Health, Safety and Environmental Management in Offshore and Petroleum Engineering

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Module – 03
Accident modeling, risk assessment and management
Lecture – 08
Fire prevention practices

Welcome friends to the 8th lecture in module 3.

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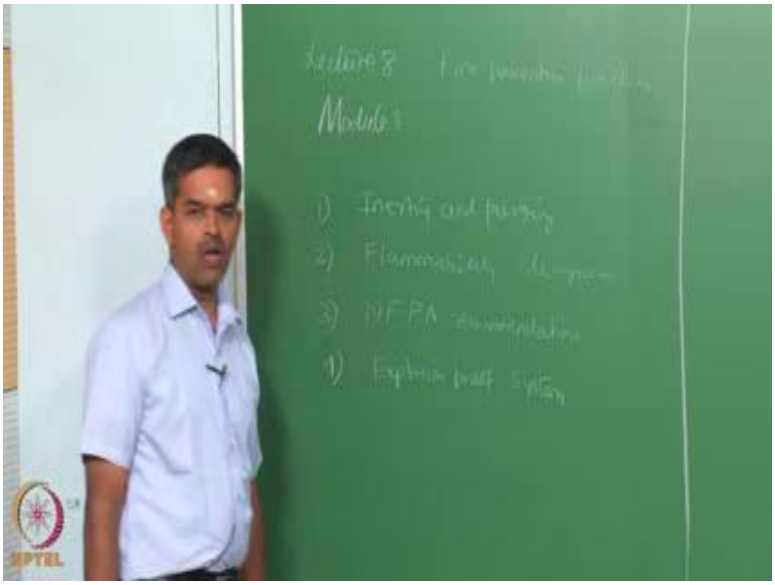

In the online course on HSE practices in this lecture we will talk about fire prevention practices. We already said fire and explosion is related to a rapid release of energy which needs to be controlled. In fact, there are 4 methods, what we advocated in the last couple of lectures by which fire and explosion can be assessed controlled and managed.

One could be essentially the process by which we do inserting and purging the second was effective use of flammability diagram to really see what could be the concentration of oxygen mole in a given mixture. So, that the given mixture does not remain within the flammability region. So, flammability diagrams can be effectively used as the tool the third could be strictly follow national fire protection agency recommendations, in terms of design layout LOC control etcetera the fourth could be providing explosion proof system either by design or by operational conditions. However, interestingly fire

prevention can also be done using sprinklers other kind of systems which we will see now in this lecture.

Let us talk about the control by which one can do by redesigning the ventilation for storage and process area.

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So, one can even take this as sort of guidelines which will be helpful. So, that in case of any fire by accident the fire can be controlled from its spreading to a larger area. So, in this let us talk about the storage areas first, what are the control phenomena or what are the recommendations given by international regulatory bodies for storage areas the ventilation inside the storage area is recommended as follows; one for the rate of ventilation being 0.3 cubic meter per minute per square meter floor area.

If we have a rate of ventilation of this order then one should provide interlocked alarm systems as one of the important recommendations for fire prevention on the other hand all alarm systems should be networked and such a manner they should be conditioned and controlled automatically that is what we say as interlocking with the rate of ventilation measurements, if the rate of ventilation is designed and maintained at this then no alarm if it is changed or altered significantly alarm should be automatically activated and that is a mandatory.

When ventilation fails then location of inlet and exhausts should be clearly visible for

cross movement of the pedestrians in the entire area.

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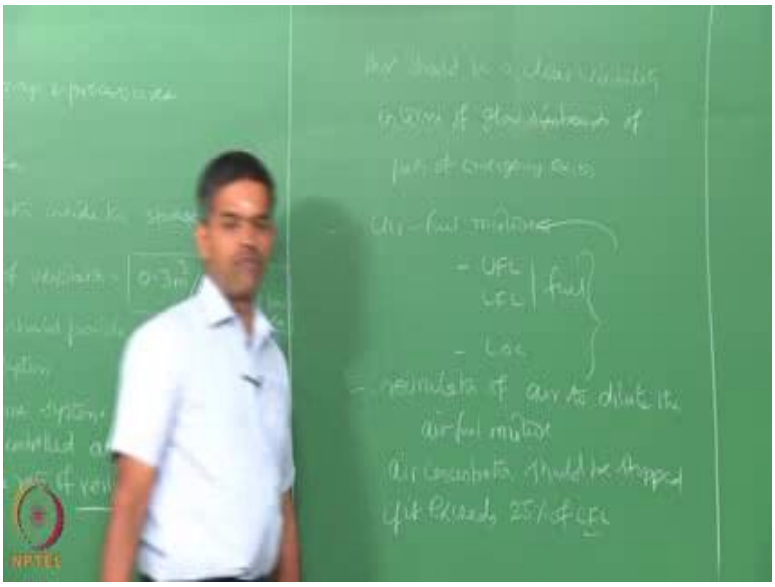

So, there should be a clear visibility in terms of glow sign boards of path of exit I should say path of emergency exits which should cause free movement across the entire area interestingly one can also allow recirculation of air because we know air fuel mixture which controls the UFL the LFL of the fuel which also controls the limiting oxygen concentration which is required for fuel to burn is all depend upon the air fuel mixture.

