Health, Safety and Environmental Management in Offshore and Petroleum Engineering

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Module - 03
Accident modeling, risk assessment and management
Lecture – 01
Dose-response assessment

Welcome to the online course on HSE practices. We are talking about lectures on module-3.

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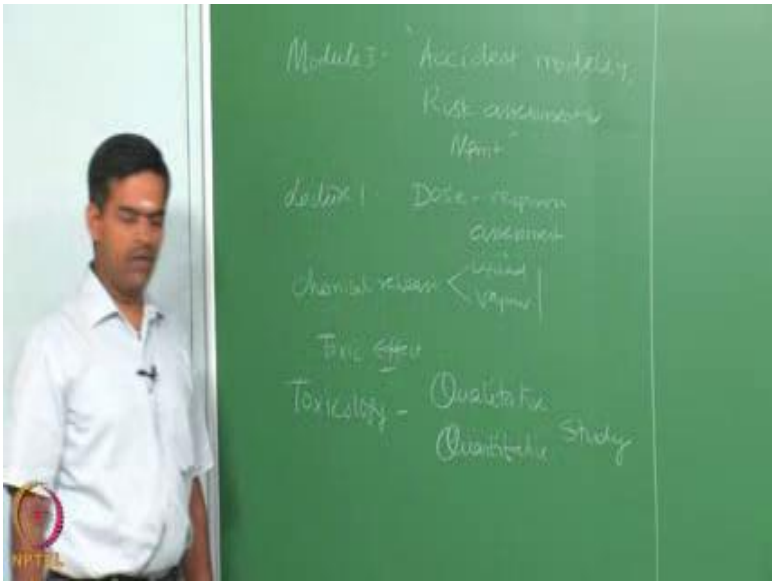

In module-3 we will focus on accident modeling, risk assessment and management. That is going to be your focus in module-3. We will talk about lecture-1 in module-3 where we are going to discuss about Dose-response assessment.

We have already said in the previous lecture that there are many sources through which the environment is polluted because of drilling operations in the open sea. There are many chemical releases possible in the form of liquid, in the form of vapor, which can get released dispersed in the environmental atmosphere which also causes catastrophic

effects or consequences on the general public as well on the individual who were working on the plant. So, on the whole all these chemical releases are talking about something called toxic effect, let us talk about what is toxicology.

Toxicology is defined as qualitative and quantitative study of adverse effects of toxicants on the biological organisms.

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Now the question is what is a toxicant? Toxicant can be a chemical or a physical agent, which can include dust particles, which can also have fiber, which can also even have something like noise and radiation. So, friends all these are possible consequences which can arise from different sources which essentially have a very serious effect on biological organisms, not necessarily human being even on marine aqua culture etcetera. If we plan to do some quantitative assessment of this consequence and the effect or qualitatively monitor and estimate the damage caused to the biological organism we call that entire study as toxicology. So, toxic need not be always chemical, please understand it can even a physical agent like noise pollution, like radiation effects, etcetera. It need not be always chemical right.

Now, the question comes how do toxicants enter the human body.

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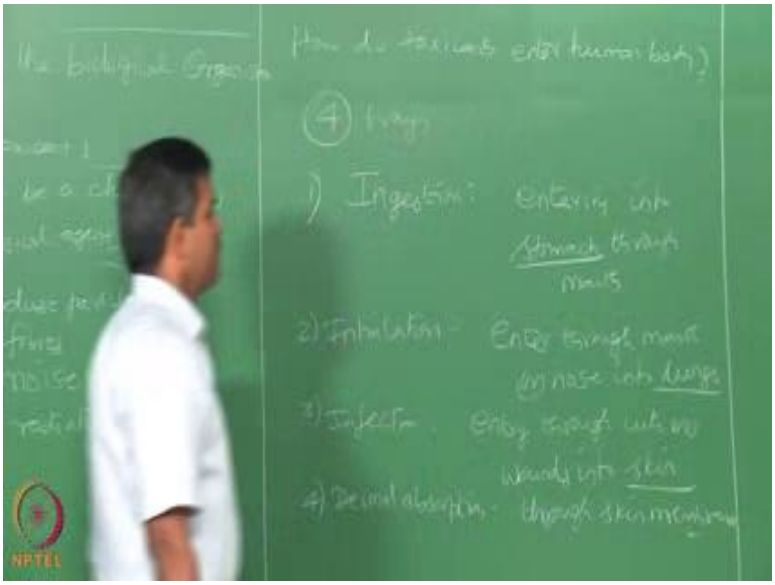

