventilation system.

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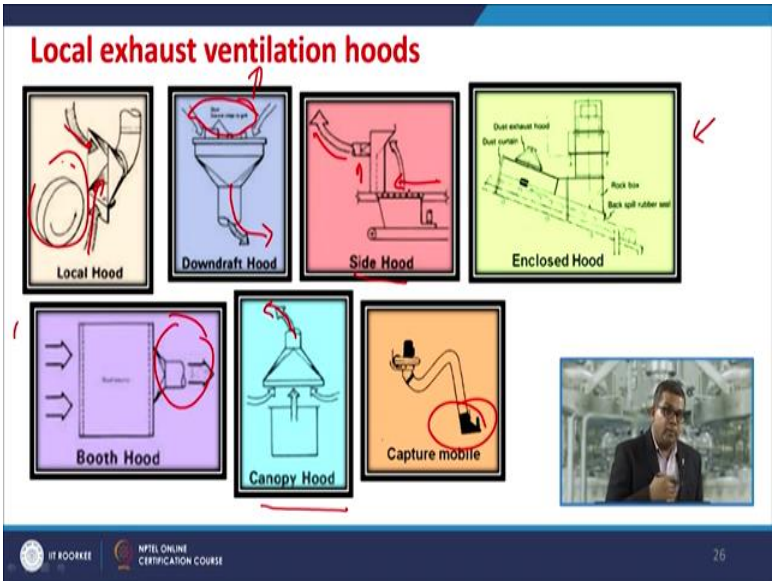

Now these are the various type of local exhaust ventilation hood. Now this is the local hood, here you are performing something maybe dust particles if they are being generated at this source, it is being sucked away by this local ventilation tool. This is the downdraft of downdraft type of hood, you are performing something at this particular point and the dust particles or a toxic substance they are being generated and sometimes it is not possible to snatch away these dust particles from the top of the reactor or top of the process then you may utilize the downdraft aspect.

This is the side hood, so you are having some processes going on here and if something hazardous is coming out then you may install the hood and this can be discharged the contaminants to the atmosphere or to the some other safe places. This is the typical design of enclosed hood, I will discuss in the next slide because this is the most common a type of hood. This is the booth hood, hood here the something is going on like this as, this is my working place and somehow because of the space consideration because of the process requirement I cannot install the hood just about this particular workplace.

So, it may have some side type of snatching device, so this is the booth type of hood. This is the regular or you can say the conventional type of a canopy hood, this is work place is just above you may have a canopy type of hood which may utilize the either the force convection or a natural convection through which the contaminants may get snatched away at this port.

This is the capture mobile type of hood and it is again very popular in some of the industry and you can use this particular type of hood or local exhaust ventilation system anywhere

because suppose I am working over here and sometimes because of some batch preparation I may need to go to some other place, so I can snatch the dusty particles or a toxic substance through the flexible hose from anywhere else, so this is the flexible hose through which you can snatch away can completely remove the toxic substance from the mobile workplace.

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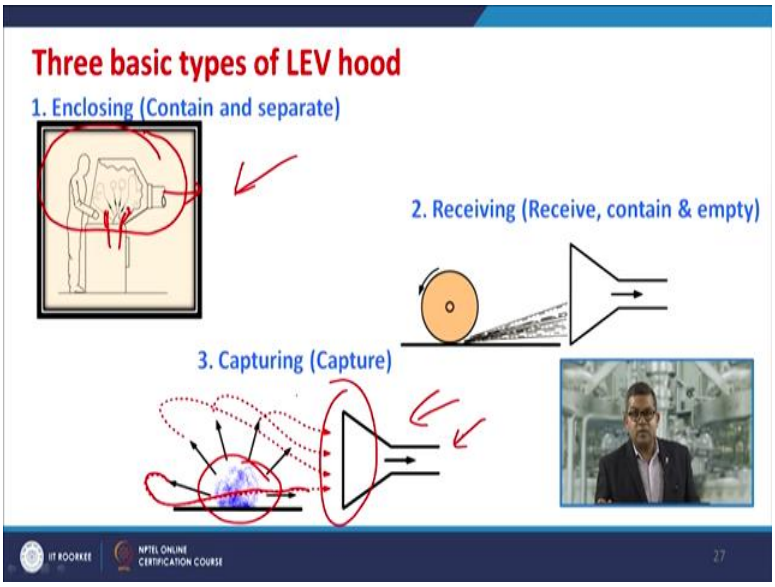

Now, these are the three basic LEVs which we have discussed and moreover the design consideration how the design consideration plays a vital role, we will discuss in this particular slide. Now, this is the enclosed type of hood which we discussed in the previous slide. Now, you can see that this particular hood completely enclosed the work place, so any kind of contaminants which is being released from this place they are housed within this enclosed chamber and it can be go away from this place.

