Health, Safety and Environmental Management in Petroleum and offshore Engineering

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Module No. # 03

Lecture No. # 01

Dose assessment, Safety regulations

So, ladies and gentlemen, today we will start discussing about the lectures on module three and the course on health safety and environmental management in petroleum and offshore engineering. We will talk about the module three, where we will start discussing certain topics in fifteen lectures.

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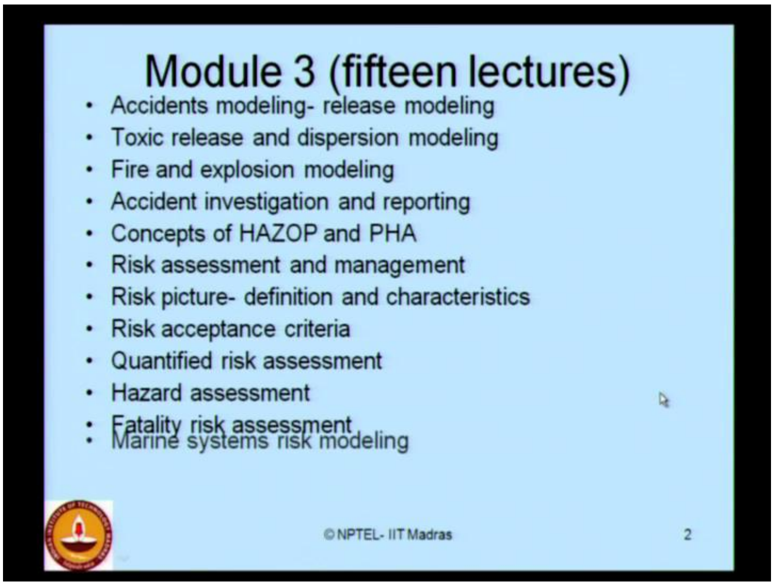

We will talk about accident modeling methods and release modeling methods. We will discuss toxic release and dispersion modeling techniques. We will also speak about fire and explosion modeling. We will start discussing on accident investigation and reporting methodologies. We will discuss concepts of HAZOP and PHA in the last module of module one. You must have discussed in detail about the HAZOP, but still I will again present overview of HAZOP in this model as well, and I will present a case study one more additional case study on HAZOP in this module.

We will also talks something about probabilistic hazard analysis then we will speak about risk assessment and management techniques with more emphasis. We will talk about risk picture, we will discuss about risk acceptance criteria. Then we will talk about quantified risk assessment, which we called as QRA. We will also discuss very briefly again on hazard assessment then we will talk about fatality risk assessment. So, the module three will comprise of fifteen lectures; today we will discuss the first lecture.

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Before we understand accident modeling, there is a fundamental question, which is required to be answered. Let us define safety, what do we understand by safety? Safety is categorized by international electro technical commission by certain standards. Safety is a subjective issue generally a person feels safety is addressed only to human health; certain set of people argue that safety may be related to operational safety only. So, since these issues are having multidimensional subjectivity, international electro technical commission has defined certain standards for safety levels which we called them as IEC standards.

IEC standards are extensively used as benchmark standards in oil and gas industry. I can give you couple of interesting codes of IEC standards; however, for interesting learning one can access to this standards in detail and study them. Of course, in this course, we will not cover the deliberate discussions on IEC standards, but we will pick up certain algorithm and standard equations, which are given in IEC with the reference of course, given in the respective slides.

For example, if you look at IEC 61508, which is a functional safety of electric, electronic, programmable electronic safety related systems released in Geneva 2000. This discusses about the safety standards on electrical and electronic safety related systems. Similarly another standard on IEC 61511 talks about system for process industry. So, it is functional safety, the safety instrumented systems for a process industry sector Geneva released on the year 2003. Similarly, there are many IEC standards, which are very common and extensively used in oil industry. I leave this as an exercise for the user to refer back to IEC standards, and try to understand what all are the extensive discussions present in these standards, and what kind of safety measures have been defined for different kinds of industry like electronic industry, process industry etcetera as for the international electro technical commission.

