Industrial Safety Engineering
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Lecture – 02
Key Concepts and Terminologies

Hello everyone, welcome to Industrial Safety Engineering. Today, we will discuss Key Concepts and Terminologies.

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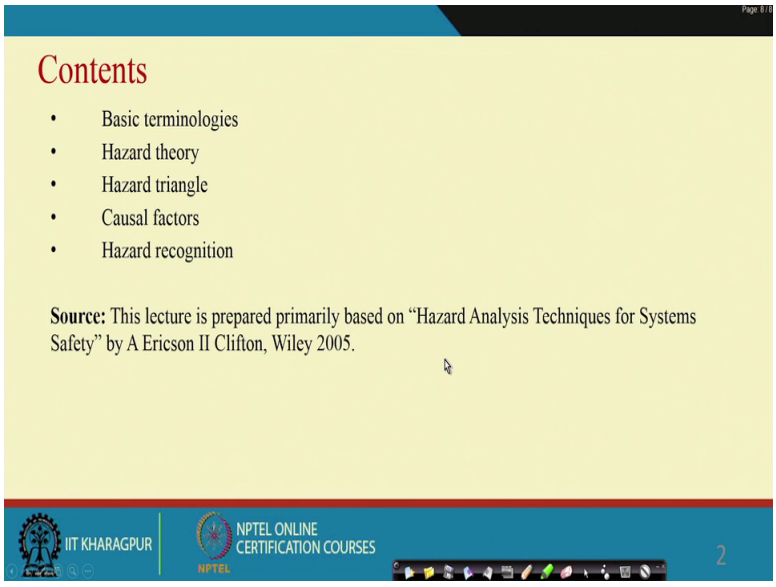

Let us first see the contents. I will explain some of the terminologies related to safety engineering. Then hazard theory followed by hazard triangle, different causal factors hazard recognition. This lecture is primarily based on the book, "Hazard Analysis Techniques for Systems Safety" written by A Ericson II Clifton published by Wiley.

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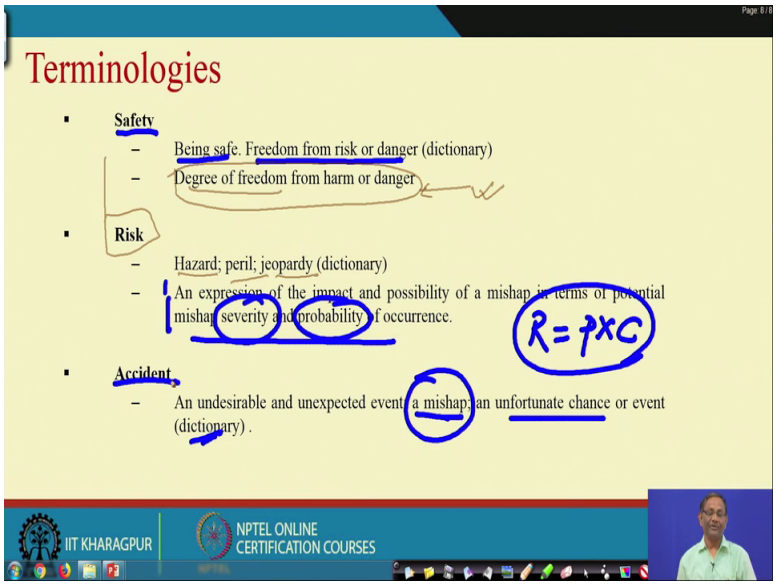

So, as you know that safety engineering is a interdisciplinary subject is taken or borrowed knowledge from different disciplines. And over the years it matured and it has it is own vocabulary or language and knowing safety engineering or being expert in safety engineering, essentially also includes that you know the language of safety engineering.

In today's lecture I want to explain those vocabularies. And, the definition in such a manner that you spell out or speak about all those terms and terminologies in that manner, and then it will be understood that you have gone through this course, you have knowledge on safety engineering at the first instance.

So, under terminologies the first one first one is your safety. So, if you go through dictionary, you will find this definition being safe freedom from risk or danger, but a better definition could be degree of freedom from harm or danger. So, the basic premises behind this definition under industrial safety or as such under safety engineering every activity, whatever you do that contains some amount of danger or risk or harm.