Now, this particular capturing type of hood or sometimes you may referred as a mobile hood or captured hood etc. Now, one important feature at this particular to this particular type of hood is that you must know the fluid behaviour or you must know the flow profile of that toxic substance or fumes from at your workplace, so that you can design these capturing type of hood in such a way, so that it can snatch away all the fumes, all the dust to this level.

So, it all depends then whenever you know the flow pattern of these fumes only then you can set the power of section of this particular in capturing hood and opening of this particular hood, so that it can snatch away all the the undesired contaminants from the workplace.

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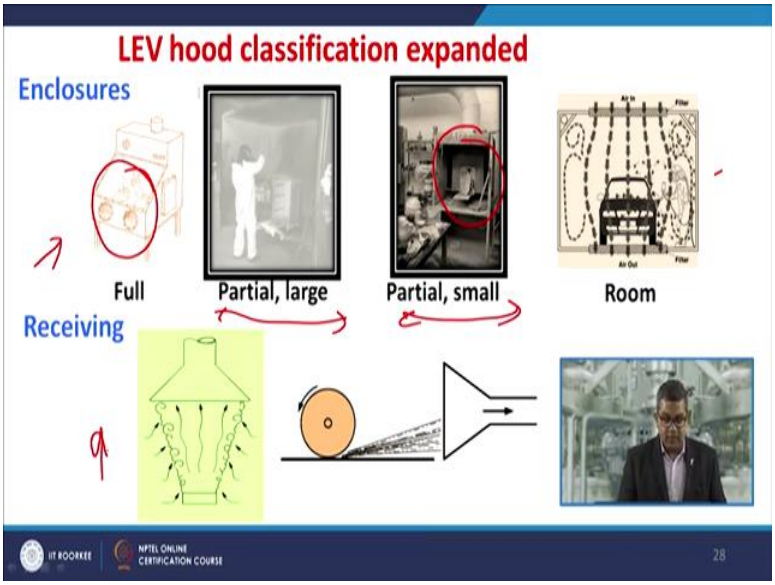

These are the again the typical example of LEV or local exhaust ventilation hoods these one is the enclosed hood, sometimes you may find the gloves inside so that any part of the body will not be get contaminated to the toxic environment. These are the some partially large hoods, partially small hoods like this you can see they are enclosed ventilated rooms or hood type of things. So that they can snatch away all the contaminants from anything, this is the natural receiving hood etc.

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Now, main reason we must understand sometimes these ventilation tools do fail. Now, why do they do fail? There are certain reasons associated with it, like incorrect type of hood is chosen and could never provide the sufficient protection. Now, sometimes because of

because you do not have any idea about the flow pattern of fumes or toxic substance you have chosen the incorrect type of hood then definitely it will fail, sometimes when the enclosed hood is required and you have chosen the mobile type of hood then again it will fail.

The airborne contaminants is not contained or captured, again if you have not much knowledge about those airborne contaminants then definitely your ventilation tool will be failed. LEV hood design does not match the process and source, so definitely because in the previous slides we have discussed so many types of LEVs, so if you are not able to install the proper designed LEV hood then definitely it will fail.

Now, see I am giving you a couple of example here you may see that these fumes or dust are being generated. So, you may utilize that the local exhaust ventilation or a mobile capturing unit you can see that this is being snatched away by this local exhaust tool. Similarly, here the person is generating a lot of dust, so it may require the local exhaust ventilation tool sometimes if it is being toxic then definitely you may utilize the dilution ventilation also.

Sometimes you may experience, the insufficient air flow because you may need to decontaminate the workplace as well as you may need to dilute the workplace exposure and for this you may not have a sufficient air supply, in that particular case, your ventilation system will fail.

