Health, Safety and Environmental Management in Petroleum and offshore Engineering

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Module No. # 01

Lecture No. # 5 & 6

Hazard classification and assessment

Hazard evaluation and hazard control

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Now, ladies and gentlemen, we were continuing with the lecture on health safety environmental management in petroleum and offshore engineering. Let us have an overview. This lecture will be covered in four modules. Module one is now what we are currently covering up. In module one, today we will look at lectures five and six. So far, we have covered introduction to HSE, basic terms and their definitions in HSE, after understanding that we also discussed about some tips on safety assurance and how to access safety. In assessing safety, we indirectly discussed risk assessment tools then we moved on to safety in design and operations. We discuss certain cases where the

operational safety or the risks involved during operation in offshore and petroleum engineering industries or discussed very briefly.

I will discuss them in detail, with two case studies in module four. After understanding the necessity for studying safety in design and operation; we also discussed how to organize for safety. We have also given you one tutorial and some frequently asked questions on the previous units, what we discussed in the previous lectures. Today's lecture, we will focus on hazard classification and assessment and hazard evaluation hazard control. You should also recollect that we have emphasized the importance of safety in petroleum industry by giving some classical examples. We will also discuss these examples in detail case studies in module four.

So, now ladies and gentlemen, today we discussed about hazard classification, assessment evaluation, and how to control. Just to recall, let us look at the terminology what is a hazard? Hazard is actually a chemical or physical condition, that has potential to cause damage to people, property or environment. Let us look at the key words in defining hazard as a condition. The condition can be physical or chemical. The condition has a potential to cause damage; there is no certainty that the damage will be caused. When we say what kind of damage, it can be damage to life of the people, which is a fatal accident. It can be damage to the property or it can be damage to the environment.

So, hazard is actually a condition. We also said, incident is loss of contamination of material or energy. Wherever you encounter loss of contamination of material or energy, we identify that event as an incident. Remember, all incidents do not propagate to an accident.Iif we are able to control this contamination by some methods, then

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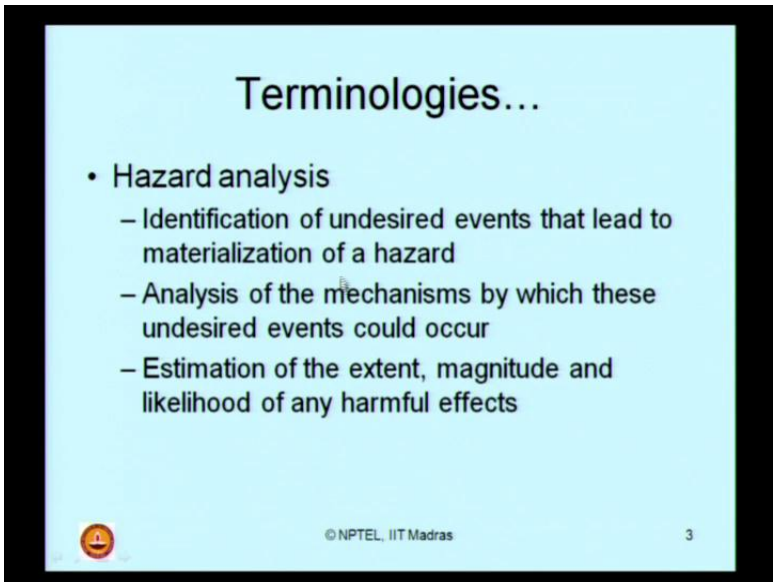

these incidences do not reap up to accidents. Having understood this, we will discuss what is a hazard analysis, what actually do analyze in hazard? Hazard analysis contains identification of undesired events that lead to materialization of a hazard, then also deals with analysis of mechanisms by which these undesired events could occur, further estimate, the extent, magnitude and likelihood any of any harmful effects. So, there are actually three steps in hazard analysis, identify the undesired event, then analyze the mechanism by which these events could occur, then further estimate the extent magnitude and likelihood of any such harmful events. Put together, we call this as hazard analysis.