So, to control fire or to prevent let us say fire to spread further or to let us say outburst one can always also think of recirculation of air to dilute the air fuel mixture because that, can be one of the methods which can be intelligently thought of, but on the other hand please understand the air concentration should be stopped. If it exceeds if it exceeds 25 percent of lower flammability limit these are summary of interesting guidelines for the storage areas. Let us talk about the process areas which are highly vulnerable for fire accidents.

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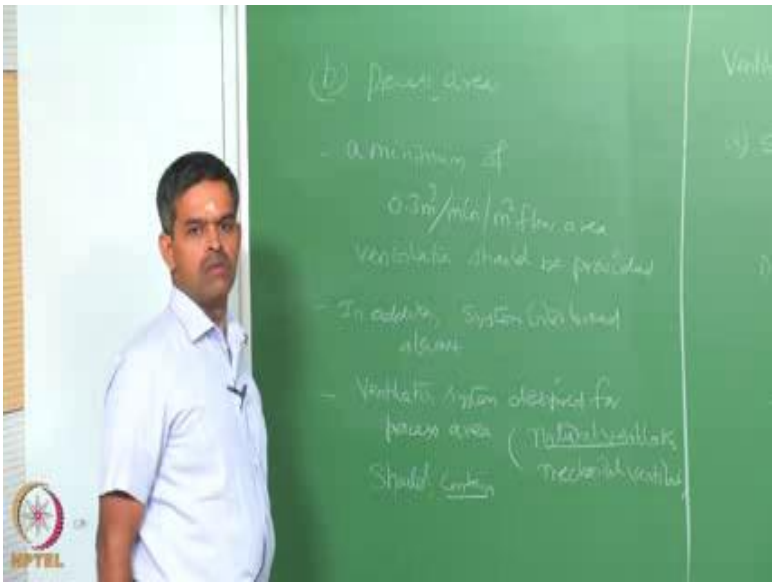

So, process areas a minimum recommendation of 0.3 cubic meter per minute, per square meter floor area ventilation it will provide in the design itself it should also have in addition system interlocked alarms in case the ventilation fails the ventilation standards are same for both storage and process areas the ventilation system what you designed for a process area should contain the concentration within 1.5 meter radius. So, the ventilation system designed for process areas one can ask me a question, what are the possible ventilation systems we can have? One can have a natural ventilation system depending upon your space location and availability, one can also have mechanical ventilation usually natural ventilation is difficult because of process generally happens in a closed confinement sector. So, people go for mechanical ventilation. So, the ventilation system designed for the process area should contain that is control the concentration of the spread if it outbursts should contain the concentration within 1.5 meter radius this is true when LFL is lesser than 25 percent.

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Additionally one can also think about sprinkler systems or fire fighting devices sprinkler systems are also one of the effective means of controlling spread of fire. So, they control spread of fire they cannot control the initiation of fire, but they can always control the spread of fire friends we all know and we agree that, it is mandatory for all process plants including the downstream sector of oil and gas industries to have a well designed sprinkler system for ensuring safety to personnel plants and equipments. What are the common sprinkler systems which are generally discussed and used in oil and gas industries? So, let us see what are the common sprinkler systems and what are the standards, which are used in oil and gas industries topmost in the list is what we call anti freeze sprinkler system anti freeze sprinkler system actually consists of a wet pipe. What do you mean by a wet pip? Wet pipe is a pipe which always contains an anti freezing solution.

Anti freezing solution which will also be connected to water supply system in case fire outbursts the sprinkler system opens in case.

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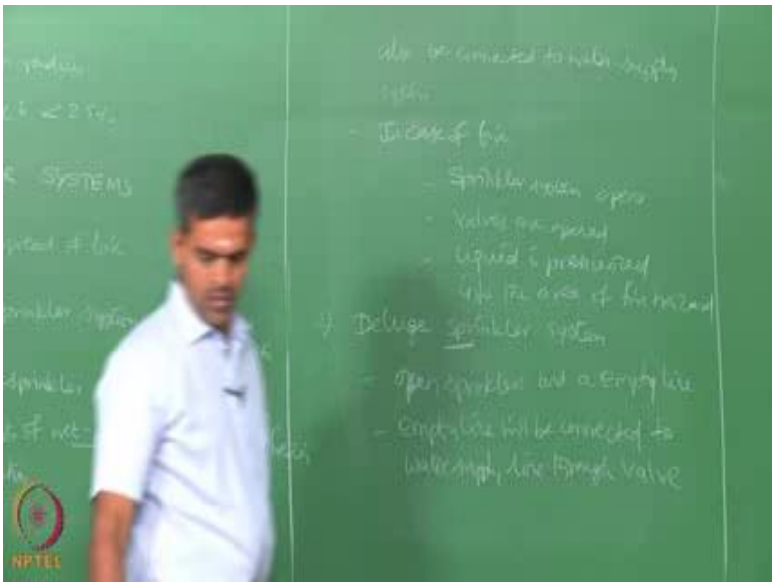

In case of fire sprinkler system opens valves are opened and the liquid is pressurized into the area of fire hazard. So, we call this as anti freeze sprinkler system, the second system which is also commonly used in downstream sector of oil and gas industry is deluge sprinkler system deluge sprinkler systems consist of open sprinklers and an empty line. So, they have open sprinklers and empty line the empty line will be connected to water supply line through a valve.

