Health, Safety and Environmental Management in Offshore and Petroleum Engineering

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Module – 03
Accident modeling, risk assessment and management
Lecture – 09
Industrial hygiene control

Friends, today we look at the 9th Lecture in Module 3, where we are going to focus on Industrial Hygiene Control.

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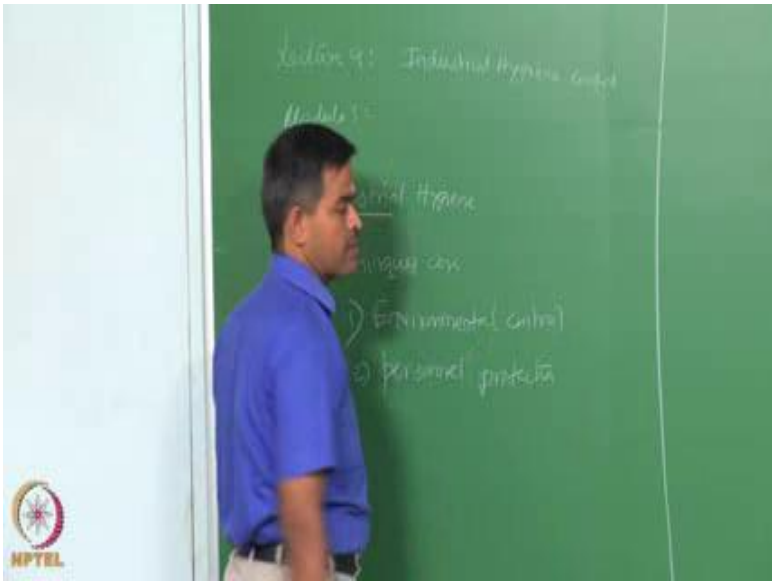

This is lecture in Module3 where our focus on accident modeling, risk assessment and management. We already saw that how fire and explosion can be averted, prevented, how they can be modeled effectively so that fire and explosion can be avoided to some extent. Or the serious damages which could arise from an explosion may be detonation may be deflagration can control to some extent so that the economic loss does not matter much in case of explosions.

Extending the study we will focus on industrial hygiene control. There are two major

techniques by which you can control hygiene in the industry. The two major techniques are; one environmental control; second would be the personnel protection. So, when you talk about environmental control the main aim in environmental control.

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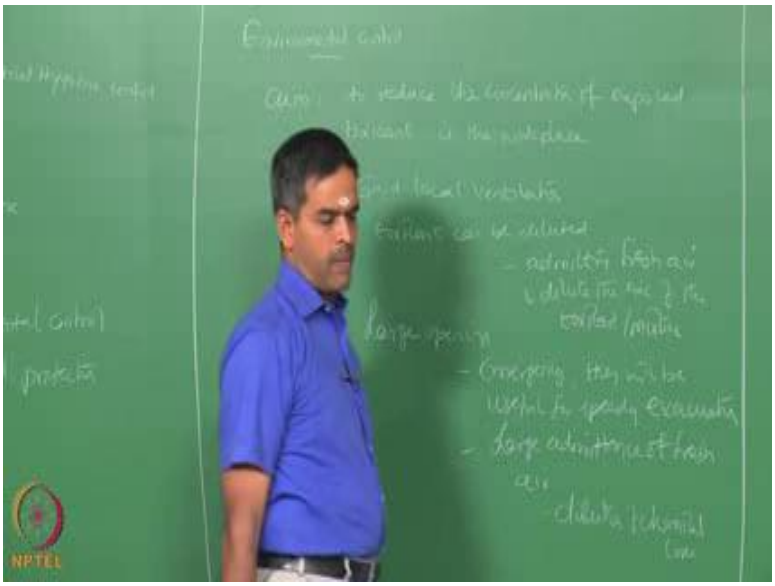

The main aim is to reduce the concentration of expose toxicants in the work place. So, the main objective is to reduce the concentration of exposed toxicants in the work place. How to achieve this? One should provide good local ventilation. One should also see how possibly toxicants can be dilute diluted in sense by admitting fresh air and therefore dilute the concentration of the toxicants or the mixture.

So, one can also provide good and very large openings. These have two purposes; in case of emergency they will be very useful for speedy evacuation, two it becomes also easy and convenient to have large admittance of session, so this very useful in diluting the chemical concentration. One can also alternatively use what is called wet methods.