One advantage about IEC standards are, IEC standards are very voluminous; they cover industrial safety standards in a very elaborate manner. And therefore, if you use or employ such standards in your industry, this exercise can lead to process and design input in an extensive manner. For example, if you really want to improve on the existing safety measures of your industry or you want to work upon more safe standards on process or the techniques employ in your industry to improve on the design input as well as in the process segment of the industry, IEC standards of relevant issues can be referred and that will be very useful to produce a very extensive idea related to improvement in safety in process as well as the design stage itself. Alternatively, OLF also gave some guidelines in a simplified requirement. You may wonder what OLF is, we will discuss that.

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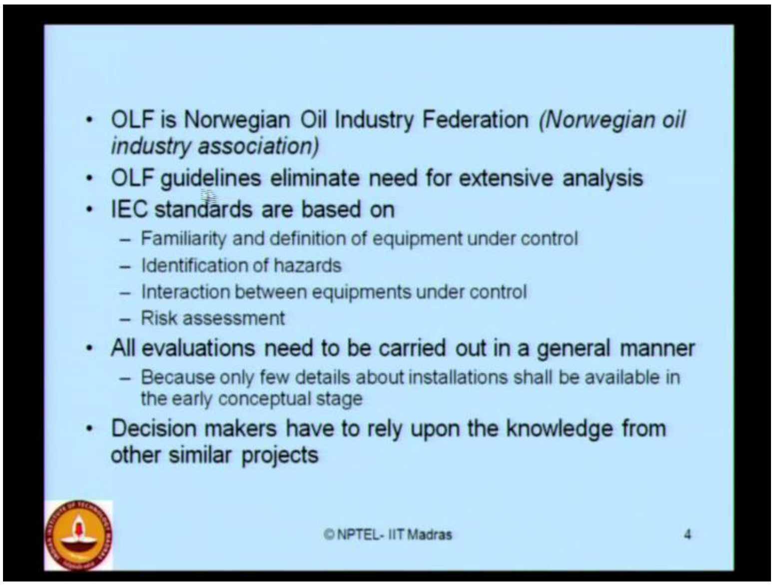

OLF actually is a Norwegian oil industry federation. This is Norwegian oil industry association; they derive certain standards exclusively applicable for oil industry. The advantage of these standards are they are written to the point of interest especially for safety in oil industry only. Unlike IEC these documents address a very clear cut point issues related to offshore industry. OLF guidelines eliminate need for extensive analysis. IEC guidelines on the other hand will intuit you towards extensive analysis in the design and process sector, where as OLF guidelines are something like bullet points which can be directly applied on to the oil industry, and therefore, extensive analysis can be eliminated.

So, this can be seen as a one of the shortcut techniques of employing safety in oil industry; however, we are not indenting to compare the quality of these standards as applicable to oil industry. Both of them are perfectly all right, and both of them are extensively written in a very nice documental manner. One can recommend any one of them for employing in their own industry for process and the design sector as well.

Now, just to compare very quickly with a brief note what just now I said. IEC standards are actually based on the following parameters. Based on the familiarity and definition of the equipment under control, standards are defined. Based on the identification of hazards standards are again redefined, considering the interaction between the equipments under control certain standards are elaborately given and of course, based on specific risk assessment methods IEC standards are defined.

All evaluations need to be carried out in a very general manner, because only few details about installations shall be available in the early conceptual stage. It will be rather difficult at the early conceptual as a designed stage to carry out a very descriptive analysis or extensive analysis in a more generic manner in the beginning, but IEC standard emphasize such kind of evaluations in a more general manner in a comprehensive way. Therefore, in such situations the decisions makers have to rely upon the knowledge what they have acquired from other similar projects.

So, ladies and gentlemen, we can put it a cross like this if you have got to employ an IEC standard for your process or designed input improvement towards safety directions, you need to know or you need to be experienced with sound knowledge of similar projects. Then only you will be successfully able to employ these standards, because they are based upon certain parameters.