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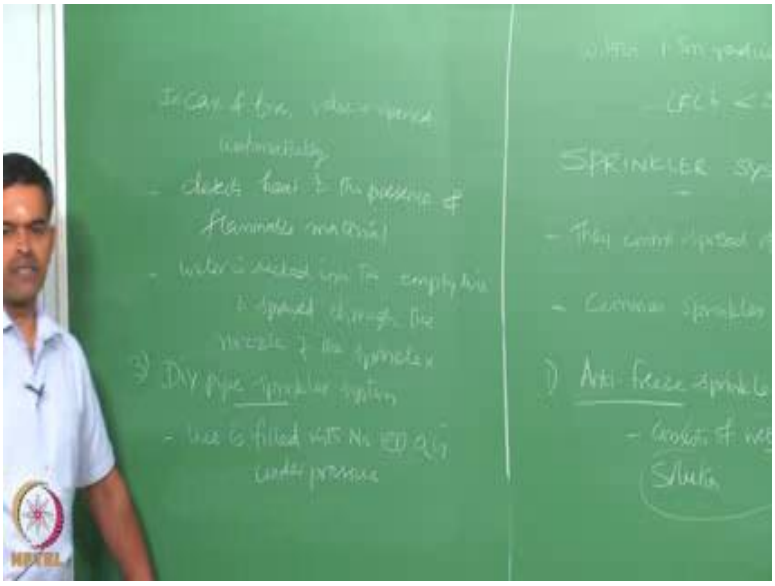

In case of fire the valve is opened automatically because, it detects heat and the presence

of flammable material on detection of these 2 the valves open and water is pumped into the line. I should say water is sucked into the empty line and sprayed through the sprinklers. Let us say through the nozzle of the sprinklers which controls the spread of fire this system is called deluge sprinkler system the third which is also a common practice is a dry pipe sprinkler system this system is generally filled with nitrogen or air under pressure the line is filled with nitrogen or air under pressure.

So, in the first case you saw the wet pipe is filled up with anti freezing solution of course, connected to water supply line also to make it wet all the time the second was an empty line which has no fluid inside, but the empty line will connected to water supply system and the valves will break open. When they have excessive heat detected because of the flammable presence material the valves open, water is sucked inside the line and spray it to the nozzles.

In the third case the dry pipe means that the pipe is not actually filled with water or with anti freezing solution, but contains nitrogen or air under pressure, When the sprinkler nozzles are opened because of detecting detection of heat the system is depressurized and allows water to flow into the system which is further sprayed through the nozzle.

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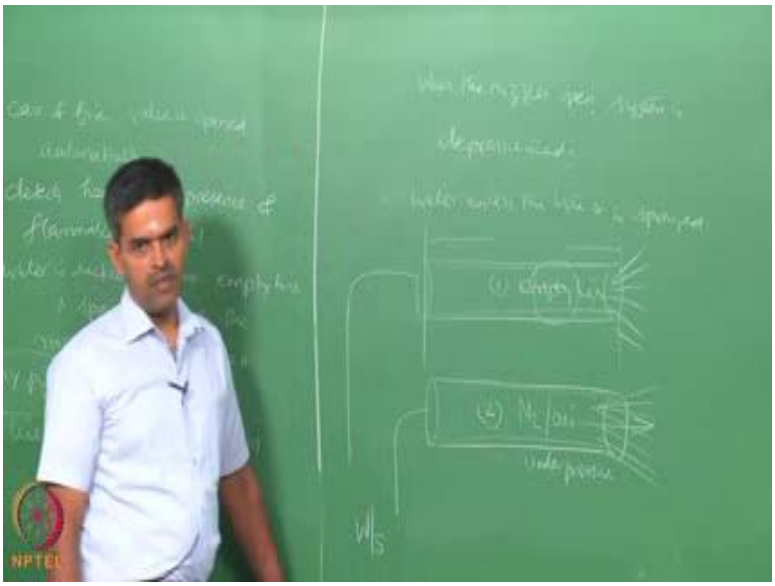

So, when the nozzles open system is automatically depressurized water enters the system or enters the line and is sprayed, then one can ask me an interesting question, when the water ultimately has to be sprayed through the nozzles then, what is actually the

difference between a dry pipe sprinkler system and the deluge sprinkler system.