So, as a result 100 percent harm that the hazard field operation is difficult to have. So, by safety we want to mean when you do some activities or you work somewhere, then what is the freedom you enjoy from harm or danger? So, that is why that freedom is degree of freedom ok.

For example, if you are working in a control room, AC control room and you are working in a blast furnace or you are you are you are operating a machine in works, in soft load or a person who is driving a car, or someone who is who is basically launching that missile, or somebody who is basically cooking in the kitchen? So, you find out that they do not expose to same amount of danger or risk there is degree of difference.

So, that degree of freedom is safety. So, we will speak to this definition degree of freedom. When, we talk about safety essentially we also talk about risk, because the safety and risk they are very much related terminology, when safety is degree of freedom from harm or danger risk is perhaps the major of that harm or danger. So, if you go by dictionary definition, you find out that the this is hazard, peril, jeopardy this many things are common main definition of risk, but from safety engineering point of view the definition, what we want to follow is this. It is an expression of the impact and possibility of a mishap in terms of potential mishap severity and probability of occurrence.

I will explain later on when we discuss about risk assessment or risk quantification in in a better manner I can say that better manner means in more objective manner, but for the time being risk is basically a quantification it is the quantification of hazard potential I will explain hazard little later. So, it is basically mishap in terms of severity that is important word and another one is probability. So, risk if a risk is R, then this is probability of occurrence some undesired event, times consequence or severity of that undesired event.

So, this is our most additional definition of risk. So, we will basically follow the second definition, not the dictionary common man definition a safe safety engineering definition is the second one. And, we will elaborate in detail on risk. The third con terminology, which is accident. So, accident an undesirable or and unexpected event a mishap an unfortunate chance etcetera etcetera, but this is based on dictionary.

We will not follow this dictionary definition; we will follow definition given by some standard authority. Where accidents are mishap, accident is a misshapen mishappenings. So, that we will define when I define mishappening, that time again I will define accident. For the time being you think of that someone working at height there is a chance that he will fall. So, fall off fall from height. Worker working in material here

there can be there can be possibility; they will be hit by moving machines hit by objects. So, these are all accidents. So, accident is unfortunate undesirable event so, then few more definition incident.

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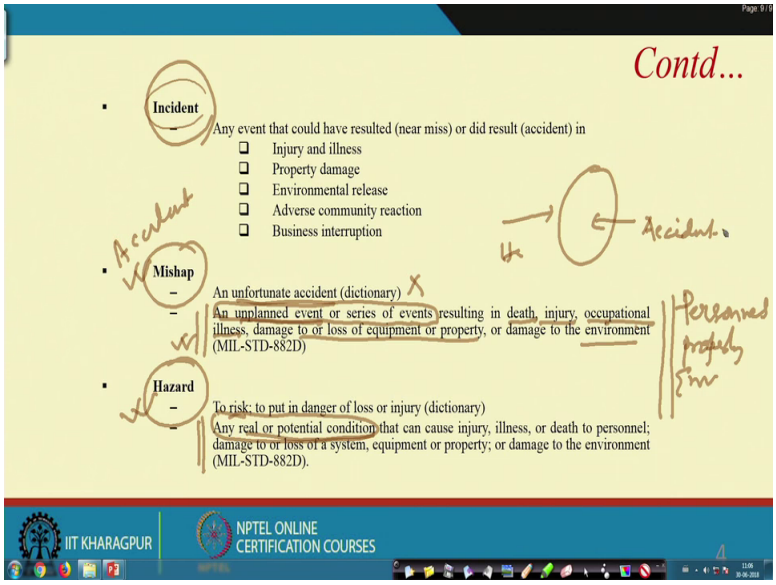

For incident and accident there is similarity as well as dissimilarity. Incident here anything what is basically may be desirable may be undesirable, but we will basically talk about undesirable incident. And, and it is it can be of any severity any consequence without consequence without severity that is incident, but when you talk about accident the severity of consequence is bigger larger than incident.