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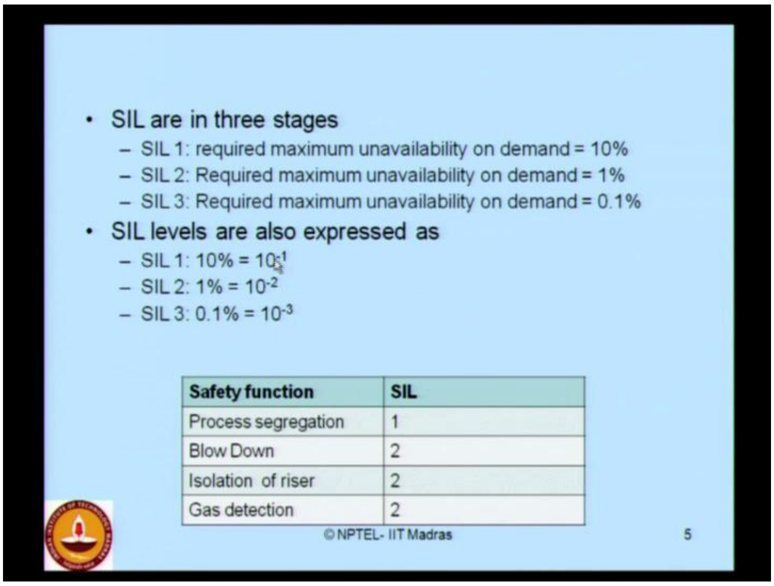

I can give you some example here. These standards converge into what we call as SIL safety for industrial limit are in three stages given SIL one, SIL second stage, SIL third stage. SIL first stage says, the safety required with the maximum unavailability and demand is about 10 percent. How do you understand this statement? For example, let us say IEC standard defines a process safety related to electronic equipment may be a sensor, what is the maximum unavailability of that particular instrument on demand when it is required? So, you have got to maintain the requirement of the availability by about 90 percent, maximum unavailability on demand of that facility or safety instrument can be only allowed as 10 percent. So, if your industry has that kind of phenomena then it comes under the standards of SIL 1 or level of SIL 1.

If you look at a SIL two then the required maximum unavailability of any safety equipment on demand should be only 1 percent. It means your industry a process safety and manufacturing techniques should be of that update, so that all your devices which are meant to implement proper safety in process sector should be up kept. So that on demand maximum unavailability permitted is only about one percent. On the other hand, 99 percent all those instruments should be made readily available and should be functional which are essentially required for improving or maintaining safety environment in the industry.

Comparatively, if you look at SIL level three, the required maximum unavailability on demand is only 0.1 percent - it means 99.9 percent all your safety instruments should be in order. So, you can look at the safety levels standards of SIL-3 is much more stringent and tougher compare to the tough SIL-1, for example, let us say, in your process sector, you are talking about certain segments where you do process segregation. For example, you are taking out the byproducts from the crude oil for during the process sector that is what we call as let us say segregation. If in that sector your SIL limits can be of level one, it means if you are employing any specific safety device to maintain safety during operation in a process segregation sector of the industry, then those instruments can be maximum unavailable on demand by about 10 percent. So, 90 percent they should be functional and remain in order your tolerance limit is only about 10 percent.

On the other hand, if we look out operation like blow down then the SIL level is two, if you look at isolation of riser level the SIL level is two, the gas detection sensor systems SIL level is two. It means about 99 percent, they should be all in order to enhance or to emphasis safety during process. However, SIL three is a very kind of a strict level of demand in my opinion, this kind of safety standards can be strictly implemented in very highly sophisticated plants like nuclear power plants etcetera.