Why a dry pipe should be filled either with nitrogen or air under pressure very interesting question let us imagine a pipeline in both the cases of some diameter. Let us say this is case one which refers to the deluge which is empty line this is case two which refers to pipeline filled with either nitrogen or air under pressure both are anyway connected to the water supply line both are sprinkler nozzles. When the valves open in this case the water is sucked from the pipeline here line is filled with water it is sprayed and fire is controlled spread of fire is rather controlled in this case. When the nozzles open system depressurizes releases air or nitrogen first followed by spray of water ultimately in both the cases the control is only by spread of water through the nozzles, but there is an advantage in second system as compared to the first one.

In case of the first system even after the nozzle opens and the valve is made to open to suck the line there can be a very good time delay depending upon what is the length of the line. How many bends the line has and where is the nozzle opening and the suction or the air lock inside the line will take some time to get released sometimes they can also spoil or damage the pressure nozzles. So, it may partially work and not completely, where as in this case since the system is already in pressure the nozzles are ready to receive that pressure once it is depressurized when the nozzles open there is always an instantaneous and smooth flow of water into the line and immediately the water will start spraying on the space. So, the time delay cost by option one because of air lock in an empty line is completely avoided in the second case.

So, that is very interesting and also when the fire fighting system is not in use since the line remains empty there is always a possibility that the inner layer of the pipelines can get corroded because of environmental effect on the outer cover of the pipeline where as in this case because of the containment of the material inside may be nitrogen or air the corrosion possibilities of this line compared to this is far lesser.

So, you always have a long serviceability guarantee of working in case of demand in system two compared to one therefore, generally people feel system two is better compared to one then one can ask me a question what is advantage of anti freezing sprinkler system, why do we use an anti freeze solution in certain cases ? When the temperature goes lower in cold regions or cold countries water may not be available in a

flowable state. So, in that case it can also cause an air lock in the line even though the valve is opened. So, people generally use anti freeze solution to fill up this which is then connected to the line and the water line pushes this and therefore, it starts spraying.

So, the purposes of different options given in sprinkler systems are to avoid a time delay or to avoid the air lock in a given line. So, that the sprinkler nozzles work effectively and instantaneously starts spraying water as and when, they are demanded to do. So, that is how the difference between system one two and three by enlarge is about fourth option can be a wet sprinkler system.

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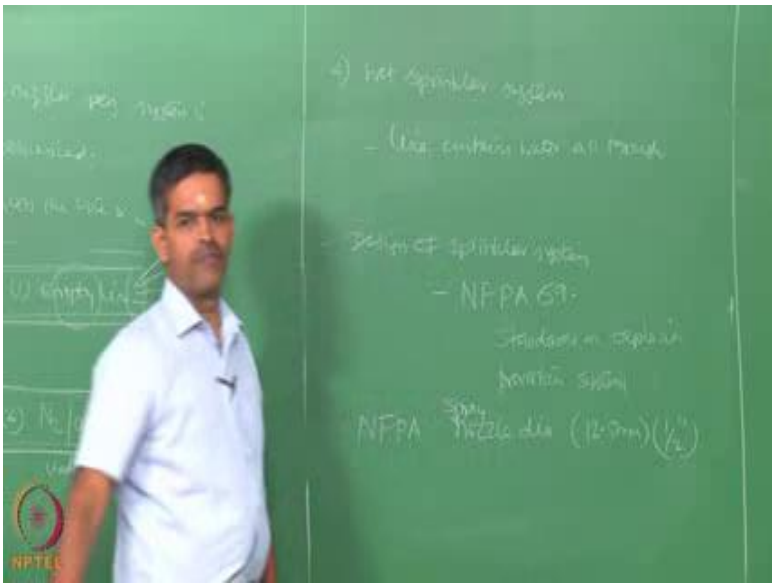

This system contains water all through the line contains water all through all the time which is discharged through the nozzle when the nozzles open when fire outbursts in a given plant now all the four methods of design of sprinkler systems are directed by standards of NFPA 69 which says standards on explosion prevention systems, as per NFPA norms the nominal discharge rate for an specific diameter is fixed generally as per these NFPA norms. The nozzle diameter which is used for spraying or discharging is about, let us say twelve point five millimeter that is half an each that is a spray nozzle. What could be the nominal discharge rate the nominal discharge rate can be easily seen from the table shown in the screen now.