They enter the human body by 4 ways – one, what we call as ingestion, ingestion means entry is through mouth into stomach, entering into stomach through mouth. Inhalation, it is a second source by which toxicants can enter human organisms which is through the mouth or nose into lungs, enter through mouth or nose into lungs. So, different parts of the body are vitally affected. Third could be injection, entry is through cuts into the skin or wounds and it enters the skin membrane. Fourth could be dermal absorption, dermal absorption is through the skin membrane itself directly.

These are the possible four ways by which a toxicant can enter human body; therefore obviously, we look at the practices of safety implemented in offshore industry. If you really wanted to assess the qualitative way of how the biological organisms affected one should be able to qualify what is the tolerable limit of these kind of toxicant entry in human body or on the other hand one can quantify what would be the radiation effect which in human being can sustain in terms of quantifying this value. So, either they one can assess the consequences or the effects caused by the toxicants on biological organisms.

Now, the question is when we talk about the tolerable limit or acceptability of these kinds of toxicants entry in human body then one is bothered about what is the maximum

dose, and for that dose what is the response of the human body.

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So, we should like to know the dose plus response assessment. Biological organisms respond differently to the same dose of toxicants; biological organisms respond differently to the same dose, what could be the reason for this? The factors which can cause this kind of variety or difference in the behavior or response behavior of biological organism may be due to any factors, for example, age, sex, weight, diet and other general health conditions.

A mixture of people, set of a group of people who has got different factors inherited in them will behave in a different manner to the same level or dose of toxicant that is very important. Therefore it is very rather difficult and complex to assess qualitatively the response behavior of an individual, when they are present in a group which has got a wide variety of differences because response to each group or each factor will be different when they are exposed to different dose of chemicals or toxicants. Therefore, international literature or references suggests qualitative response behavior based upon dose of the toxicants. There are different dosages which are helpful to assess qualitatively their effect on human being.

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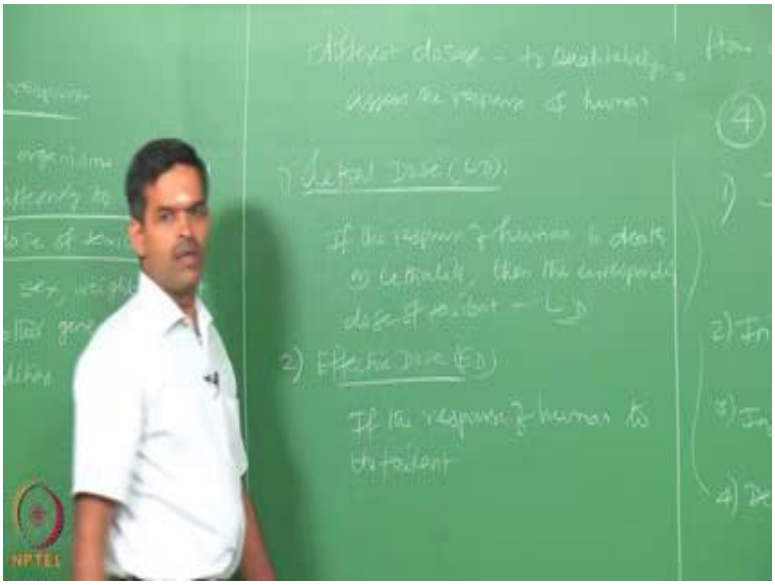

So, different dosages which can help to qualitatively assess the response of human body - first is what we call Lethal Dose – LD. Lethal Dose is defined in a simple terms like if the response of human or any biological organism is death or lethality then the corresponding dose of toxicant is called as Lethal Dose.