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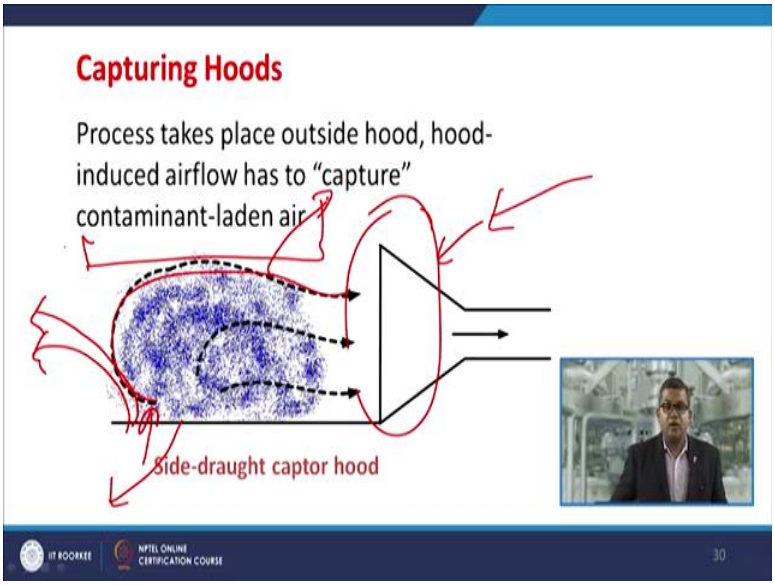

Now, as I discussed because whenever you are having this type of a different type of ventilation tool then you must know the pattern. Remember these pattern governs with two factor, one is the rate of generation and second is that what is the power being employed to

suck it out? Now, if this power is insufficient then definitely the dust particles or the fumes may go out and it may contaminate the workplace, so being sure that you are using the sufficient power ventilation as well as you are practically aware of that what kind of material it is and what is a flow pattern and if it requires then definitely you may use the natural draft ventilation tool.

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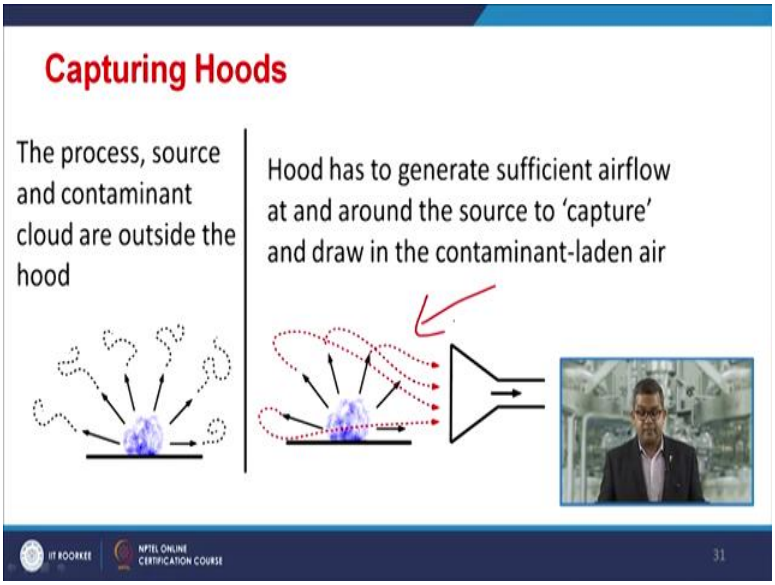

These are the other examples of capturing hoods, the process, source and contaminant clouds are outside the hood, then hood has to generate sufficient airflow at and around the source to capture and draw the contaminant-laden air.

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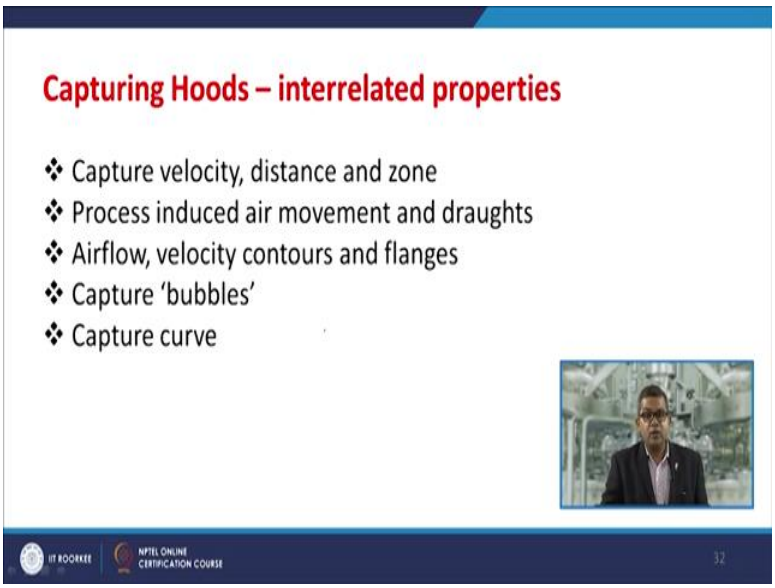