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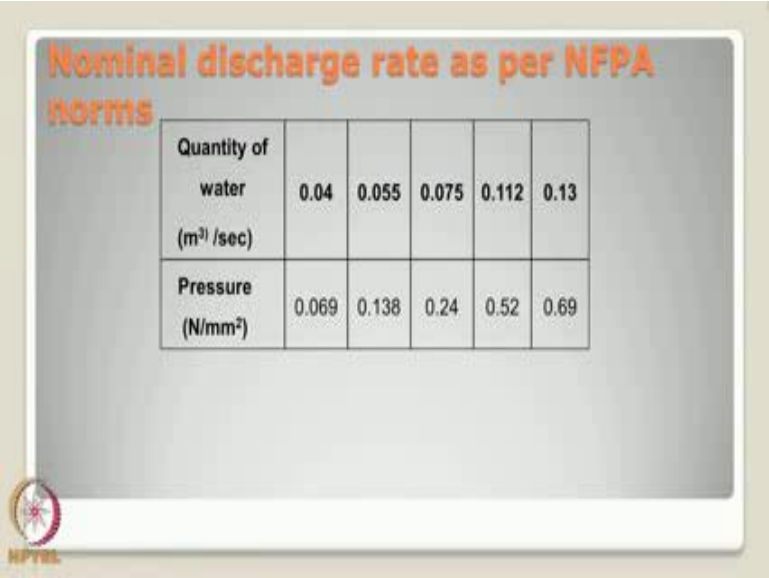

For different cases of quantity of water in q secs that is cubic meter per second and the corresponding pressure associated with that in Newton per millimeter square.

Depending upon your quantity of water to be sprayed through the nozzle which depends upon the diameter of the pipeline and the discharge from the water supply tank to the pipeline etcetera you can always see what could be the extent of pressure which can be generated depending upon the quantity of flow what you admit in this sprinkler line.

So, these are some of the methods in the few lectures we discussed about fire and explosion control planning and management and modeling fire and explosion is instantaneous release of energy which can cause detonation and deflagration. It has got a cumulative effect; one is when the peak overpressure is reached it causes damage followed by which the pressure drops and becomes negative which is also causing the sectional damage in the given pipelines or in the given system. So, it because a cumulative damage over a period of time which is to be prevented or to be avoided, one case damage should be as far as possible minimized.

Now, the second as far as oil and gas industries are concerned in terms of process plants is a toxic release and dispersion models because we are dealing with chemicals which can always have an accidental release in the atmosphere people living around the vicinity of the plant production plant or the process unit can be also affected, it can cause an individual as well as societal risk if the threshold value of the discharged chemical

dispersed in the environment reaches or exceeds the permissible limits as acceptable by human standards. So, let us quickly now look into in detail about the toxic release in dispersion models.

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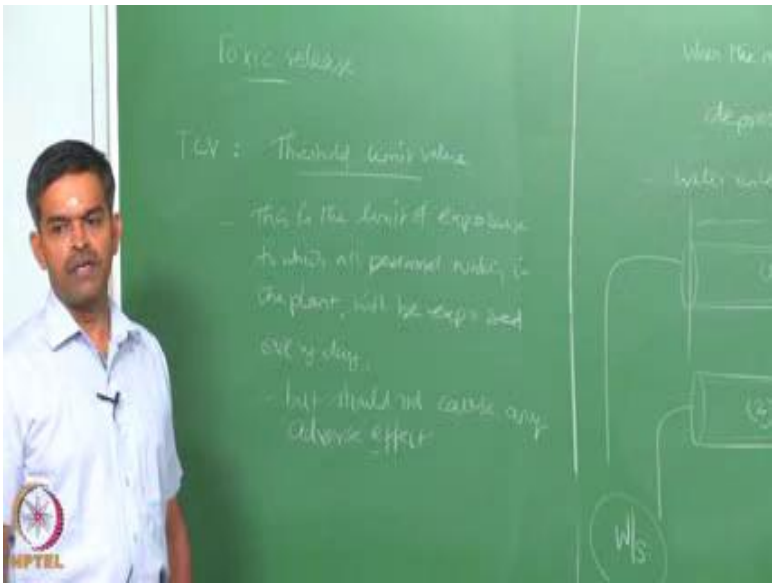

The moment I said toxic release you cannot hundred percent avoid this release because I am talking about accidental release of these toxic chemicals then what should be the upper limit with which an human being can sustain this what we call as TLV. TLV stands for threshold limit value.

Threshold limit value represent conditions to which all workers will be repeatedly exposed everyday without any adverse health effects, it means this is the limit of exposure to which all personnel working in the plant will be exposed every day, but should not cause any adverse effects. So, what is that threshold value of every chemical which is generally used or generally released in a process industry of oil and gas? Therefore, for any dose value below this human body can be detoxified and it is not harmful.

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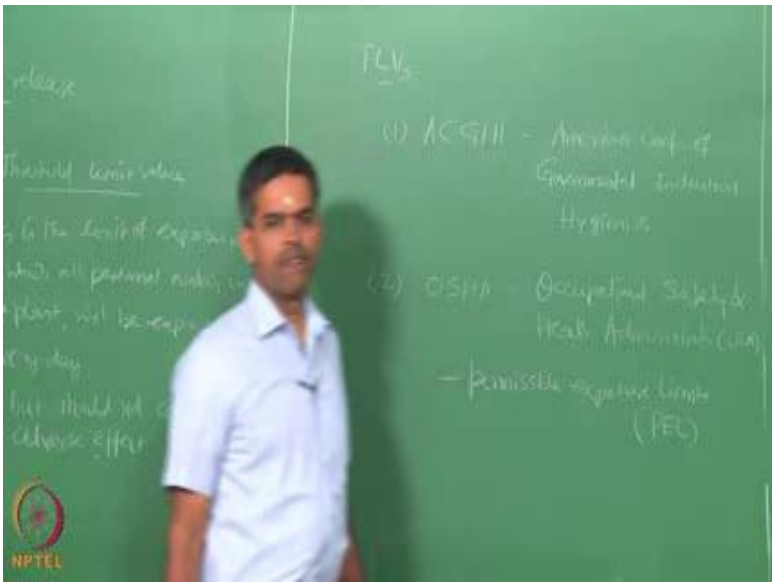