But, anyhow incident measurement is an important, important or incident management is an important issue. Let us differentiate between incident and accident suppose, I said that working at the soft floor sometimes the worker may fall on the same floor or may what may happen that about to slip, while about to slip is incident, but fall at the floor level that is accident ok.

So, an accident is an incident, but an incident may not be accident, but nowadays this definition a there is very very less differentiations what I can so, the less differences ok. I told you about mishap which is nothing, but accident, but here the dictionary definition is unfortunate accident, we will not stick to this, we will stick to the second definition given by military standard 882 do 2 D depot. It is an unexplained event or series of events resulting in death injury, occupational illness damage or loss of equipment or property or

damage to environment. Carefully observe that it is unplanned event or series of events. What it will do, it will do, it may lead to death it will lead to injury it may lead to occupational illness these all related to personnel.

Then, damage to or loss of equipment and property it is related to property, then damage to environment third-one is environment. So, there will be an accident or mishap lead to damage for personal, for property, for environment, individually or collectively or in combination. And mishap and accident are synonyms for us mishap and accidents are events, these are unfortunate events, these are random events ok.

So, many a we say accident two types one is basically man made another one is the chance event. So, whatever may be the reason, that we will discuss later on, but for the time being you please stick to this definition, it is an unplanned event or series of events resulting in death, injury, occupational illness damage to or loss of the equipment to property and environment damage ok.

Then, another important definition for us is hazard, very important definition hazard. If, you go by dictionary see it is basically to risk to put in danger or loss or injury, but shifting a definition should be like this. Any real and put or potential condition, a real or potential condition, that can cause injury illness death to personnel damage to or loss of the system equipment property or damage to environment both coming from military standard 852 D, if you see the difference between the two definitions. Then, you see in the first definition when you talking about accident or mishap, we are saying an unplanned event or series of events resulting into loss to person property or environment.

When we are talking about hazard, we are talking about any real or potential condition, accident event, which is realized, hazard condition which is not realized, but it can lead to accident. The difference between the two the difference between the two in the in the one is realized another one is not realized. Hazard is potential and the accident or mishap is the event which is already occur, but the rest of the thing in this two definitions like, after resulting in death, injury, illness, all those property damage environment damage.

And, in the second case also the potential condition that can lead to lead to loss to personal, property, and environment. So, that is why carefully observe the two definition and you see that apart except this first part the result series of events these up here. And,

here any real or potential condition, this this is the difference rest of the things are same written ok.

So, that mean accident and hazard, they are very much connected and that connection we usually say that if we talk about a coin, then if the one side is hazard and other side is accident. So, that mean accident and hazard they are the two they are the two sides of a coin. So, one side is potential condition, another side is a realization of that potential condition, in terms of undesired events leading to loss to property, loss to personal, environment of different degrees of freedom or degrees of risk.

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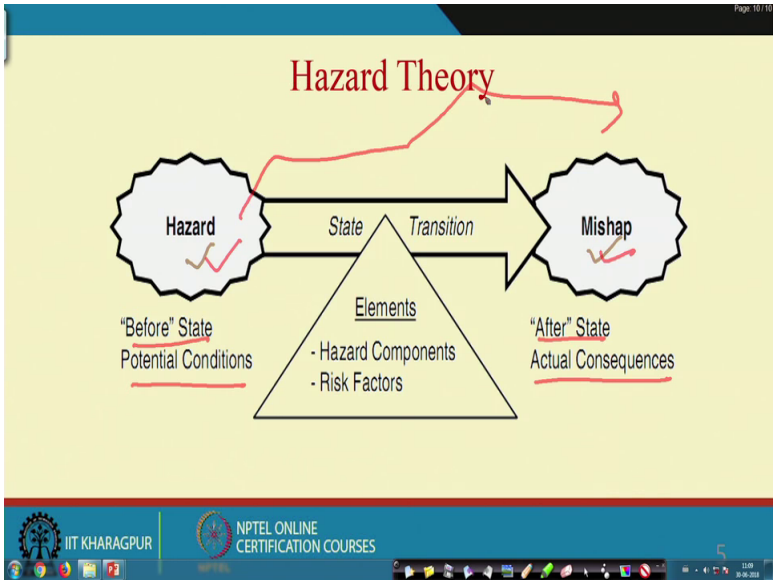

So, we will go with some example now that, we will basically see that what is the accident and hazard? As I told you that accident and hazard are the two sides of the coin. So, at the hazard the theory says that the hazard ultimately converted to accident, hazard to accident.