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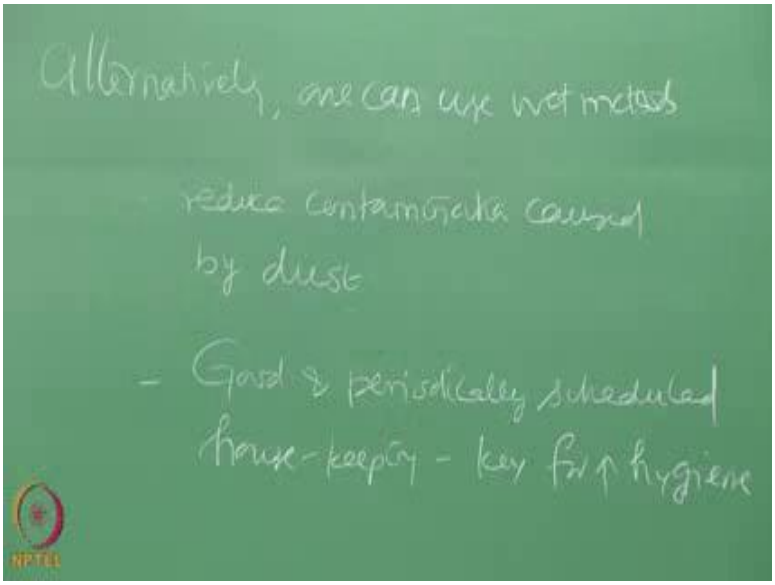

By making the surface wet you can always reduce the contamination caused by dust. More importantly a very good and periodically scheduled housekeeping is the key for an improved hygiene in the industry. And this helps to control the toxicant concentration and the dust contamination to a very larger extent in your places. The second idea could be personnel protection.

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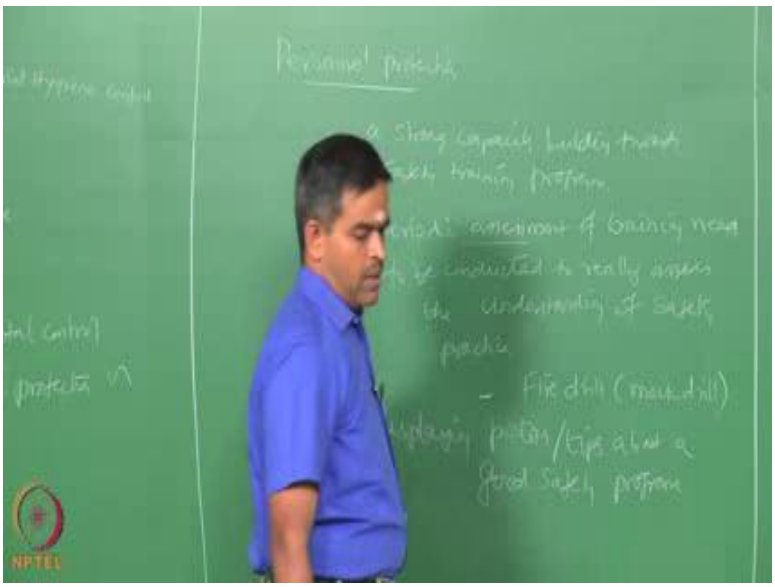

The foremost interest in personnel protection is a very interesting and a strong capacity building towards safety programs; let us say safety training programs. It is also interesting that periodic assessment of training need to be conducted to really assess the understanding of safety practices. Sometimes you know people used to conduct fire drill which is essentially a mock drill, but this is going to give one to hand experience in case of any fire etcetera.

So, periodic assessment of training is also important in addition to that one can also use certain safety measures by displaying posters or let us say tips about a good safety program. I have seen a very interesting poster which I would like to share with you in one of the work places.

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It will say HSE; Health, Safety, Environmental management actually comes in cans. They draw as picture of a can as it comes in cans; you can, I can and therefore we can. So, this kind of posters will help people to develop self confidence on the workplace safety. And you should also indicate rules about rules on let us say do's and dont's very specific in case of work places.