So, TLVs the threshold limit values are advocated by two agencies internationally one is suggested by ACGIH. This stands for American conference of governmental industrial hygiene's the other standard of TLV limits for chemical exposure is advocated by OSHA, which stands for Occupational Safety and Health Administration of the united states. OSHA of course, defines the permissible exposure limits and does not give you the recommended values of PLV which slightly differs from ACGIH, recommendations it gives the value in terms of permissible exposure limits for personnel working in process industries TLVs are of three types.

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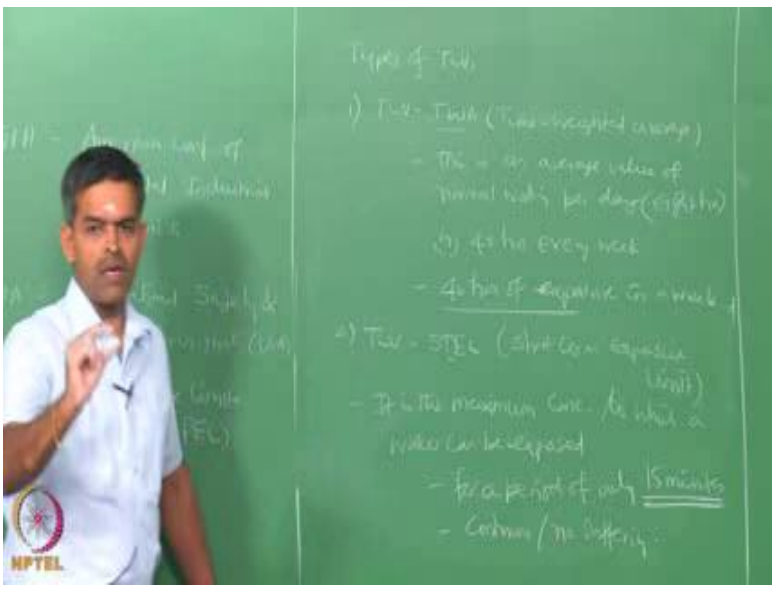

One is what we call TLV, TWA. TWA stands for Time Weighted Average, this is an average of normal working hour a day this is an average value of normal working per day usually it is 8 hours or it is 40 hours a week, because Saturday, Sundays are not considered to be a working day in a process industry.

So, it is actually 40 hours of exposed of exposure in a week that is what TWA means. So, you got to average the threshold limit values over this working hours. If you try to find out that limit that limit is called TLV, TWA. The second one is TLV stel. Stel stands for short term exposure limit. Interestingly it is the maximum concentration to which worker can be exposed can be exposed for a period of only 15 minutes. So, beyond 15 minutes it can result in fatal while during 15 minutes it can be continuous, but no suffering. So, if you are able to find out that chemical concentration to which a person can be exposed for 15 minutes continuously without any suffering that maximum concentration which a person can sustain for 15 minutes continuous exposure is what we call threshold limit value of short term exposure limit. The short term is because it is for a very small failure and that is going to talk about the limit what we have seen.

So, therefore, it is maximum concentration if it exceeds their concentration then if TLV TWA or TLV stel are exceeded.

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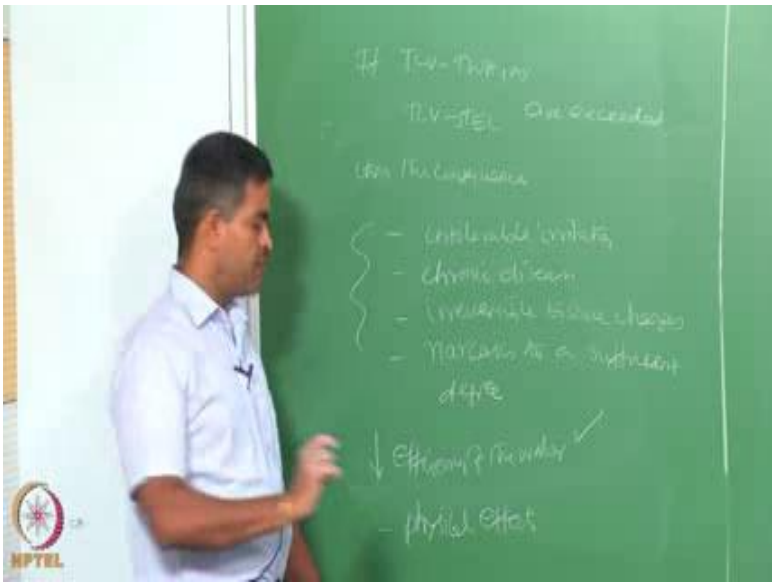