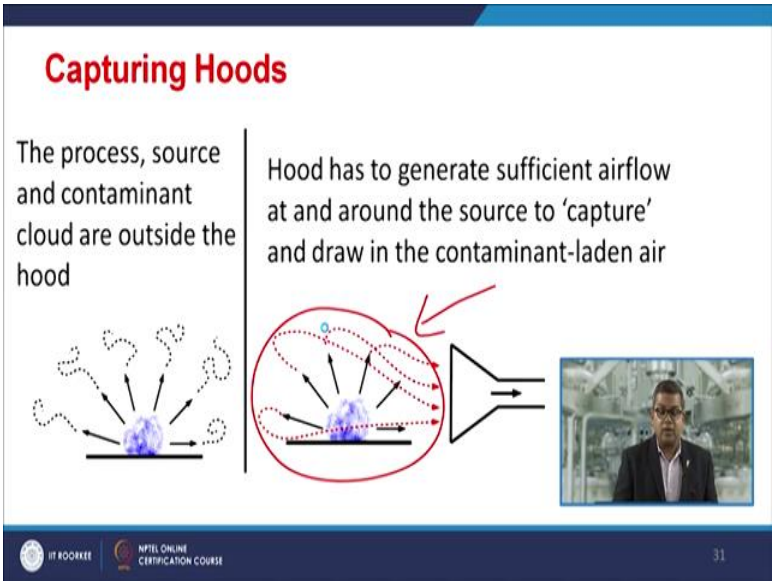

Now, while capturing hood, they are there certain interrelated properties they must have adequate capturing velocity, they must be properly placed at a sufficient distance and a zone. The process induced air movement and draughts must be well-defined. Air flow, velocity contours and flanges these are the various contours if you see, these are the various air flow contours it may it has it must be well defined.

You must know that, where you can have the different type of bubbles and you need to capture those bubbles adequately. You must form the capture curves by a priory before using any kind of ventilation technique.

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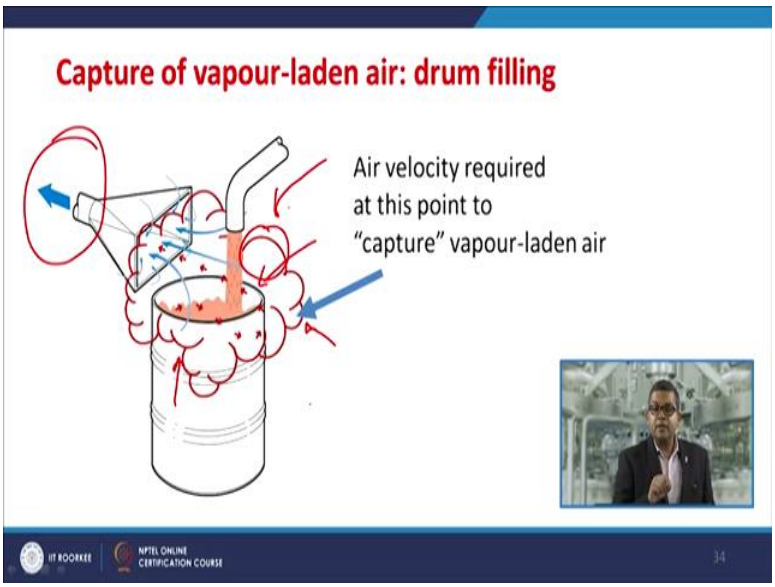

Now, this is again the typical problem. This is the problem of evaporation and you can see the different type of evaporating vapours, vapours these are the profiles of those evaporating

vapours. So, here because of the variety of reasons you cannot use the over enclosed hood then you may use the mobile or a zonal hood for to capture the vapours being generated sometimes these vapours are flammable in nature, they may form the flammable mixture. So in the previous modules we have discussed that the lower flammability and upper flammability limit. So, they may capture this thing and it may create a fire hazard to anywhere. So, be aware about this type of scenario.

Now, whenever again one more thing is that which we have discussed in the evaluation module, sorry. In this evaluation module, we have discussed the vessel filling operation, now whenever this vessel is being filled you may see the two type of effect, one is the rate of evaporation of that particular substance, another one is the rate of movement of those vapours to the upper part.

So in the last module we have discussed that it is dominated by the area in question, vessel filling operation etc. So based on the concentration at this juncture, the air velocity must be properly calculated and air velocity you may require to put some additional air velocity at this level to capture the vapour-laden air. So, remember again if you are handling with the flammable vapour then it may create a future problem like fire, etc.