So, I am giving huge importance to these two words, hazard and mishap the reason is that if you if you know, what is an hazard? And accordingly identify hazard in workplace or the system, for which your concern about or which the safeties and issues, then identification of hazard is very very important one and you know that once you know the hazard then it is possible to come back with the hazard.

So, now a safety engineer wants to know that if given the hazard, what way it will ultimately lead to actual consequences; that means, accidents. So, hazard is before state potential condition, and accident is after state actual consequences. This hazard is converted to accident and that is known as state condition, that mean hazard is a state and accident is another state.

So, there is state transition for any system, for any workplace, for any job. And, then with reference to hazard theory how the hazardous state is converted to the accident state here have to identify, we have to know we have to find out the path. So, that that condition path, if you know how a hazard will ultimately lead to an accident and accordingly the path is known path is known then much work is completed.

So that means, my hazard theory what do we mean that? Hazard is a potential condition for accidents. Now, how this potential condition ultimately leads to accident knowing the path is the job of safety engineer. And, accordingly putting intervention or barriers in between in such a manner that, that path will not realize. So, that is, what is basically hazard theory?

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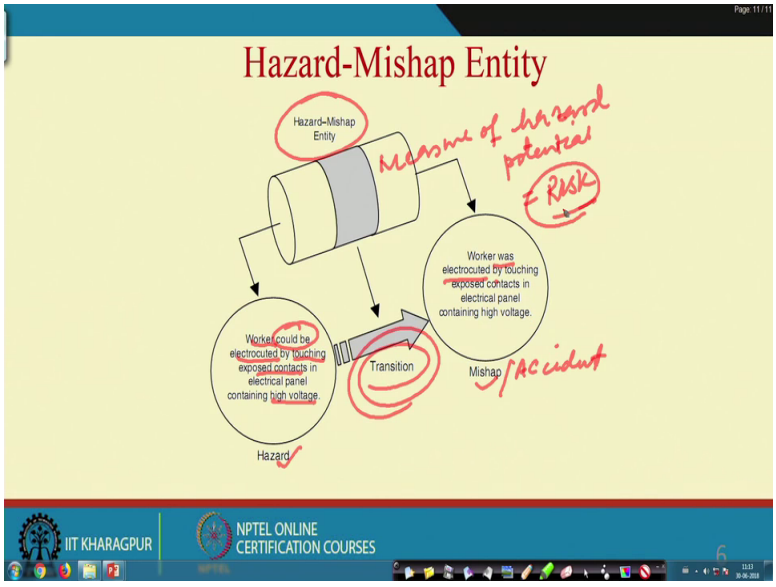

Now, I will give you one example that what do we mean by what is the difference in terms of hazard and accident? You see the difference we see the example, worker could be electrocuted by touching exposed contacts in electrical panel containing high voltage, in electrical panel containing high voltage worker could be electrocuted. So, what is very

important could be electrocuted? So, I mean this is the potential case. What is accident worker was electrocuted ok. So, worker could be electrocuted and worker was electrocuted that is the difference. So, could be electrocuted is a condition and was electrocuted is an event.

And, then what way it has happened by touching exposed contacts in electrical panel containing high voltage. So, there is no differential also by touching exposed contact in electrical panel containing high voltage. So, this is the transition that, worker could be electrocuted to the condition you must know and accordingly you put barrier. So, that it will not happen, but if you do not do anything what will happen this will ultimately allege into accident. Safety engineer must understand that how this potential state will convert to accident state this transition I am repeating the word transition ok.

And, you see apart from this that hazard and accident or mishap. There is another quantity called hazard mishap entity. What is this this is nothing, but measure of hazard potential measure of hazard potential ok. That means, what do you mean to say, what is the amount of hazard? That is involved in this particular job particular work. So, this is what is also known as risk, this is what is known as risk ok. So, from hazard theory point of view hazard is an entity is an important concept which is basically risk ok.