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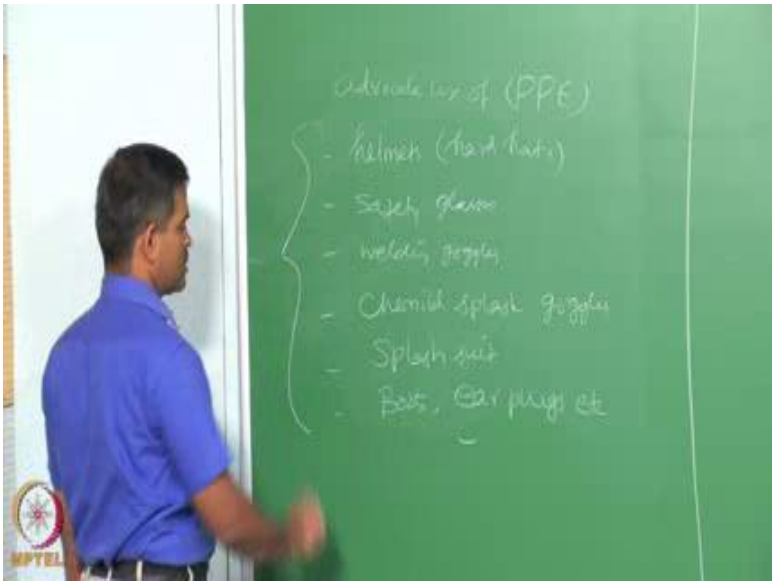

People should also advocate use of personnel protection equipments; PPE like, helmets or what they call in industrial language as hard hats, safety glasses, welding goggles, chemical splash goggles, splash suit, boots, ear plugs, etcetera. So, one should always advocate very strongly, in fact the industry should supply and their cost all these personnel protection equipments to people on board so that one can always improve the industrial hygiene to some extent.

Once we talk about accident modeling and we learn how accidents are occurring and how they actually spread because you have seen dispersion models. You have understood the causes because of over pressure and negative pressure. We have already seen what is a blast wave and a shock wave, the difference between detonation and deflagration which occurs essentially from the dust and from the chemical pollution.

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So let us now see, what are those elements which are important to control process accidents? We all agree and know and now at least realize that chemical plants are an important source of accidents. I mean there is no doubt on this because the process is highly hazardous and eventually a situation may change and this can become a disaster. For example; oil spill, fire, explosion, toxic release of chemicals, reactor run away, fugitive emissions, etcetera. Which are unavoidable and they are really accidental.

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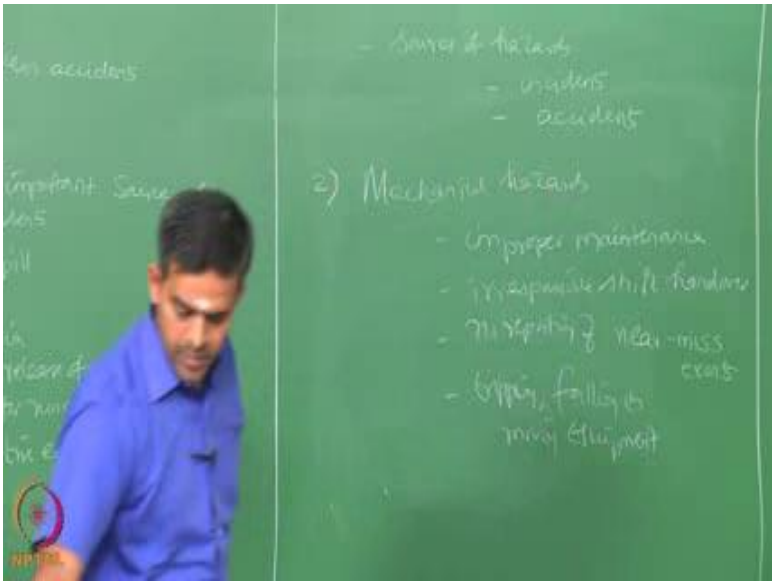

So, these are possible sources of hazards. If not managed properly they may result in initially incidents and then they can propagate to become or they can grow to become accidents. We already know terminology difference between incident accident, hazard and risk, etcetera. In addition to this the second interesting sources of process accidents come from mechanical hazards. These are because of chemical plants or chemical releases stock of inventory of chemical. Mechanical hazards can also be very interestingly a problem in process accidents. This includes improper maintenance, irresponsible shift handovers, no reporting of near miss events, improper because of tripping, because of falling or moving equipment.

So, they all become main contributors for oil spills, fire and explosion in chemical industries. Let us quickly summarize them interestingly.