The second qualitative assessment can come from measurement of Effective Dose, what we say as ED - if the response of human or any biological organism to the toxicant is not death but causes minor and reversible damage.

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Reversible damage in the sense they can be cured with immediate medical attention, I can give examples of this eye irritation, nausea, etcetera. Then the corresponding dose of the toxicant is called effective dose. The third qualitative assessment of the dose versus response is toxic dose. If the response of human or any biological organism to the toxic agent is not death, but causes undesirable irreversible, irreversible in sense causing a permanent damage to the human organ, I can give example blindness, etcetera.

If the response of the human to the toxic agent is not death, but causes undesirable irreversible effects then the corresponding dose is called toxic dose.

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So, various types of doses are generally expressed the logarithmic curve. Please pay attention to the figure shown in this screen which indicates different types of doses on a log scale.

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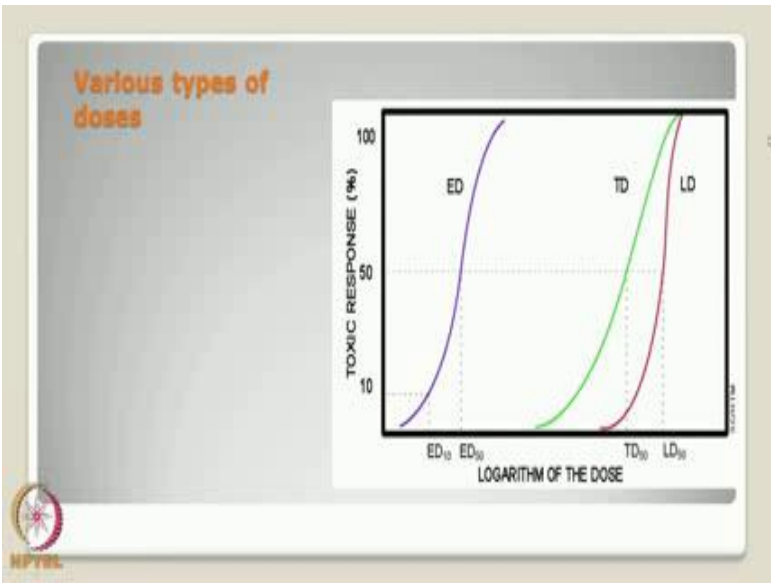

The y axis indicates percentage of toxic response in terms of 0 to 100 and the x axis

indicates logarithmic value of the corresponding dose. For example, this curve indicates effective dose, the green curve indicates toxic dose, and red curve indicates lethal dose, can always see the corresponding numbers of LD 50, TD 50, ED 50 and ED 10. Let us see what are these values - lethal dose 50 let us say for example, is a corresponding acceptable or permissible.

Limit of the toxic dose which can be obtained directly from the curve as you see back on the screen now for example, LD 50 corresponds to the dose on the scale of 50 percent which intersects the corresponding curve and the appropriate dosage on logarithmic of the dose is what we call LD 50. It means out of a scale of 100 or 100 percents expose to this toxicants 50 percent of the people of the 50 people are injured with lethal damage definition. Lethal damage indicates that it causes lethality or death.

On the other hand take ED 10 only 10 percent of the population exposed to this particular toxicant or having effective dose qualitatively. So, that corresponding dosage is what we call ED 10. So, for all types of chemicals which are generally released in a process plant, all these standards of LD 50, TD 50, ED 50 and ED 10, are prescribed in the literature. One can also find the TLV concentration of the toxic agent. TLV concentration is based on certain standards.