Now, SIL levels on the contrary are also expressed in a different format. You can express them in percentage or can expressed them as 10 power minus 1, 10 power minus 2 correspond to SIL level two, and 10 power minus 3 corresponds to SIL three. You can easily work out this 10 by 100 – 0.1 therefore, that comes 10 power minus 1. And similarly, so on 1 by 100 - 10 power minus 2, 1 by 1000 - 10 power minus 3. So, SIL standards sometimes SIL will be given in exponential powers of 10 as well. So, do not be confused you can express them either as percentage of unavailability or in terms of 10 power minus 1 etcetera.

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When we talk about safety, when we talk about accident modeling, we always ask an inherent question in our mind in a process industry, we have seen in the first module and second modules of lectures saying that oil and gas industry has lot of inbuilt risk phenomena involved, because the process is complex. The mechanical systems have very complex systems in behavior and design and layout. Therefore, there always exists a certain level of risk. Now the question interestingly comes is, what is an acceptable risk?

Again, it is a subjective issue. A risk which is acceptable to me may not be acceptable to you, but there should be a common platform at which both of us sit and agree that these are all the following acceptable risks. Before we talk about accident modeling, before we emphasis on a safety, let us try to understand that offshore industry oil and gas industry in particular has certain level of basic risk allowed, what is that acceptable level.

The risk is generally acceptable to regulatory agency and also to the public. Any legal authority implementing let us say penalty class on any process industry also allows certain level of risk of course, public also accept certain level of risk. I will give an example below. Now according to the United States EPA criteria a lifetime risk of one in million is defined as acceptable for carcinogens, 1 into 10 power 6 or one in million is that level of risk standards which when you are exposed to carcinogens. For non-carcinogens, the acceptable risk is hazard index of less than one. According to United Kingdom health and safety executive, this standard defines acceptable risk in terms of fatality accident rate. So, any fatality accident rate acceptable value is about 1.0.

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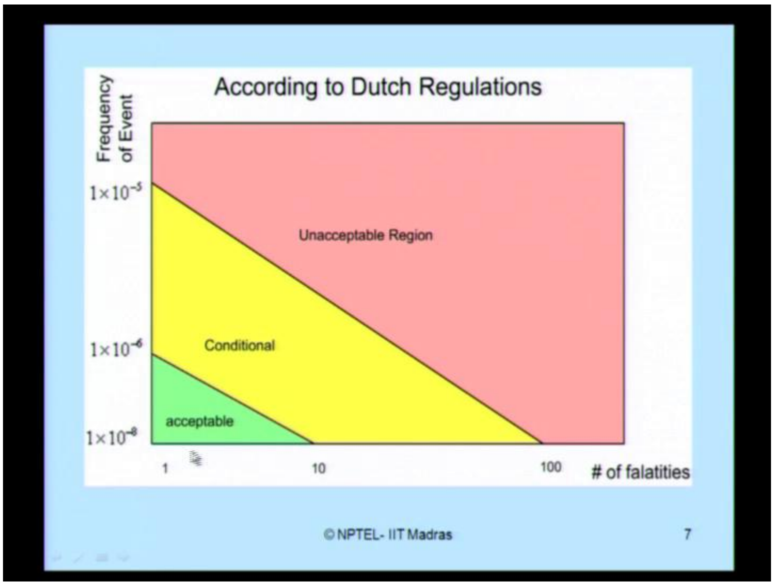

The risk acceptance level is being defined by different international regulations. If you look at this curve according to Dutch regulation, the number of fatalities versus frequency of event has been discussed in a pictorial form. And this tells me, which are all acceptable region of risk and which is unacceptable region of risk. For example, any fatality which is less than 10 in number which has a frequency varying from 10 power minus 6 to 10 power minus 8 is an acceptable risk level as per Dutch regulations.

If the number of fatalities exceeds hundred, and the frequency is also in the range of 1 into 10 power minus 5 and above, then this becomes may unacceptable region. So, on the other hand, ladies and gentlemen, the moment you talk about risk assessment in offshore industry there is something what we call acceptable level of risk and this is subjective value. Therefore, define international agencies define these acceptance level depending upon their acceptance criteria. So, once as example what you see here is as for the Dutch regulation. So, this become may unacceptable reason of risk, this is conditionally accepted. For example, if your risk falls in this yellow band then your risk is acceptable provided to take some measures to not to make it as catastrophic and of course, if the risk is less than this region of green it is considered to be acceptable level.