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Now, ladies and gentlemen, what are the differences between hazard and risk? In the previous lecture you discussed something about risk assessment tools. Hazard is a scenario - it is a physical or a chemical condition; it is a situation resulting in more likelihood of an incident. Whereas, risk is actually the realization of this hazard that is when the hazard gets realized it becomes risk. On the other hand, this incident becomes an accident. So, hazard is a scenario risk is realization of that scenario; I think that clearly distinguishes between hazard and a risk.

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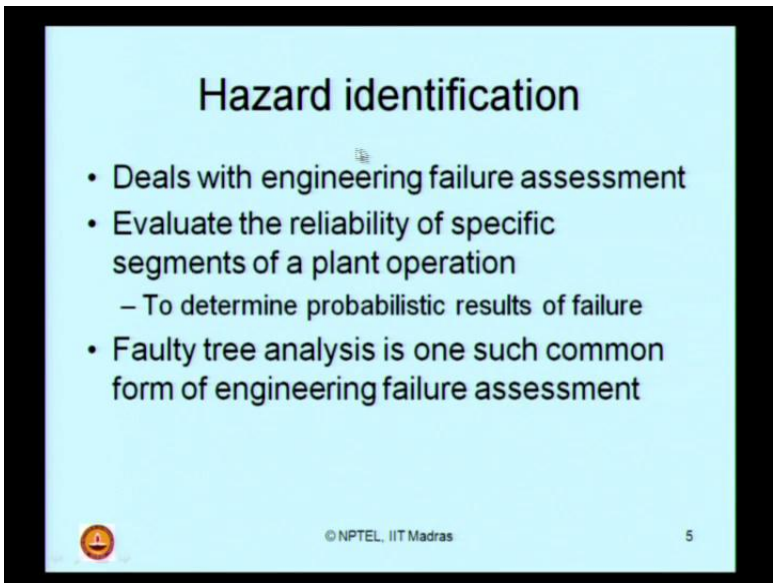

We will talk about hazard identification. It deals with engineering failure assessment. The necessity is to evaluate the reliability of specific segments of a plant operation. On the other hand, for example, you have an operational plant, may be a petroleum plant, may be a chemical industry, or more generally may be any process industry, you identify different segments in that plant which is currently under operation. Then try to access or identify the possible engineering failure of specific segments of this operational plant. When I say access possible failure, you have to use probabilistic tools. So, I can put it the other way, to determine probabilistically the results of failure, fault tree analysis is one such common form of engineering failure assessment.

We will look into many kinds of this failure assessment in the coming lectures. So, in general, hazard identification means, assess the failure within engineering background. Obviously, for a given plant in operation, you will not be interested to assess the whole failure of the plant, we try to look at the failure of specific segments of the plant.

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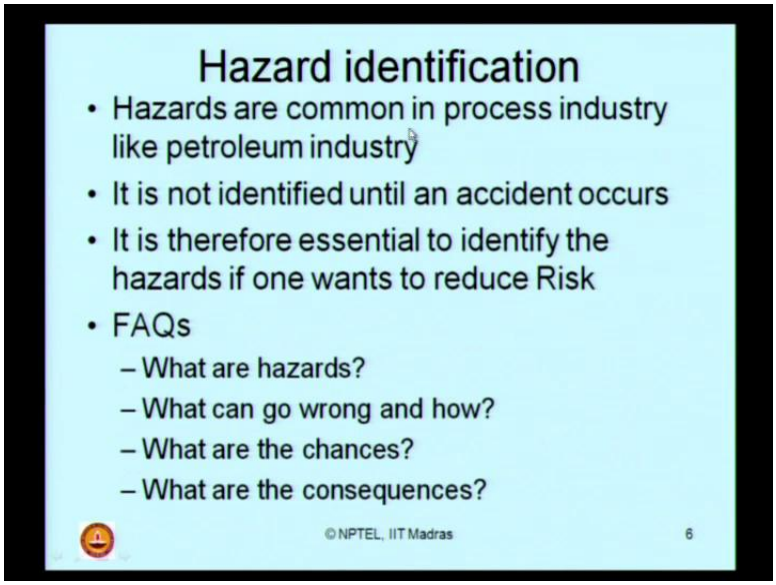

Hazards are common in process industry, I mean, you cannot say any process industry really exists which has a zero hazard. Hazard is a physical or a chemical condition; it is a scenario that will be generally present in any process industry, for example, lets petroleum industry, now it is not identified until an accident occurs - that is the most unfortunate part of the hazard identification. As long as you do not encounter or you do not see an accident probability, you do not identify the hazard.