Then the consequences could be intolerable irritation chronic diseases tissue irreversible tissue changes narcosis to a sufficient degree all these will reduce the efficiency of the

work that is the first problem we have. Secondly, you will be able to indirectly know that the concentration will be exceeded by looking at these physical effects because these are all physical effects and they cannot be measured except that you can see a person and notice that these are all being happening on him and with that consequences physically happening one can always know that the threshold value concentration in the given system is exceeded.

So, there are different ceiling limits which can be computed for this.

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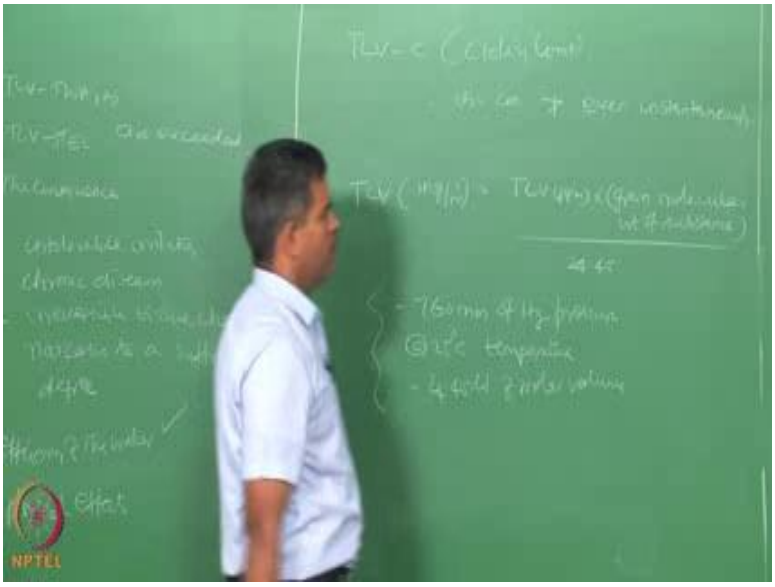

If you look at TLVC, which is called the ceiling limit it is that concentration which should not be exceeded that is why it is called ceiling limit it is this concentration which should not be exceeded at all even by accident or even instantaneously. So, the concentration cannot be exceeded even instantaneously. So, this can be also found out in milligram per cubic meter which can be given by if you know the TLV, value in parts per million then multiply this with gram molecular weight of the substance divided by 24.45 because, this corresponds to seven 60 mm of mercury of pressure at 25 degree Celsius temperature with 24.45 litres of molar value which already has been given to you in the previous lecture, but just for completion sake I am writing this equation for our understanding.

One can also estimate the chemical hazard exposure evaluation using time weighted average method weighted average will be able to estimate the concentration in parts per

million.

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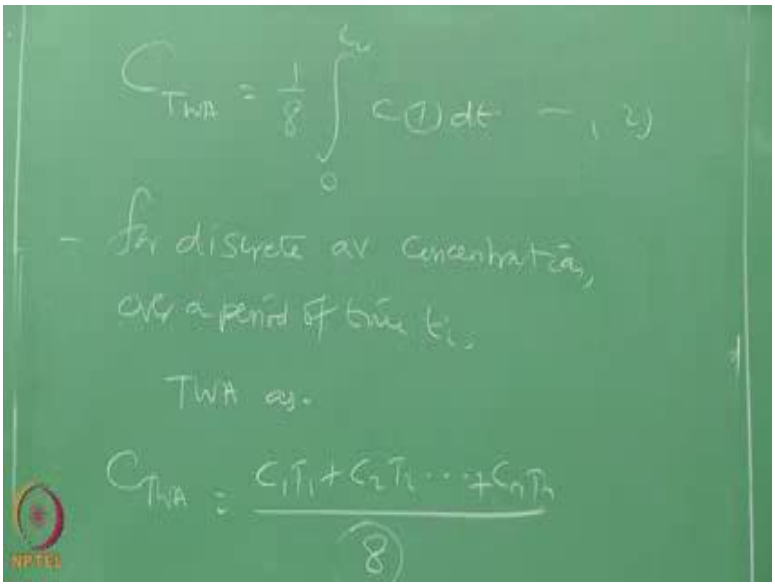

As an average over a given time which is TWA, which can be over 8 hours a mixed concentration of 0 to TWTC of dt can be simply sum of the chemical exposure of different concentration over a period of eight hours and make an average of this. So, we call this as time weighted average concentration, if you have a discrete concentration. Let us say it is not continuously exposed where, there is a break for discrete average concentration over a period of time T 1 can easily find the time weighted average concentration as let us say C TWA instead of continuous we can say different concentration for different time divided by let us say 8 hours because this 8 hours exposure is fixed. Now interestingly one has to really know what is the efficiency of reduction in the worker capacity when you have this exposure available by because of chemical release. So, one need to calculate what is called overexposure at workplace.