So; that means, what we have learnt we have seen some definitions particularly common definitions, what a safety engineer should know hazard, accident, risk, then incident, and safety by what is the definition of safety? And, then we have found that hazard and accidents are 2 sides of the coin and a safety engineer must know how the hazard state is converted to an accident state? And it is the role job of a safety engineer.

So, you first know how hazard will be converted into accident and what is a path which path it should follow there can be multiple paths. So, one very important concept that is at the hazard theory that state transition from hazard state to accident state.

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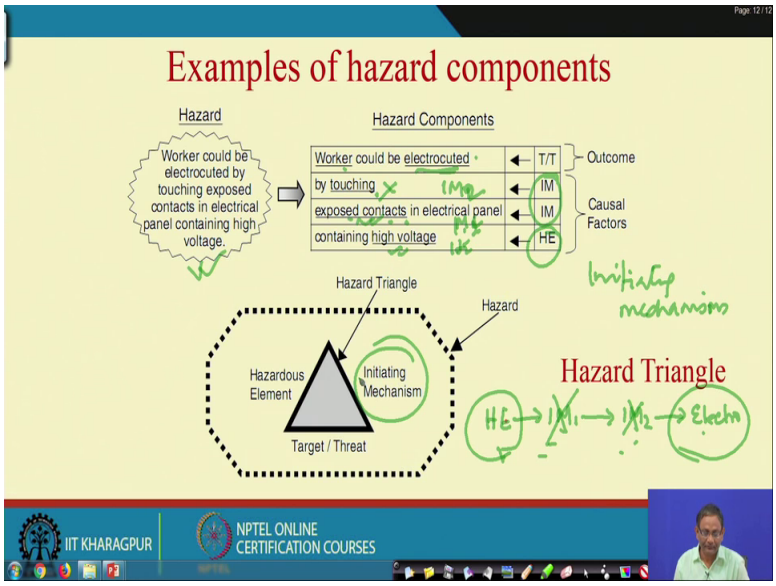

Let us see this example, that the example we have discussed that your hazard example I will go by some other color. So, this is one is known to you now, that worker could be electrocuted by touching exposed contact in electrical panel containing high voltage ok.

Now, why this way we have written here? Is it the complete definition of hazard, how do I, I say hazard is the act potential condition that can cause the this in actual context when you investigate a work place or a job or a machine. So, you identify hazard and then, what way it should be documented. What are the components of a hazard? That is known as hazard components, if we carefully analyze this then you will find out a beautiful structure that worker could be electrocuted.

Here, one is worker who is a target hazard, because worker is exposed to the hazard. What is the exposure electrocution? So, that is the threat. So, worker could be electrocuted worker could be electrocuted. So, electrocuted is the threat.

Now, this electrocution will not be possible, if the worker do not touch what exposed contacts and what is it is inte co what I can say that hazard content is high voltage. So, these example if we write in this fashion, then worker could be electrocuted because of 2 different other things should happen; one is that worker must touch, what exposed contacts?

So, these two events it does not take place the electrocution will not take place. So, these two in between events are known as initiating mechanisms. IM stands for initiating mechanisms then containing high voltage; high voltage this is the source this is the source of hazard. So, hazard this source of hazard is known as hazard element.

So, as a result a hazard has 3 elements; one hazardous elements, which is essentially the source of hazard. For example, it here high voltage, second one is initiative mechanism, because that high voltage will not cause electrocution unless the wire is exposed there and as well as person do not touch. So, person does touch the exposed wire. So, that is why electrocution is takes place. So, as a result this is bas this is the basic mechanism.

So, if I write say this is my IM 1 then it is IM 2 or I will I will write this IM 1 and say this one is IM 2 and this is HE and this one is your target and threat. Then basically HE this must be present and then IM 1 when it is exposed contacts, then IM 2 what is this touching by worker then electrocution. So, this is the path that may hazardous element with a series of intermediate events finally, lead to electrocution of the person or the worker. So, then this is the path so; that means, this hazardous state element this state is now contour the 2 electrocution stage. So, you to identify this stage so, hazard tra define by in definition itself the path must be reflected, when a someone investigates and accident already occur.