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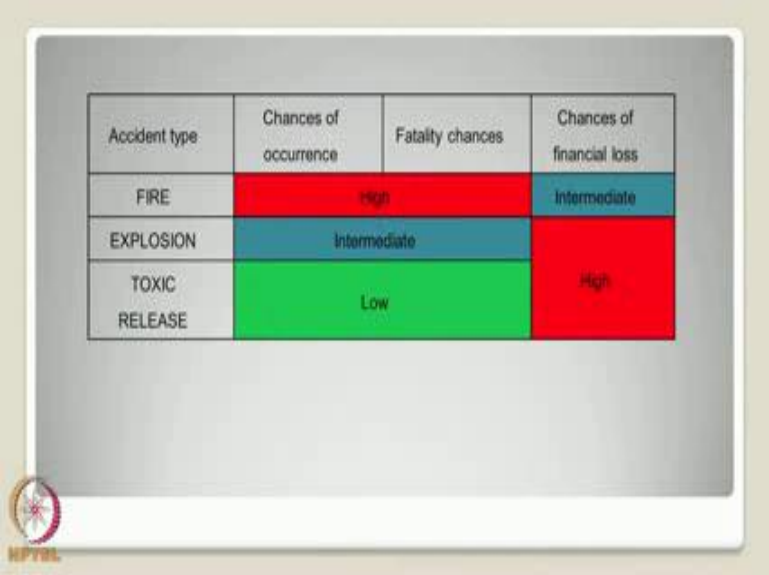

Please pay attention to the comparative chart or in fact a table which is shown on the screen now. Let us look at three major type of accidents; fire, explosion and toxic or chemical release. Let us divide this into three categories of chances of occurrence that is probability of occurrence fatality chances that is the consequences are very highly damaging or we can also see what the probability of financial loss is. As I said risk assessment and management should ultimately encounter or encompass also the financial aspect or the economic prospective.

So, if you look at fire as an accident type the probability of occurrence and if it occurs the fatality chances are very very high, whereas the financial loss is intermediate. Whereas look at the explosion the probability of occurrence and fatality are intermediate, but if they occur by any chance the financial loss is phenomenally high. Same with the toxic release, but one good thing about the toxic release is generally because of effective design and good dilution of released chemical because of addition of fresh air in dispersion models you know the chances occurrence and fatality result from those occurrences are relatively low compare to these two type of accidents but however, the financial loss involved is very very high.

So, one looks actually a combination of this. So, accident type may be fire, since because

the financial loss is intermediate we need not be happy. On the other hand the toxic release the chance of occurrence in fatality is very low we need not be happy. All the three are important to be handled in risk assessment and management very effectively.

Having said this now let us talk about some discussions on toxic release models, because we discussed about the fire and explosion models in detail we have understood how they can be modeled and what are the serious consequences, how you can easily find the work place over exposure limits for a given mixture. If such chemicals or toxicants are released in environment how do we mathematically model them and actually how do we know what is the indirect risk caused by these kind of released chemicals to the society and to the individuals. To know that let us start with understanding the different class of hazardous materials.

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Now, hazardous materials come under different variety which are very commonly used in (Refer Time: 17:02) industries like oil and gas downstream sector. Let us say flammable material, in our case the hydrocarbons are highly flammable. Combustible material, in our case the gas and oil produced are highly combustible in nature. Toxic chemicals, in our case whatever chemicals we add for recovering the commercial oil and gas from the crude oil processing is all toxic.

We also deal with what we call unstable materials that is why interestingly we have understood the dispersion models in TNT equivalence. If you remember in the previous lectures we discussed about this TNT's considered to be one most unstable system which can be easily mix up, and highly reactive chemicals. Now they all fall under the category of hazardous materials we deal with almost all of them. Once you have a presence of hazardous material then accident has got three stages which already discussed earlier, but let us apply this towards safety practices.

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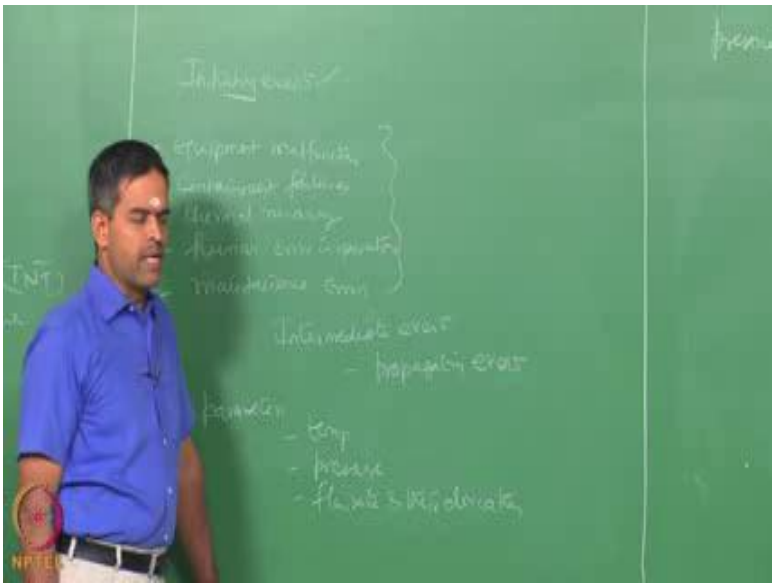