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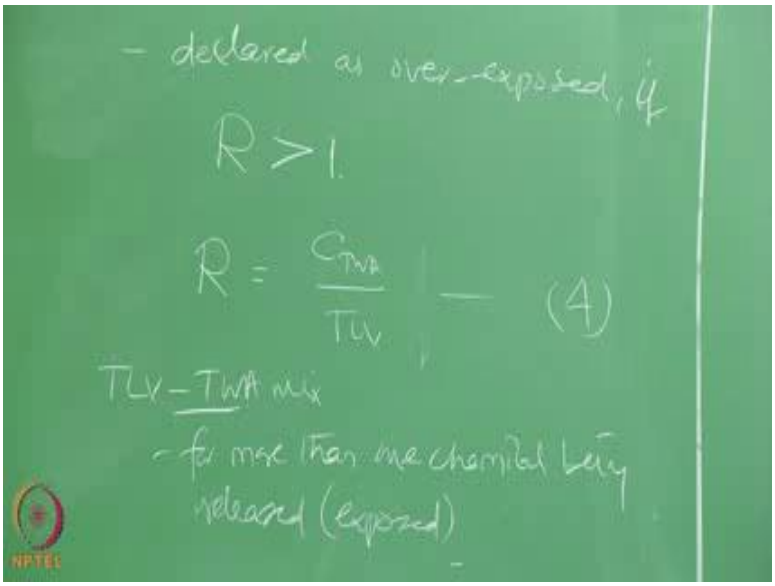

The work place is declared as overexposed the workplace will be declared as overexposed if the R value exceeds one where R is called the overexposure limit which is given by the time weighted average by the threshold limit value of the chemical.

Let us say this equation number four if I have a mixed concentration, let us say it is not a single chemical, but the mixture is keep on changing then one can go for TLV TWA mixture for more than one chemical being released at a time being released let us say R exposed one can calculate the mixture of time weighted average.

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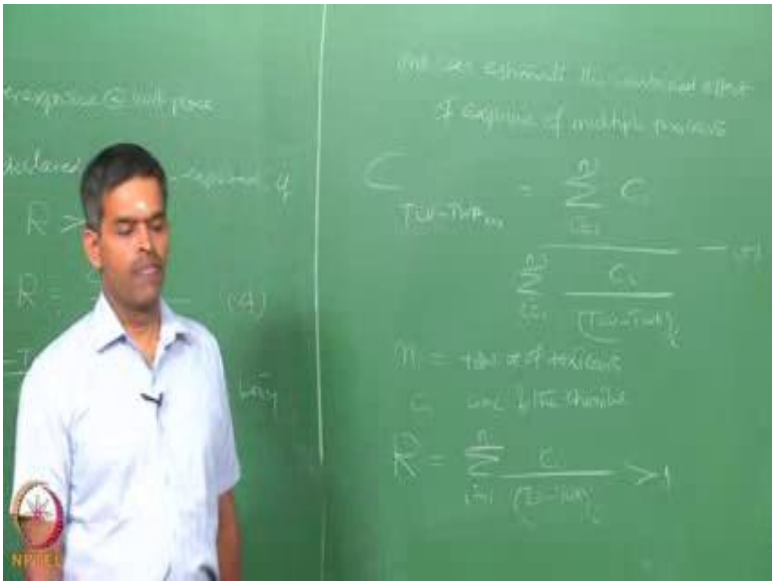

So, one can estimate the combined effect of exposure of multiple toxicants which can be given simply by the concentration of TLV TWA mix is given by sum of I equals one to n of different a concentration TLV TWA mix is given by sum of I equals one to n of different concentration divided by sum of I equals one to n c I by sum of this TLV TWA of every ith chemical we call this equation, number 5 where, in this summation n is the total number of toxicants c I of course, is a concentration of the chemical of the ith chemical let us say with respect to the other toxicants the respective chemical I is what is beginning exposed in workplace in that case the overexposure limit on the workplace can be given by summation of I equals one to n c I by TLV TWA of I n should exceed one if it exceeds one then we can say it is overexposed.

Friends, in this lecture we are able to understand different fire prevention methods apart from what we discussed in the previous lectures. We have also learnt about the another important hazard present in oil industry in terms of downstream industries what is the chemical release we have seen that threshold value can be discussed by 2 international regulatory bodies based on which the TLV, the threshold limit values can be declared as accepted.

If you are able to compute them in different formats and ultimately estimate what we call overexposure limit in a given system. If the overexposure is ensured and is foreseen then it will result in a hazard which can decrease efficiency of the worker in a given plant as well as it can be even fataled to the working person. So, personnel safety can be challenged if the chemical exposure exceeds the maximum permissible limits as advocated by international agencies.

Thank you very much.