Therefore, ladies and gentlemen, I can ask you a simple question. If I want to avoid accidents, what should be my first step in my industry? Yes, the answer you are getting is right. The first step in industry should be, to identify the possible hazardous situation, hazardous scenario in the industry. It is therefore, essential to identify the hazards, if one wants to reduce risk when this is set as a goal in my mind. Then I have many frequently asked questions in a mind, what are hazards? What can go wrong and how? What are the chances? What are the consequences?

Before I answer these questions very briefly in the next slide, let us try to think for a short while, amongst these four questions, have we already seen answers of any at least one of the question think it over. We discussed about what are the chances, what are basically the probability of occurrence of anything. We also discussed about the consequences, if we really understand risk is a product of probability of occurrence and or the frequency of occurrence and the consequence of that if it occurs.

So, therefore, this forms already a part of risk assessment. Now, if you are really wanted to know some of the probability of occurrence, then this question must have been inherently asked what could go wrong and how? So, in my opinion if you agree these three questions pertains to risk assessment, then this is the only question pertains to hazard identification.

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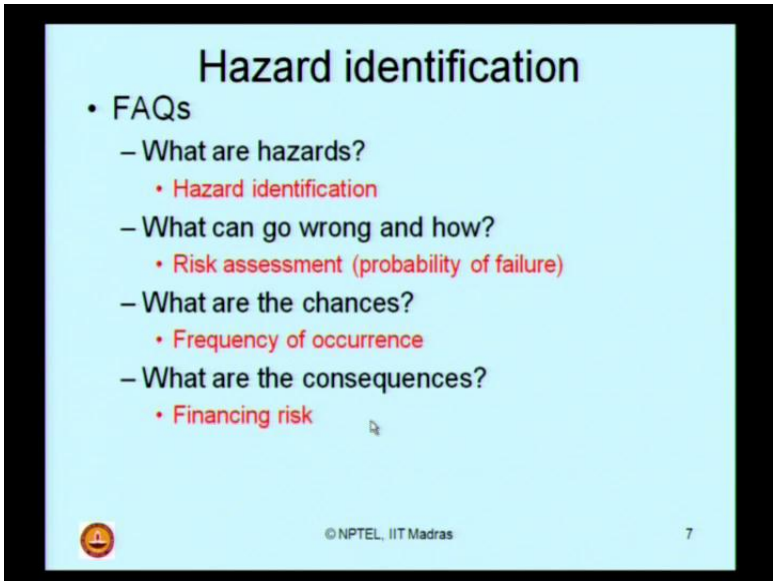

So that is what I am discussing now. What are hazards means? Identify the hazards? What can go wrong on and how means actually it is a part of risk assessment? It says what is the probability of failure? What are the chances, it means what is the frequency of occurrence of that failure? And product of these two is what we called as risk mathematically. What are the consequences If that accident or that risk realizes? We have studied this part in what we understand is financing risk. Can you give me a very simple example or any simple model, which tells you about financing risk. Yeah, ladies and gentlemen, that is right, you are able to recollect successfully financing risk I example module is Morgan analysis. Good!

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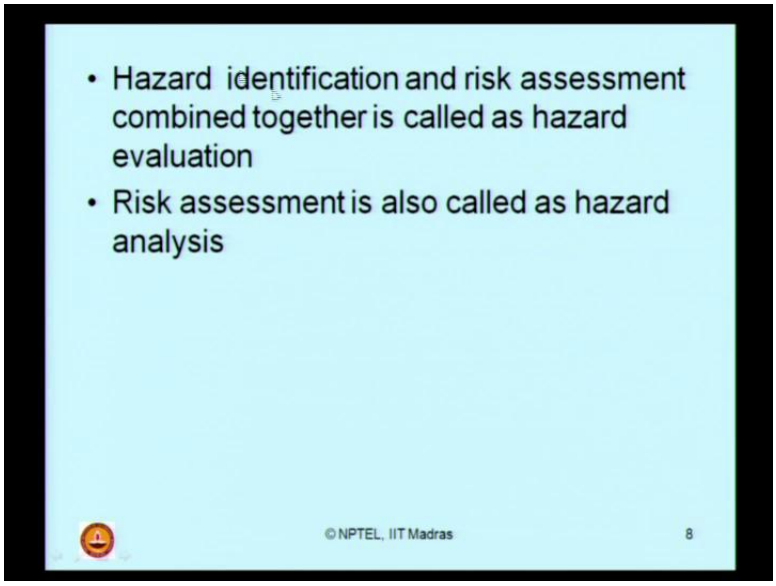