So, there are three stages initiating events which can arise from equipment malfunction, containment failures, which can also arise from thermal run away, human error in operations which arise because of over sighting, maintenance difficulties or maintenance errors. These all can be interestingly powerful initiating events which can result in a very catastrophic accident.

Once the initiating events are existing then they can be something called intermediate events which are also otherwise called as propagating events. Now these events are responsible to propagate the initiating events to result in a catastrophic disaster. What would be the parameters which would be adding significant contribution to propagate an initiating event? The parameters could be temperature, pressure, flow rate and their

deviations; they all could be interesting parameters.

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In addition to that let us say presence of toxic material in abundance, presence of ignition source, or explosion possibilities are all examples for events which can propagate the initiating event and leading it to for the disaster. Of course, we all agree and we know because you may be asking question here, sir we in offshore industry or process industry do you have any control mechanisms which are designed as a part of the system which can control either the initiating or the propagating events; answers are yes. There are intermediate mitigating events. Let us quickly see what are they?

We can say safety system responses. Some examples can be given here relief valves, let us say PRV pressure relief valves, grounding, and back up utilities. We have power back up utilities in case of uninterrupted power supply, in case of external DG sets etcetera. All these can be identified as safety system responses. We also have mitigating system responses.

So, mitigating responses are also present in a given system. For example, they have lot of emergency events given in containers to escape out the extra fluid or the chemical, toxic chemical which is packed in the vessel. We also something called blow out valves which

open in case of emergency. We also of course have containment dikes which you must have seen. In case of oil storage flares we also have flares and sprinklers etcetera as mitigating system responses.

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In addition we also have contingency operations. Friends it is important when you talk about risk management and assessment or industrial safety practices you have to use actually the appropriate terminology that is very important. You can list all of them in one shot and say these are my safety devices, but they are actually grouped in different functionalities. So, one should pick up these terminologies properly and when you speak about them you should always use these kinds of phrases that is important, that is way I am making you to align you are thinking in this form.

It is not that we do not know all of them we have been in industry practice, we know what we mean by grounding, what do you mean by back up utilities, and what do you mean by vents and blow outs valves we know them. But the question is how to group them because there are mitigating events, why as intermediate because all of them or most of them will work only when initiating event occurs. It means a blow out valve will not open until the pressure exceeds a threshold value. Pressure exceedance of threshold value itself is what is called as an initiating event. Therefore, most of these responses

may be the safety system response the mitigating responses will be active only when initiating event is started. That is why we put them in intermediate mitigating events.

So, as continuing here contingency operations also we have like, alarms, we also have emergency procedures which should be followed in case of any a happening, etcetera. In addition we also have personnel safety equipments which are also useful in intermediate mitigating events. We also have evacuation procedures, we also identified assembly point in case of emergency in every plant it is must and you would have seen this, security alerts may be sirens, etcetera. All come under mitigating events which are intermediate in a process industry.

Once we have an initiating event we have the propagating events even though mitigating events are present ultimately it may result in an incident or it may lead to an accident.

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So, occurrence of accident is unavoidable because there are many uncertain parameters which can lead to occurrence of accidents, but what we are interested is to reduce minimize the consequences of accidents that is very very important. Therefore, a good safety program for industrial hygiene will focus on reducing the consequences of accidents. A best safety program will talk about even reducing the probability of

occurrence of an accident itself in addition to this. So, when both are addressed we can call that program as a best program mostly this is addressed in all safety programs in industry so we call them as good safety programs and we need to tell about a bad safety program we all know that.

Now, the question come accident or occurrence of accident is actually unavoidable, because they happen because of very high uncertain parameters. We have already seen the presence of initiating events and the presence of propagating events will lead towards accidents which are all present. Even though we have intermediate mitigating events, however these events put together can align to form a mistake and they can result in incident which can be catastrophic and can be called as an accident. Therefore, what would be those steps involved in risk analysis for a process accident.