Or in which inspect a workplace particular location site or particular job or particular machine being operated. So, he must inspect or investigate in such a manner that this path is clear is understood. If, the this path is not understood then, what will happen? You will not be put barrier here for to the to make it does not happen or even if we had it happens this should not happen. So, any one of this 2 does not happen what will happen means electrocution will not happen. So, that is very important concept hazard triangle is a very very important concept, this 3 element or these 3 component of an hazard makes hazard triangle.

If, hazard triangle is complete that mean accident has taken place ok. So, we will see some more example some more example I will repeat this important con concept that hazard components.

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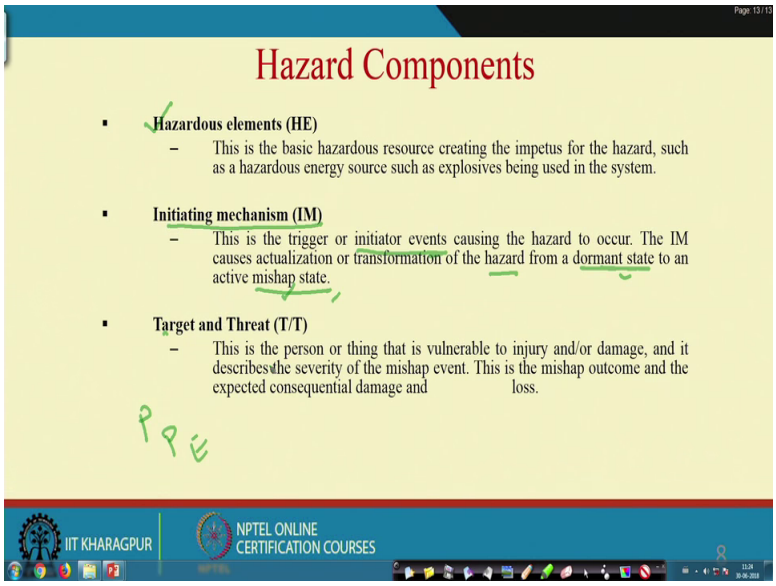

Hazardous element the base this is the basic hazardous resource creating the impetuous for the hazard such as hazardous energy shows, such as explosive being used in the system ok. So, keep in mind that your hazardous element is the starting point are you able to identify all hazardous elements, where you are working or for which you are designing. So, way as you are a safety engineer. So, basically you are a designer; you will design a system for the people to work, design a product for the par for people to use. So, in that case you must know what are the hazardous elements already in build into the system it can it can those elements be reduced eliminate it.

Suppose this is not possible that your technology from operation and function point of view requires the hazardous source to be there to be present to be designed. In, that case you have to know, what are the initiating mechanisms that can take place? So, what is initiating mechanism? This is the trigger or initiator events causing the hazard to occur the IM cause actualization or transformation of the hazard from dormant state to mishap state.

That means, what I mean to say suppose some if talk about the machine moving parts are there. So, there is hazard people working underground under the roof that is that is also actually hazard is there that room may fall. Someone basically that working in the cocobon plant or near cocobon or coke plant so, expo may be exposed to the cocobon gas. So, all those things are there they are they are from the production point of view

underground minds will be there coco coke plant will be there, machine parts will be there.

So, you cannot avoid those hazardous elements, but you must see that how what way these hazardous element ultimately triggers to we to different undesired events and finally, to accidents that should not happen. So, that mean this initiative mechanism makes the that ha hazard from dormant state to mishap state accident state. So, we do we have to understand this. Third one is target and threat it is better understood, because target means primarily people, then property, then environment. And, threat can be of different kind all those usually by threat we mean, that death injury something like this ok. For there be multiple different context different threats please keep in mind very much.