Let us talk about hazard identification and risk assessment together. If we combined these two topography in petroleum industry together, I call this nothing but as hazard evaluation. I identify the hazard and also access the realization of that which later on becomes a risk. So, if we put together hazard identification and risk assessment, then I call this as hazard evaluation. Sometimes, risk assessment alone is also called as hazard analysis. So, by these two statements, you will be able to easily understand there is no very clear cut difference between hazard and a risk. Because hazard and risk put together is hazard evaluation, whereas risk assessment alone is called hazard analysis. It means they are actually two eyes of a human being. Both of them are equally important; both of them parallelly work. If you really want to have a good vision, you should use both your eyes. There is no marginal difference between a risk and a hazard.

Let me recollect here very carefully, hazard is a scenario; it is a situation; it can be physical; it can be chemical whereas, risk is realization of that situation or scenario or condition to become an accident. So, risk is a ripened stage of a hazard. If you want to basically control, mitigate, reduce, eliminate risk then I must focus on hazardous scenario first. Therefore, risk evaluation, assessment, risk control, everything initially starts from hazard identification, control, mitigation etcetera. Because practically the situation of hazard, which becomes a risk, is actually a maturity of hazard to become a risk.

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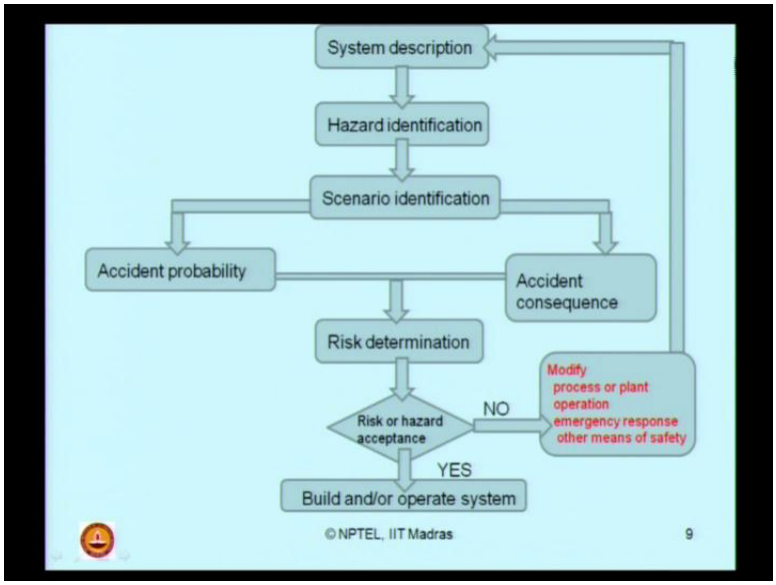

Now, let us see can you explain this using a simple flow diagram. Now, I have a system description. A system description can be any plant, which is under operation, it can be a process plant; it can be a mechanical engineering plant; it can be an automobile sector; it can be a petroleum industry as well. So, you describe the system completely. It means you should have full operational layout pressure in instrumentation diagram process and flow diagram of the industry, ready with you, in terms of drawings and details.

I call this as system description. Once you have the system description then for the system described in detail look for hazard identification. Hazard is a scenario, it is a condition which can result in an incident. Incident is not an accident; all incidents do not become an accident. Further, once you have identified the hazardous scenario present in your given system, then identify specifically, which is that scenario which can become

very hazardous. So, select each scenario separately one by one. Now, ladies and gentlemen, you may ask me a question. If one scenario becomes the cause for the successive scenario, then what should we do? very good question. What I have to do here is, for a given system description, let us first try to identify non-dependable hazard scenarios. I identify those scenarios first which are not interdependent on each other; if one scenario is followed by the other, for example, fire, temperature. At high temperature, gas may catch fire. So, you can say, that there is a consequence of one scenario, followed by the other. So, what I wish to say you here is, in a given system description, first try to identify independent scenarios.