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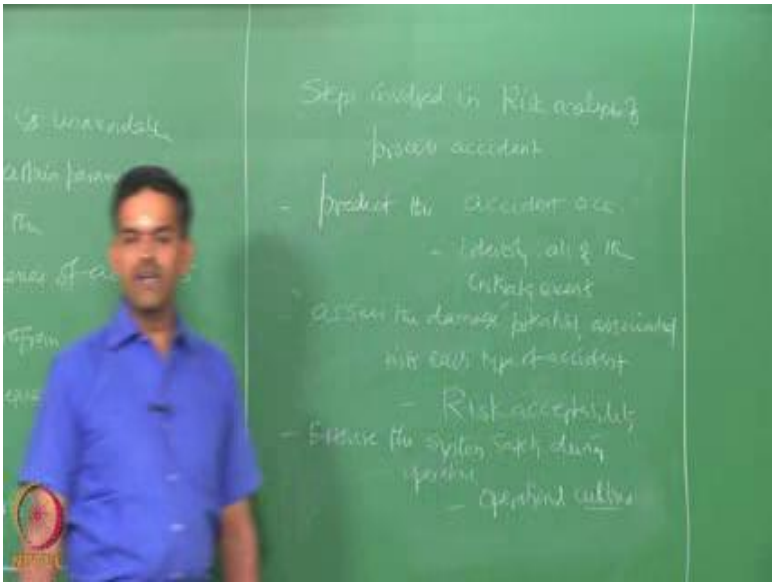

So, let us say steps involved in risk analysis of process accident. First step should be one should be able to predict the accident occurrence. To do that one should intelligently identify all of the initiating events. One should also be able to assess the damage potential associated with each type of accident. As he said we already have something called risk acceptability. Therefore, one need not have to focus on all type of accidents which may not result in serious destruction or damage to the system especially in

economic prospective

So, one should be able to actually assess intelligently the damage potential which can be caused by this kind of accidents. Once you do this ensure the system safety during operations is what we call operational culture in industrial safety. Do not violet any safety norms when you are operating equipments and do not neglect any serious alarms raised by the equipment or machinery when it is under operation. So, ensure system safety during operations. Now with all that one can always say there can be accidents occurring we need to assess them.

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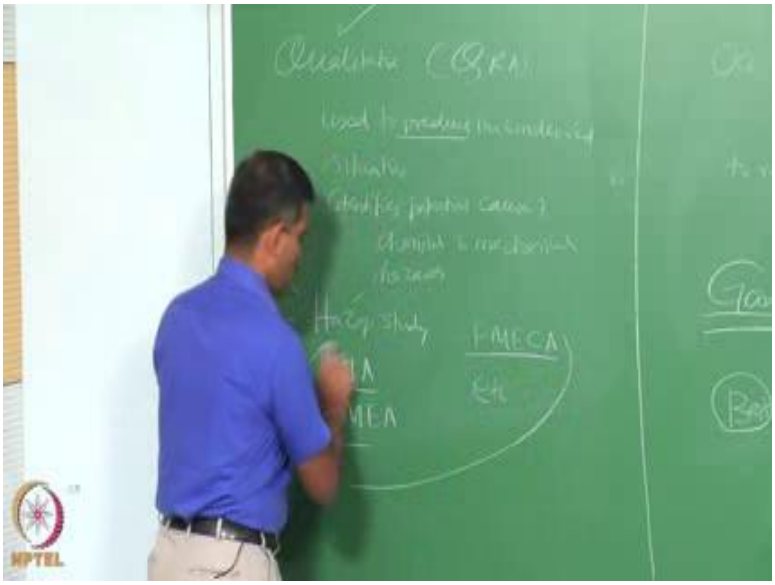

You can do it by two ways as we all know. One can do qualitative way which we call again QRA; Qualitative Risk Analysis which is used to predict the undesired situation. Please understand these only prediction it is not a post analysis of accident, so predict undesired situation which may arise in a process system. This identifies potential causes of chemical, mechanical hazards which result from the process industry.

Some of them are hazard studies, probabilistic hazard analysis, failure mode effect analysis, failure mode effect and criticality analysis, etcetera, these are all qualitative. However, you will agree except for hazard FMEA, PHA and FMECA, etcetera to some

extent also quantify the hazards or quantify the risk in terms of let us say risk priority number we already seen them in detail.

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We can also do it quantitatively which is also called fortunately as QRA. This method is actually useful to evaluate the likelihood of occurrence of accidents; it evaluates the likelihood of occurrence. This approach will be useful in determining the cause and consequence of potential hazards.