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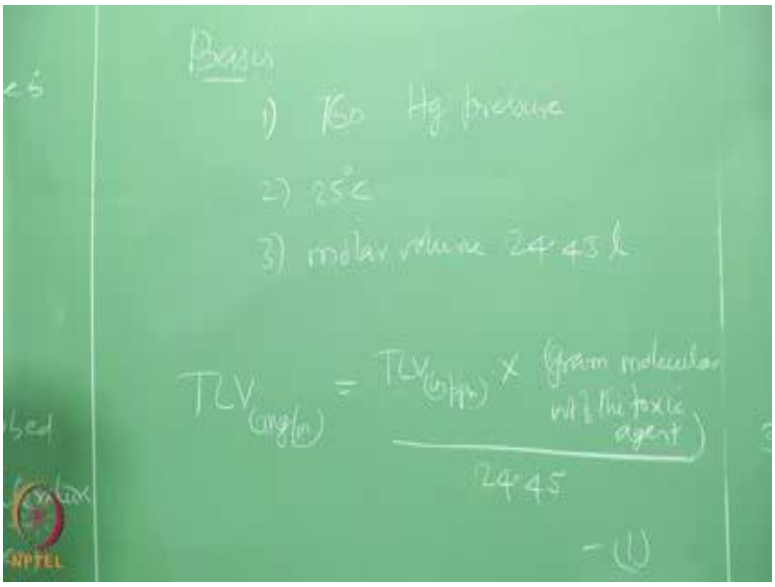

The basis for measuring the TLV concentration is based on 760mm mercury pressure, temperature is at 25 degree Celsius, molar volume is 24.45 liters. So, one can always find out the TLV concentration in milligram per meter. So, TLV in milligram per meter concentration is given by a TLV in parts per million concentrations, multiplied by the gram molecular weight of the substance of the toxicant; the gram molecular weight of the toxic agent or the toxic substance divided by 24.45 which is the molar volume of mercury. So, one can work out TLV concentration in milligram per meter for a given system.

After understanding this, if the chemicals are released which has effect of different variety on human being then we will talk about what is called Industrial Hygiene.

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Industrial hygiene focuses on identification, evaluation and control of occupational conditions that prevail in the industry or in the work place which can cause sickness or injury to the personal. Identification deals with determination of possible work place exposure, so determines possibility of exposure to toxic agents in the work place what is the possibility and what is the probability of expose this can be generally done through a detail study, a detail study need to be undertaken, inspection need to be conducted. To really find out what are the possible chemical processes probability of operating

conditions in change in the environment and operating procedures. So, this can be easily estimated qualitatively and quantitatively as given by the procedures by Efthimia et al.

Interestingly, to estimate the consequences or possibility of expose or work place to different kinds of chemicals, the procedures, etcetera you need variety of source of information.

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Now, the source of information to conduct such studies can be done through various sources or various information factors - one process description operating instructions or let say operating procedures, safety reviews and material safety data sheets, what we call as material safety data sheets which are generally available in different sources, one important source or can be Engelhard el 1994.

Once you identify the possible sources of information from the data what you collect from these 4 factors then one need to identify and evaluate what would be the consequences of these conditions on human being.

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So, evaluation deals with determining the magnitude of exposure. So, therefore, for a toxic agent what is the concentration of the dose of toxic agent to which the public can be exposed, what would be the likelihood of duration of exposure, what are the possible mechanisms by which the toxic agent can spread or let us say can disperse in air. So, I need to identify all these factors which come under evaluation.

And third factor of course, is the control which identifies possible control measures available in the plant to take care of the consequences, are they preventive or they post corrective need to be actually examined and if any weakness is present in the control methodology this need to be revisited and proper control methodology should be available in placing the plant. Many methods of estimating the control mechanisms are available in literature.