Once you do that, then you can differentiate this identified scenarios into two parts; one is what is the accident probability of that identified scenario? If at all the accident occurs, what would be the consequence of that accident? Remember hazard is an incident; maturity of an hazard can become an accident. So, once you identify the scenario, try to see whether the scenario can become matured enough to result in an accident. If yes then what is the probability of that kind of accident. If at all the accident occurs what is the consequence of that accident in your industry. This consequences can be material loss, human loss of life, impact to property, impact to environment etcetera all consequences are considered.

Ladies and gentlemen, try to understand, that even in Morgan analysis, where we are talking about financing risk, we also look into different kinds of consequences not only the material or men loss, we also look into the property damage as well, even the shut down time as well as we are interested in. Even the return money of the investment is also interestedly seen in any kind of these consequences. So, once a scenario is identified, I am able to clearly say what is a probability of that scenario becoming an accident and what is the consequence of that accident. This I do for every independent scenario. Once I do that the product of these two correctly is risk determination. So, I am determining the risk, so understand clearly here from hazard I have moved to risk.

As I told you just then, there is no very clear difference between hazard and a risk. Hazard is a scenario; risk is the maturity of that scenario to become an accident. Once you determine the risk, then I check whether the risk is accepted or not. What is a level of acceptance of the risk, you may ask me an interesting question, sir, how risk can be first of all accepted. If you look back the previous slides, where we gave you a example

of air travel, even a person sitting at home has an fatality accident rate. Look at table one suggested by Morgan, which I gave you in the previous lecture. So, even sitting at home can also cause a risk. So, there is always a basic level of risk acceptance of every activity and we already said process industry like petroleum industry is an hazardous industry. There is absolutely no doubt on this question at all.

So, petroleum industry has lot of scenarios which likely can become an accident. If that is the case, do I accept this risk or not? So, risk acceptance level is predefined. Now there is a very interesting decision box here. Sir, how do I really say what is my level of risk acceptance? That is a very interesting question. For example, the risk acceptable by you, may not be acceptable by your management; on the other hand the risk acceptable level by the management is not acceptable to be you as an employee. So, this is not a subjective issue basically risk acceptance level it is internationally defined by many organizations. If you look back the previous slide presented in the last lecture, you will have very clearly what do we understand by risk level of acceptance. So, look for the acceptance level for the risk, which I just now estimated, for any one such scenario in my system description. If the answer is yes, it means the arrived or determined risk is acceptable, then go on built the system or continuity operate the system.

If it is not acceptable, then try to modify the system. How do you modify the system? You can modify the process or the plant design itself; you can modify the operational methodology, you can improve upon the emergency response system present in the system description, or you can improve upon other means of safety, so that the risk can be reduced. You may ask me a question, how these individual points can reduce risk? For example, let us take one specific case like, I am introducing extra means of safety in my plant. What does it mean? When I introduce an extra means of safety in my plant, I am either fundamentally reducing my hazard scenario or even the hazard becomes an accident, I am reducing the consequence. For example, I have an fire alarm system which was earlier not present, now I introduce that, when the fire alarm system is introduced in the platform or in the plant description then whenever there is a scenario of fire which can become an accident. The fire alarm will function; if will evacuate the human which is working on the plant. Therefore the consequence can be reduced; it means the loss of fatal life can be limited.

So, I can control the accident consequence by means of introducing a fire alarm system in the system description, which was not present earlier. When it decrease the accident consequences, obviously, risk level is reduced because, risk is recollected as product of accident probability and its consequences. So, like that each and every point can be easily understood and managed to bring down the hazard level to an acceptable value. Remember, all of them individually or put together, will improve upon the initial investment or the production cost of the plant; there is absolutely no doubt on that. So, once I do this modification, I get back to the system, do the hazard analysis again. I identify scenario identification, find the risk, and check whether it is acceptable or not. If it is no improve upon further means of safety or further emergency response systems, or if it is acceptable, go and build the system or continue to operate the system with all these present in the situation.