So, this is useful to determine the cause and consequence of potential hazards present in a process industry. After identifying the specific percent consequences then it is useful to analyze the control mechanisms that are in place. Then it recommends any change in the design or process line layout so that the consequences can be reduced and of course the likelihood is also reduced, therefore risk is reduced.

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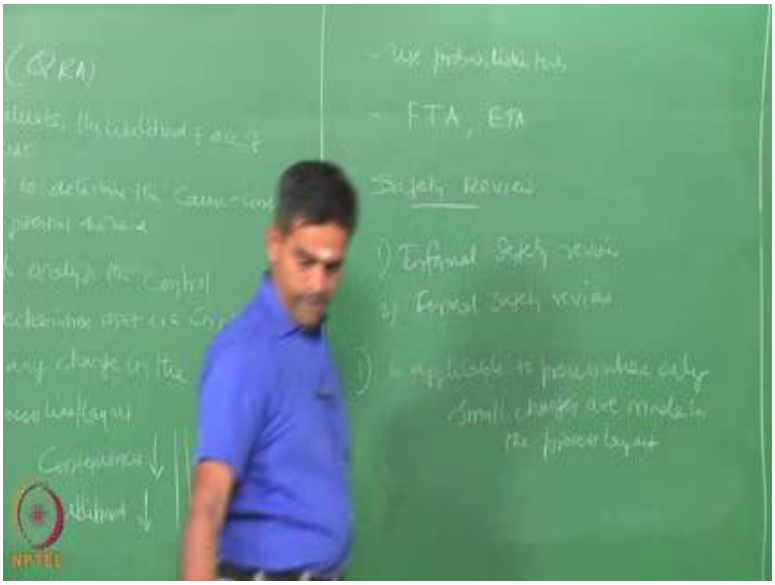

So obviously this methods use probabilistic tools to estimate them. We also do fault tree analysis, event tree analysis etcetera to conduct causes and consequences of an accident. Ultimately once we do an analysis and do risk modeling and assessment one need to also know how to review a safety program, so what is safety review? There are two types of safety which is generally conducted in offshore industries. One is what we call informal safety review, the other one is what we call formal safety review.

Informal safety review is generally applicable to the process where small changes are made in the existing layout; informal safety review is applicable to process where only small changes are made in the process layout.

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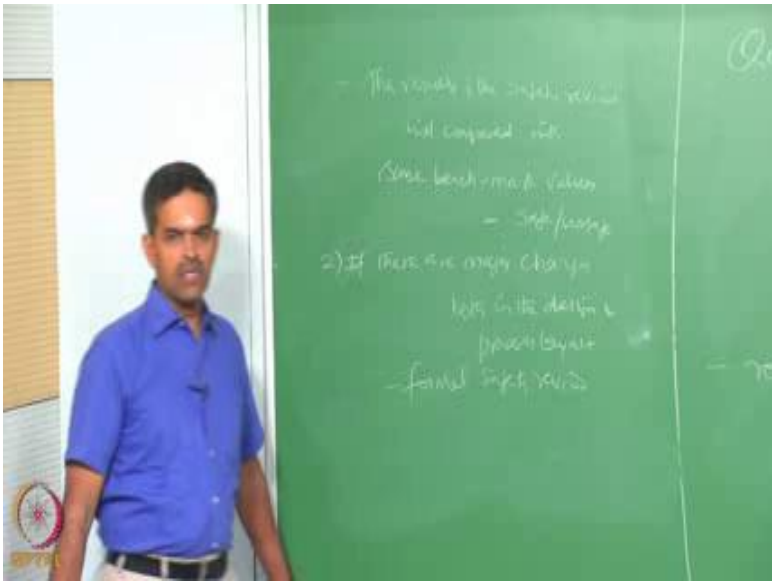

Alternatively this can be done in a more formal way when there is a major change, but small change problems generally will be addressed with bell scale labs. Results of the analysis of the safety review will be compared with some bench mark values to declare them whether it is safe or unsafe.

On the other hand, if there are major changes both in the design and process layout then one need to do formal safety review. Formal safety review generally conducted by team of experts who will identify the deviations, the causes and consequences and they prepare a detailed inspection report for the process plan. So, they can also do it by preparing what is called hazard check list.