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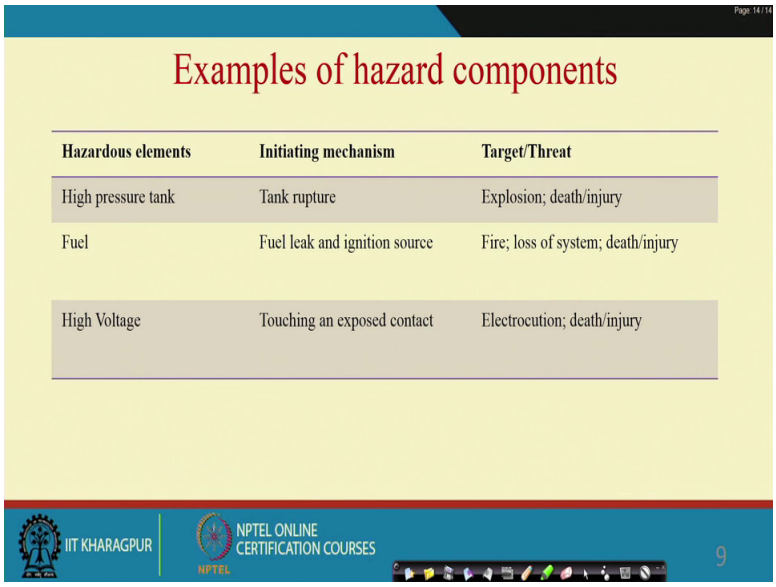

Few more example a pressure tank system, where hazardous element each high pressure tank, hazardous element each high pressure tank, hazardous element here high pressure tank may rupture lead to explosion and death. Suppose, you just think of a pet a petrol pump fuel is there, the fuel may leak there are ignition source it may lead to fire or some damage, you think of high voltage what example we already have given ok. So, these are the some example of hazard components.

Hazard is very very important concept in safety engineering and all of you must know, what is hazard? What are the different hazard components? And, we must be able to we must be able to understand that how to document hazard?

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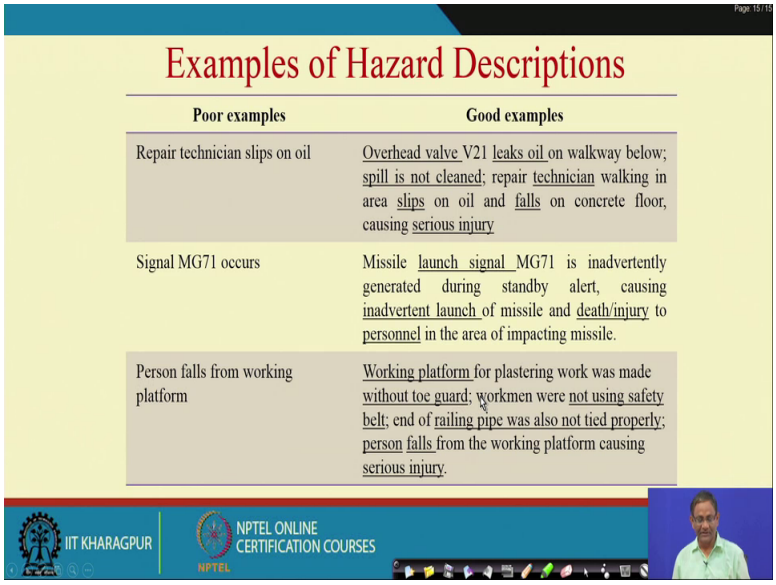

Here, you see that it is basically for describing hazard, how to write properly the hazards. In there are poor example and good examples suppose many a type what happen this time and on my experience, I have seen who on my experience, I have seen that when I have I have seen some accident report or any instruction report people have written repair technician slips on oil. So, this kind of this kind of write up is not good this, kind of write up is not good example of either poor example of either or signal mg 71 occurs or person fall oh falls from working platform.

Now, good example will be overhead valve V 2 1 leaks oil leaks oil overhead valve walk on walkway below; spill is not cleaned; repair technician walking in area slips in area slips on oil and falls you just read it all those things, what happened? You will find out that in this particular ex example a hazardous element initiating mechanisms and targets self creates are clearly written. And, after le after reading this you will be able to find out that the sequence of events.

Similarly, here also suppose person falls from working platform. Working platform for plastering work was made without toe guard; workmen were not using safety belts; end of railing pipe was also not tied properly; person's falls from working platform causing

serious injury. Here working platform at height that is basically the hazardous element and what are the initiating mechanism, it was not having toe guard and workmen were not using any safety belt. Then also the railing pipe was not tied properly. So, these 3 things 3 initiating mechanisms ultimately lead to person fall from the working platform. And, what is the threat here the threat what basically that he or she basically experience serious injury ok.