Now, this block diagram is very interesting for you to remember, which is nothing but nut shell of hazard evaluations. You may wonder why I am using the word hazard evaluation instead of identification. I already said the previous slide that hazard plus risk together risk hazard evaluation. So, I am here identifying the hazard then determining the risk as well. So, this flow chart is what we call as hazard evaluation.

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Now, hazard evaluation can be performed in any stage in the plant. For example, you can do this evaluation at the initial design stage itself. For example, FMEA is one such

methodology, this is failure more effect analysis. This is done at two stages as usual; one is at the designed stage, we call it design FMEA, the other is the process stage, where we called as a process FMEA. So, we can use it as designed stage FMEA to evaluate the hazard present in a system description. It can also be done during an ongoing operation of the project, which we call as HAZOP analysis - Hazard and operability study that is what we briefly called as HAZOP. This is how the literature addresses hazard evaluation in any process industry, which is an ongoing operation. So, hazard evaluation can be performed at two stages, either you can do an initial design stage or you can do it at operational stage as well.

If, the hazard evaluation done at any stage, shows a low probability and minimum consequence, it is a good thing, because if you do an evaluation and that evaluation shows me very low probability and minimum consequence if the accident occurs, then such system are termed as gold plated systems in the literature. What do you understand by a gold plated system? Here I am addressing system as a mechanical system, electrical system, process system anything. So, gold plated system is that system which has potentially unnecessary and expensive safety equipments and procedures which are implemented in the system to make it over safe. Why? Because the low probability and minimum consequence are the result of the hazard evaluation of that system.

Now you may ask me a question, sir, if I have a gold plated system, you said that the gold plated system has unnecessary and expensive safety equipments and procedures. For example, if I remove or replace some of this expensive safety equipments and procedures with alternative arrangement; obviously, my hazard level will go high, is that true. The answer is absolutely right, you are exactly following the lecture; that is true. What I mean to say from this presentation, this slide is that if you have a system, which has a low probability of minimum consequence, you identify that system as a gold plated system. So, the term gold plated itself will tell you that is an expensive system in terms of its safety measurements, then the gold plated means the system these hazards, you are only covering the system with the gold; it is not a gold system - it is gold plated system. So, its look like as if it safe because it is gold plated, but it is not safe completely because, system has some probability and consequence of the hazard, is that clear?

So, gold plated system is an expensive system; there is no doubt about it. So, does not mean that if you already have a gold plated system, you have got to convert that into a

worse system by reducing or by changing alternatively safety equipments and procedures. It is not done like that, basically the evaluation will tell you the status of the system. If you happened together, status where the probability is very low and the consequences is highly minimum, then you can simply term that system as a gold plated system.

Ladies and gentlemen, unfortunately in petroleum industry, we do not have any gold plated system at all. Can I guess the reason why it is so? The reason is very simple; there are many reasons, the fundamental reason is petroleum industry process is a very expensive system. To add more cost to it, I cannot keep on providing more expensive safety equipments and procedures. It does not mean that petroleum industries is highly unsafe; they are safe, but they have basically certain level of risk acceptance, which is generally higher than that of any common process industry. This has got to be clearly understood in mind.

Petroleum industries have high level of risk acceptance - that is why, the fatality accident rate number for petroleum industry, is higher compared to that of other industries. So, I am not actually comparing petroleum industry with any other process industry with the slide only. You will have to compare this after you complete the whole course on HSE, and try to make up an idea on your own what could be the hazardous situation present in a petroleum industry which is compare to any other process industry; that is your own choice.

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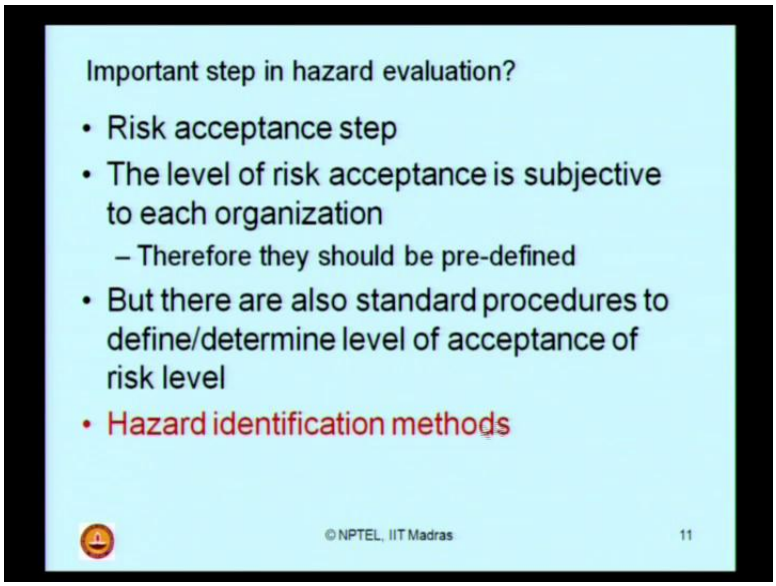