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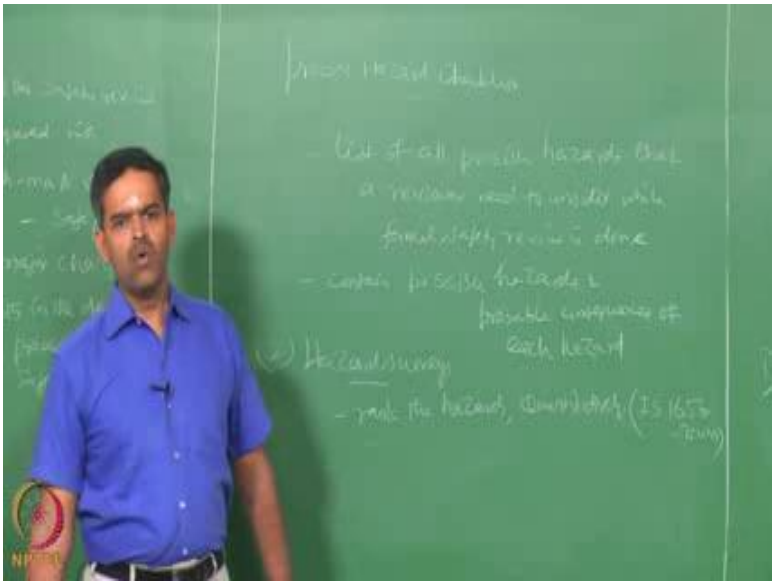

So, people do process hazard check list. They are nothing but list of all possible hazards that a reviewer need to be considered while formal safety program review is carried out. These check list contain probable consequences they contain; possible hazards and probable consequences of each hazard. So, it is a set of probable hazards that may be arising and hence n listed hazards may not apply to the all cases in the present scenario. Never the less check list reminds various of concern to the reviewers and stimulates them to revisit the recommendations and report summary so that any major accident in the future can be avoided even when the risk is highly remote.

Secondly, one can also conduct what is called hazard surveys. This is actually a technique which ranks the hazard qualitatively, so this useful to rank the hazards quantitatively. This procedure is well laid in Indian code 1656, 2000 which gives a very detail procedure about how a hazards survey should be conducted. It is very simple if the method involves only the survey inventory of hazardous materials.

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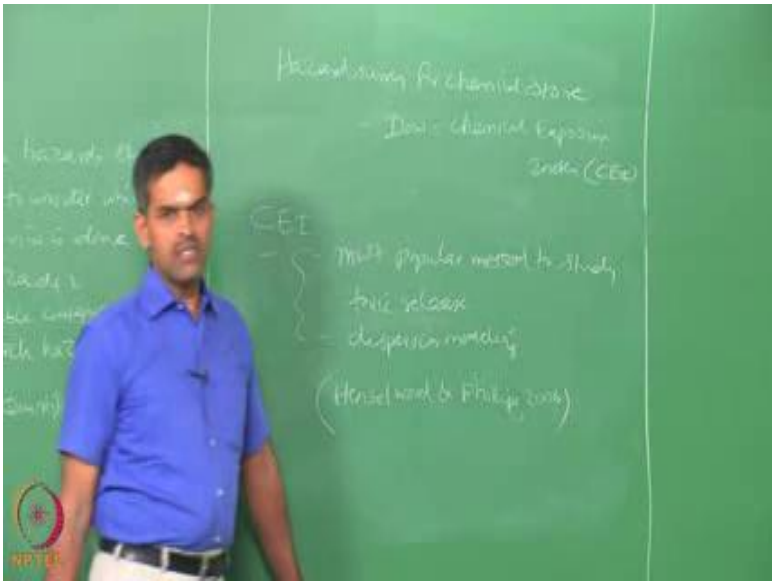

For example, for chemical release models one need to conduct hazard survey for chemical inventory. This useful for dose chemical exposure index, we estimate the dose chemical exposure index which we call as CEI which is one of the interesting models which is useful for toxic release of chemicals.

Now chemical exposure index is one of the most powerful methods to study the toxic release; so most popular method to study the consequences that arise because of toxic release, this also includes the dispersion modeling which we already studied in environmental pollution in case of module 1. So, this is a very interesting tool which is commonly used and acceptable internationally to estimate the consequences which arise from toxic release as stated by Hensel Wood and Philips in 2006.

So, friends in the next lecture we will have detail time spent on how to estimate the chemical exposure index for a toxic release. We will do couple of numerical examples to understand, we will also take an industrial example how to estimate CEI for a given problem. So, couples of lectures form next class onwards will be dedicated to how to do a chemical exposure index, what different kinds of release scenarios which can happen in oil and gas industries.

Thank you very much.