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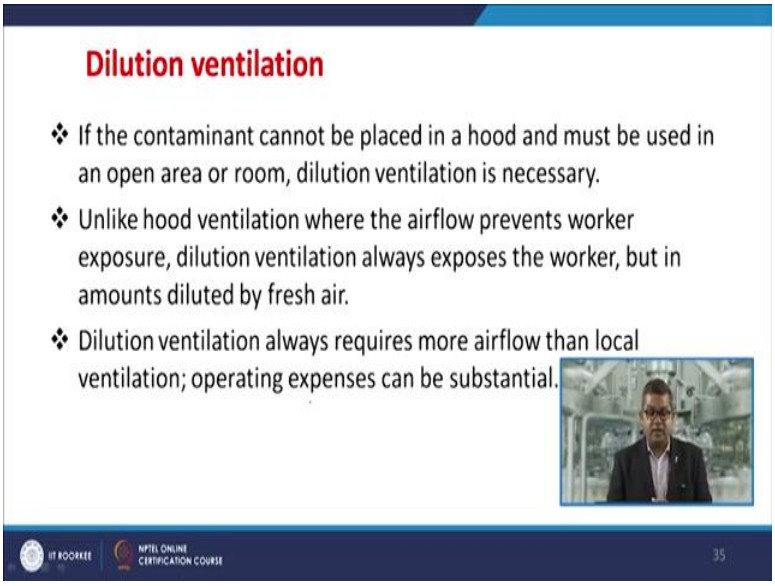

The last segment of this particular module is dilution ventilation. So, if the contaminant cannot be placed in a hood and must be used in an open area or a room, so you have to use the dilution ventilation. Now, unlike hood ventilation where the air flow prevents worker

exposure, dilution ventilation always exposes the worker, but an amount diluted by the fresh air.

So it is just like that I am working at this bench and some toxic vapours or a flammable vapour they are coming out from my pool then continuously some by a through external air supply I am diluting those generated vapours below the TLV or below the LFL, etc. So, dilution ventilation this always requires more air flow than the local ventilation, so you may experience that operating expenses this is can be substantial.

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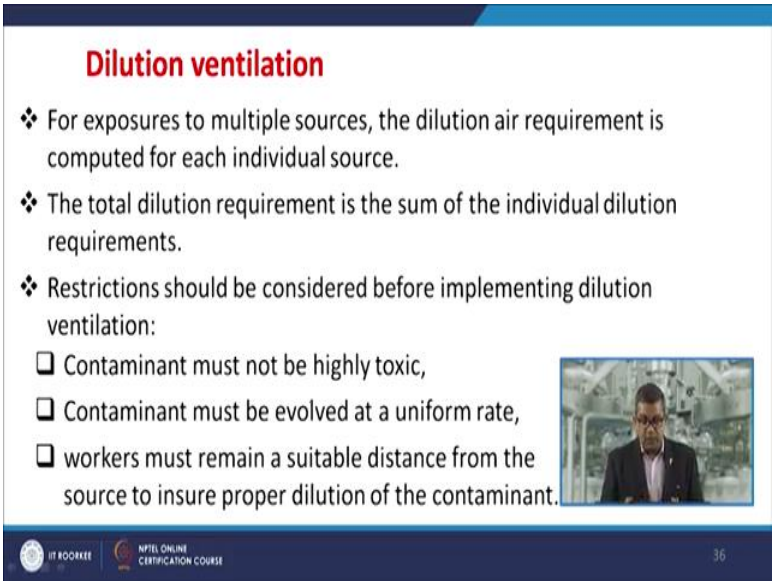

Now, for exposure to multiple sources the dilution air requirement is computed for each individual source because the rate of evaluation, rate of displacement may be different. The total dilution requirement usually is the sum of individual dilution requirement. Now, restriction should be considered before implementing the dilution ventilation that contaminant must not be very highly toxic because it is not removing remember it is not removing the toxic substance from your workplace, only thing is that it is keeping the concentration of those toxicant low. So, your workers are definitely those are in continuously exposed to those toxic vapours. So, that is why the contaminate must not be highly toxic.

Contaminant must be evolved at a uniform rate, the reason is that if there is any variation in the evolution rate then definitely the air supply or inert supply is change frequently. So, if the rate is on the higher side then definitely we need to put more air supply and if the evaluation rate is sometimes decreased then you need to put off the air because ultimately whenever you

are supplying excess air then definitely stuff no use and unnecessary you are putting more energy towards the generate the flow of that air supply.

Worker must remain at a suitable distance from the source to ensure proper dilution of the contaminants, so that has to be ensured because the concentration may vary accordingly suppose I am just putting my head over there then definitely the concentration would be on the higher side compared to if I am away from that workplace.

So, in this particular module we have discussed the various ventilation tools, various control measures applied at workplace. And in this particular segment we have discussed the industrial all aspect of industrial hygiene, right from identification to the quantification in terms of evaluation and then how do we control it, thank you very much.