Now, let us look into what is an important step in hazard evaluation. Hazard evaluation has many steps, we just now described in the previous couple of slides. The most important step in hazard evaluation is the risk acceptance level. This is generally considered as a subjective level of decision. The level of risk acceptance is subjective to each organization; there is absolutely no doubt on that, but one good thing about is that they should be predefined.

Generally, the risk acceptance level of any process industry is predefined. There are standard methods of defining risk acceptance level of every process industry. I will give you some good references on this, at the end of the presentation, later. If you are unable to predefine the risk acceptance level of the subjective value of your industry, then you can also do it with standard procedures available in the literature, standard methodologies available in the literature, to arrive at what we call as level of acceptance of risk level. What are those methods, what are those standard procedures by which I can arrive at an acceptance level of risk? One such method is hazard identification methods.

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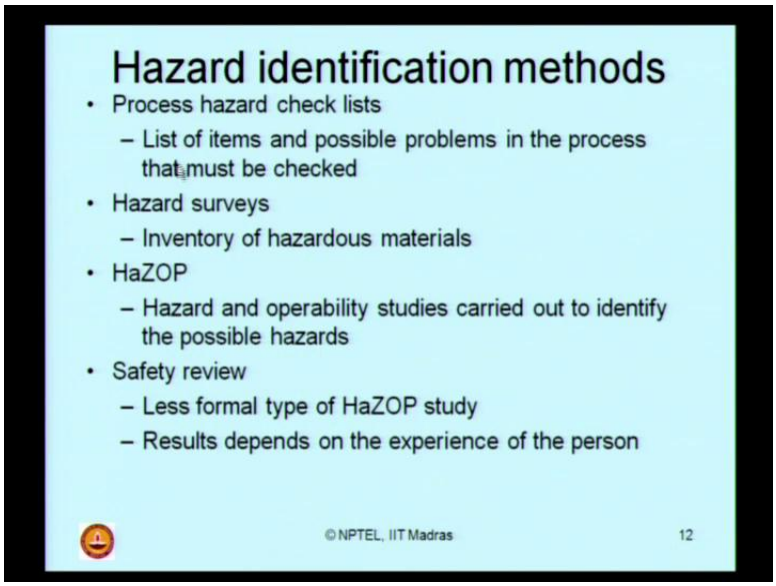

What are hazard identification methods? Process hazard check list is one such method, which actually prepares a list of items, and possible problems in the process industry that must be checked. So, what I do here is, I want to identify the hazard present in the process industry. So, I prepare a list which are all hazardous in the industry and also try to prepare the possible problems associated with that process which can become hazardous in operation. So, I prepare check list. So, one such method of identifying hazard is simply prepare an hazard check list for a process.

The second method is to conduct hazard surveys. What do you mean by hazard surveys? Prepare the inventory of hazardous materials present in the process industry. Make a list of all materials present on board which is involved in the process industry and try to identify the hazardous characteristic of each material and rank them. So, prepare an inventory of hazardous material, which is present in the process industry. These materials can be a raw material for the process industry; it can be a product of the process industry. The third method by which you can identify hazard is HAZOP study. HAZOP stands for hazard and operability studies; HAZ basically from hazard, OP from operability, put together we call as hazard and operability study briefly HAZOP.