So, this is basically the way you must write hazard. By hazard I mean to say that there are 3 component one is your one is your hazardous element, second one initiative mechanism may be one may be multiple, there can there can be sequence of initiating mechanisms happening. And finally, leading to target and threat graduation ok, this is what is known as your hazard knowledge ok.

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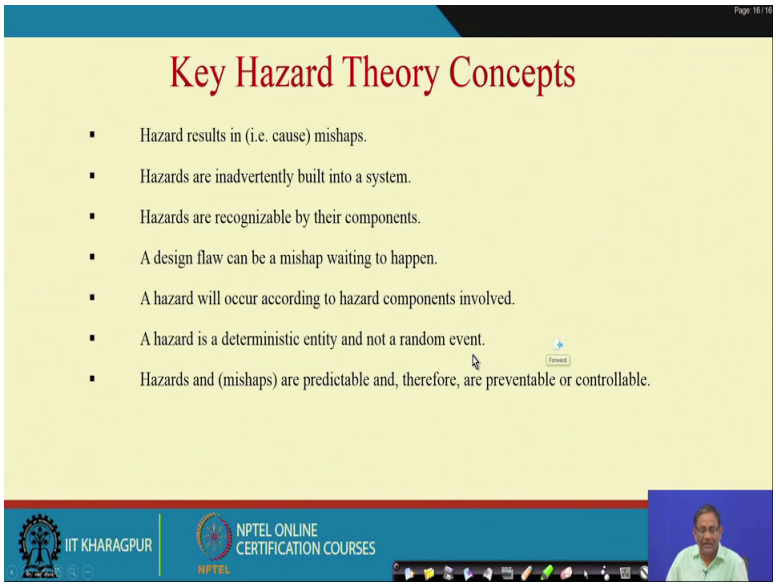

So, I just go by another slide that what we have learnt so, far just so, far in the sense in this particular lecture, just I am just basically summarizing this that what are the key hazard theory concepts? Hazards results in mishaps means hazard results in accident. Hazards are inadvertently built into a system hazards are not coming out of the that group. It is basically built inadvertently built into a system; means during design, during build, during operation, during maintenance. So, means in the lifecycle of a system sometimes somewhere these hazards are built.

Mostly design is the problematic model. Hazards are recognizable by their components means, you must know that hazard has 3 component one is hazard has elements which is basically the e source like hazardous energy source. And, initiating mechanisms these are the basically series of events that can take place ultimately leading to leading to that accident. And, accident basically puts threat to the targets; targets are people property and environment.

A design flaw can be a mishap waiting to happen suppose you design a process ok. Suppose if boiler you design and the there is a flaw ok. So, suppose a important sensor safety point of view you fail to install there, what will happen? Anytime an accident will happen ok. So, design flow is very very important one. So, that is why we say that safety engineering engineers basically do design. So, safety engineering it should start at from the at the design house, it should be in at the extreme of stream of a system lifecycle. A hazard will occur according to hazard components involved; obviously, depending on hazard components a hazard is deterministic entity not a random event hazard is a deterministic entity understand.

Accident is a random event, but hazard is not a random event it is known, if you do not know what are the hazard safety of a plant; that means, you are ignorant about the system you do not have design knowledge, you do not have system knowledge means adequate design and system knowledge. Hazards and mishaps are predictable; obviously, a hazard is deterministic it is predictable mishaps even though random they are also predictable and if something can be predicted it can be prevented or controlled ok.

So, this is for today I hope that I have give I have given you the theoretical side of hazard and the issues the com means the components of hazards and an and how you can equate hazard and accident, if you know hazard you know accident. And, it is you the design engineer a safety engineer, who will built a system in such a manner that it will be minimum hazard prone both minimum hazard will be in built. Because, that is required best for the production, operation, other functionalities point of view, but that minimum hazard also should not be kept that means, what I can say unattended, that hazard minimum hazard the hazardous element that is the residual waste later on I will tell you. So, that residual is that also when that should be protected ok.

Thank you very much.