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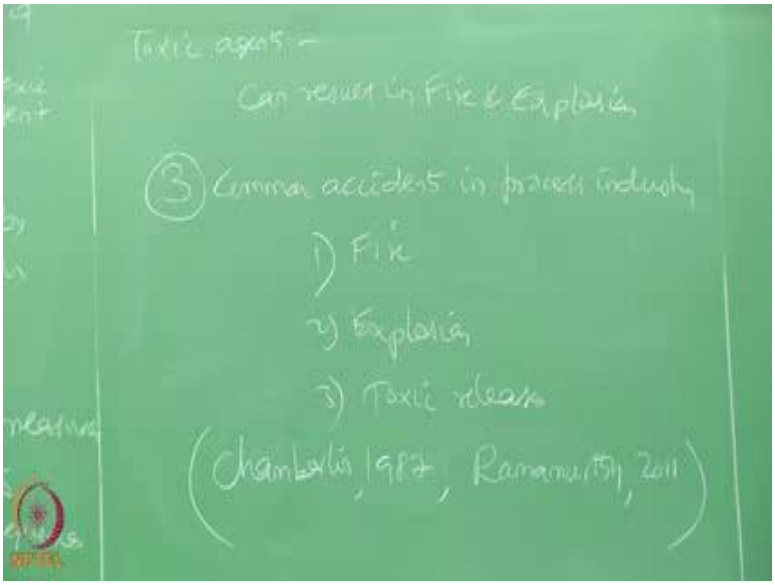

So, one can see Nivoliantou at el 2006, for more information on variety of control mechanisms an acceptable levels of control mechanisms in oil and gas industries.

Now, toxic chemicals or toxic agents will have a very serious consequence, once they are dispersed. However, there are many chemicals which can result in fire and explosion which is highly catastrophic to the human. Chemical process systems contain substantial hazards that can arise from fire and explosion. Three common plant accidents generally are, three common accidents in process plants in process industry are – one could be fire, two could be explosion and three could be toxic release as said by Chamberlin 1987 and Ramamurthy 2011.

Let us quickly see more in detail how these can be estimated for example, fire and explosion release models how toxic release can be estimated quantitatively and they can be compared and say are they acceptable within the threshold limits of LD 50, ED 50, etcetera. Let us understand that define certain terminologies.

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Let say what is fire. Fire actually is a rapid exothermal oxidation of ignited fuel. The fuel can be solid, liquid or even in vapor form. Now what would be the consequence of fire?

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Fire releases energy in the form of thermal radiation, this radiation can reach its peak intensity which can cause a permanent damage to human. Fire can also be formed as a

result of explosion then, what is explosion? Explosion is a rapid expansion of gases, what would be the consequence? It results from rapidly moving pressure waves; they are also called sometimes as shock waves. The expansion what you see as an effect from expansion can be mechanical; the expansion can be mechanical or it can result from chemical reaction. The consequence could be explosion releases energy very rapidly which can cause fire that is important.

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So, these are two major accidents. Toxic release is of course inferior compared to these two. So, when these accidents are really resulting in offshore plant or any process industry in general then one should talk about what is called accident prevention because we like to avoid such accidents. Fire and explosion accidents can be prevented if you have knowledge of fire and explosion characteristics as the material. So, they can be prevented, if knowledge of material is available. The materials can catch fire and explosion or one can say fire and explosion characteristics of material are the vital source of information to control such accidents. Fire and explosion can also be prevented by removing any one arm of the fire triangle. So, one can study what is called fire triangle, if I able to remove one of the arms of the fire triangle then one can prevent fire and explosion accidents.

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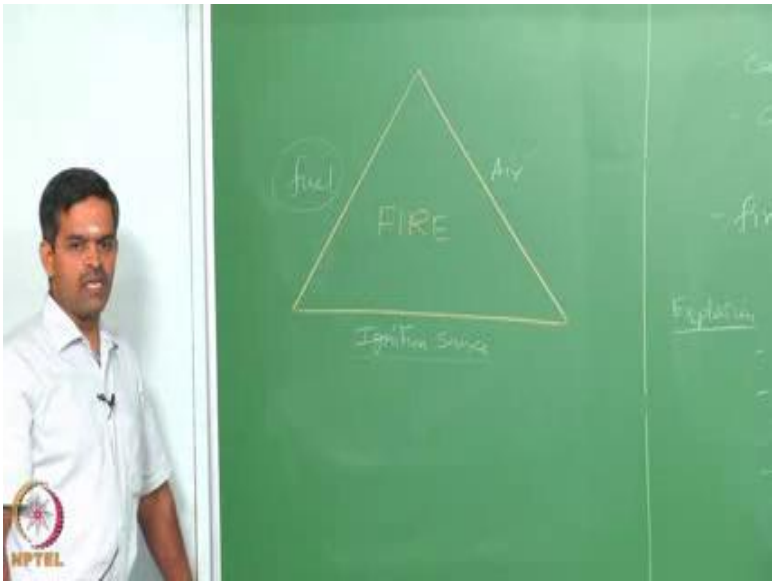