Ladies and gentlemen, this method is one of the very powerful tool, because, it identifies hazard in a plant during operation, which is a highly suitable technique for a petroleum industry. So, hazard and operability study is carried out, to identify the possible hazards

in an operational platform. The last method by which you can identify hazard is what we called as safety review. It is less formal type of HAZOP study; it is also an effective method of doing hazard identification. The results depend on the experience of the person whose conducting the safety review. So, it is nothing but a question of conducting a review on existing safety procedures. Look at all these methods, all of them address or look hazard identification in different angles. This method simply prepares a check list; this method is also similar to preparation of check list, but it reviews only the safety aspects present in the system, whereas, this only looks at the inventory of the hazardous material present in the system. This looks at hazardous situation during operation in a system. So, identification of hazard is generally done by different look out of hazard in industry.

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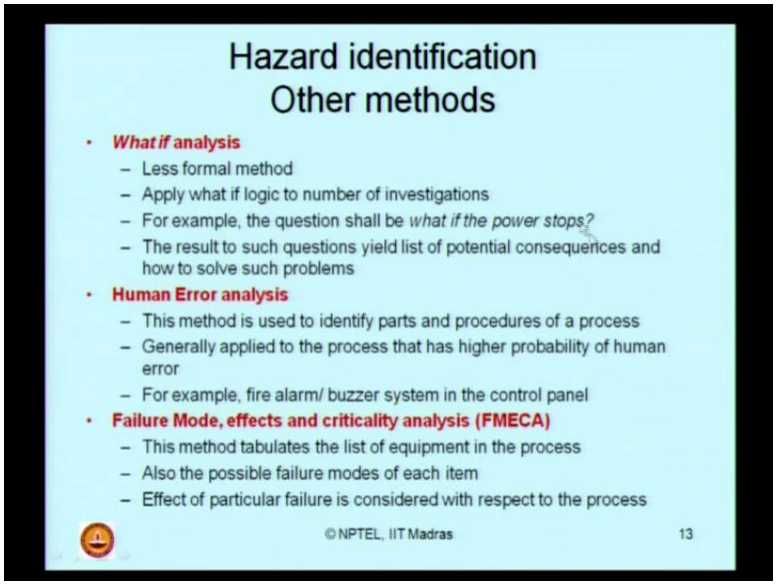

We will now look at the other methods, which are also common for hazard identification. Once such method, which is very popular is what if analysis. It is less formal method; it is applied in a simple format, that you ask a question of, what if logic to many number of investigations? For example, the question shall be, what if the power stops in a process industry? So, keep on putting simple what if questions to many of the list of investigations in industry and prepare a checklist. The result to such question yields a list of potential consequences and then also yield solution for how to resolve such problems.

For example, what if the power stops, the consequence could be the temperature and pressure in the process industry cannot be maintained. The control panel cannot be effectively functional; this can be two consequences if the power stops how to resolve such issue? You try to put a pressure in auto pressure, auto temperature gauges or prepare an automatic power back up to the system. So, that the control panel effectively records this variations in P and T. So, a simple what if analysis which is a less formal type method can easily tell the investigation replies for simple questions like this, but remember ladies and gentlemen, this method requires lot of experience to conduct such analysis.

The second method, which is also an informal method in hazard identification, is human error analysis. This method is primary used to identify the parts and procedures of a process. Generally applied to the process that has higher probability of human error, for example, I have a process plant; I have a machinery - the machinery is generally manually operated for certain control logistics. So, you need a trainer who basically operate this machinery under control logistics. Suppose, if the trainer is not able to operate during any such failure or hazardous scenario, what would be the probability of that error? So, look only for human interface error, which can become an hazard to the process industry, for example, fire alarm buzzer system in the control panel.

The third one, what we call as failure mode, effects and criticality analysis, which I shortly call as FMECA, in the last slide we saw FMEA, so failure mode effect analysis. You can also do failure mode effect criticality analysis. This method tabulates the list of equipments present in the process, it also identifies the possible failure modes of each item, then subsequently prepared the effect of that particular failure with respect to the process itself. So, for a given process identify the list of equipments in tabular form, then also identify the possible failure modes of each one of that item present in the list and if at all that item fails, what will be the effect of that failure on the whole process? So, failure mode effect and critically look at it that is why we call as failure mode effect and criticality analysis? These are some of the other methods by which you can do hazard identification.

We will now discuss in detail one of the described methods of hazard identification, which is very commonly employ in operational industry like petroleum industry, which

we call as HAZOP, which briefly is HAZOP expanded as hazard identification during operation that is hazard during operation. We will discuss this after a short break.

Thank you.