Let us see what is the fire triangle. Fire triangle has three arms as you see here, these at fire triangle. One of the arm is called ignition source, the other arm is called air, the third arm is the fuel. If any one of them is absent in the given scenario then it will not result in fire at all, but unfortunately if you dialogue and argue on this presence of air is available abundantly which is required also for healthy working environment. Of course, in offshore industry in explanation production at least you know air is available in plenty.

Of course, we are dealing with fuel therefore; there is no question of not having fuel in the present scenario. Ignition source can be a variety; can be even electric short circuiting, it can be exothermal reactions because of the chemical release etcetera. So, none of these arms can be really controlled in terms of process industry like offshore or oil and gas industries.

So, fire cannot be avoided only by deleting and depleting any one of these arms which is seems to be hypothetical. But one can always try to understand the fire and explosion characteristics of the material and based upon the characteristics one can always try to bring down the possibility of the chemical or the gas getting ignited or getting exploded. So, we would like to know what would be the characteristics of every material in terms of fire and explosion prospective.

There are varieties of definitions, a very important now. Let us look at them in detail.

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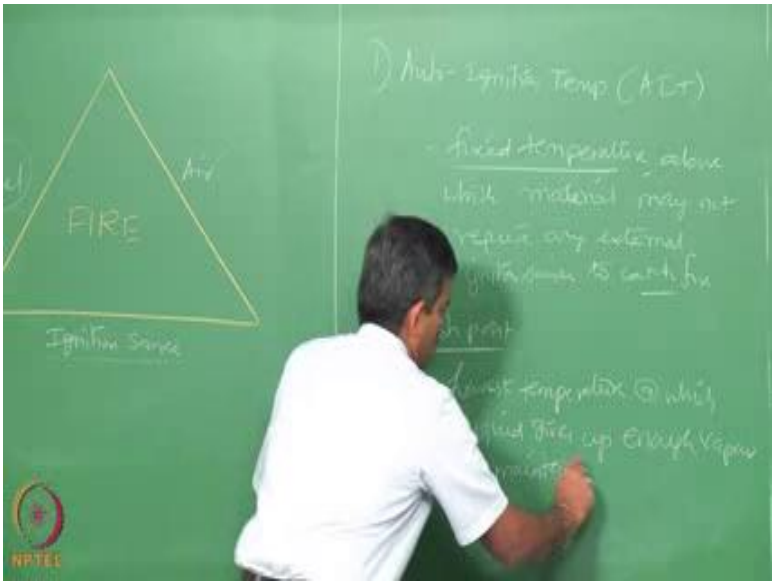

Auto ignition temperature, it is a fixed temperature above which material may not require any external ignition source; material may not require any external ignition source to catch fire. It will catch fire automatically if this temperature is exceeded every chemical or every material has this particular temperature available in the literature. Next could be what we call as a flash point, this is the lowest temperature at which liquid gives up enough vapor to maintain continuous flame for burning.

So, we will talk about many more parameters and try to understand some of the important explosion characteristics of the chemicals in the next lecture as well. So, in this lecture we tried to understand the dose response assessment qualitatively using lethal damage, expose the level damages, etcetera and toxic damages. We have also understood what are those important vital parameters for a material to catch fire. We understood what is the fire triangle, we will discuss this in detail in the next lecture as well.

Thank you.