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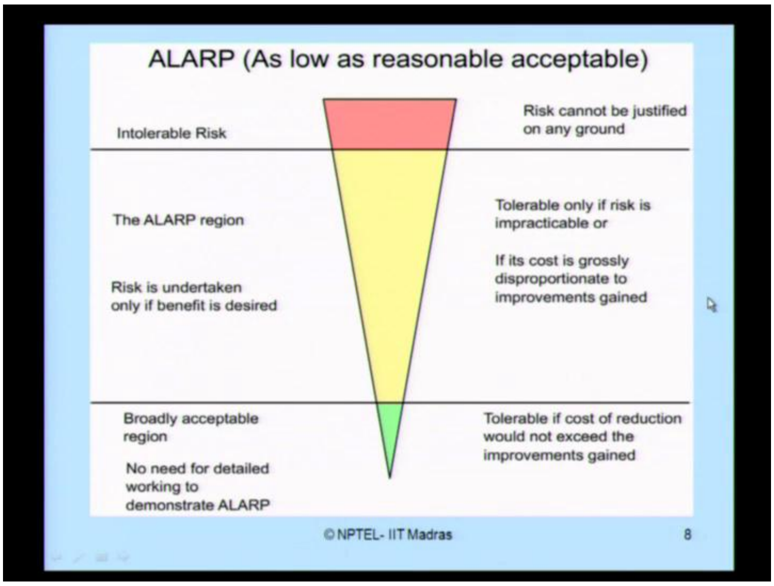

When you talk about risk acceptance then we consider something called as low as reasonably acceptable, for example, the red band what you saw is what we called as an intolerable risk; that is risk cannot be justified on any ground. If the yellow band, what you see as conditional level, then we say it is what we call as an ALARP region. The risk is undertaken only if the benefit is desired. On the other hand, the risk is tolerable only if risk is impractical or if its cost is grossly disproportionate to the improvements that is being gained. Of course, if we have a risk in green band then it is broadly acceptable reason there is no need for any detailed working to demonstrated ALARP in the situation. The risk becomes completely tolerable if cost of reduction would not exceed the improvements gained in this region.

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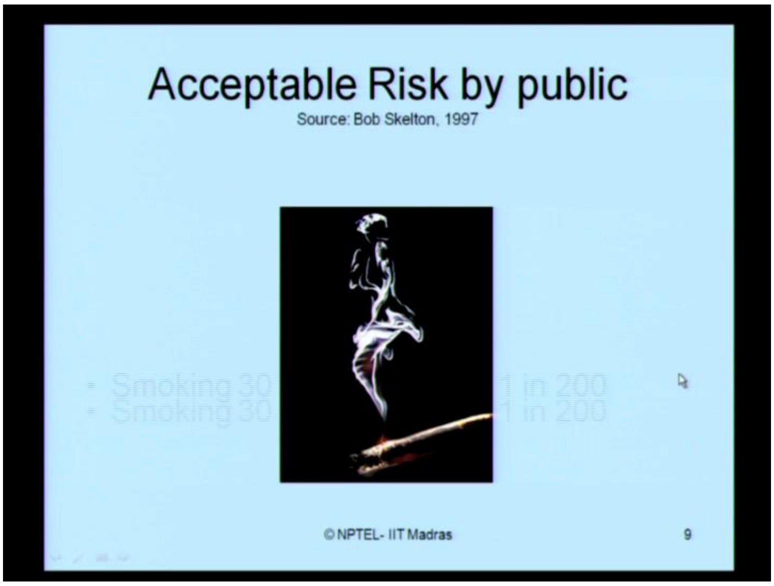

When you talk about acceptable risk by public, which is given by Bob Skelton 1997 even a cigarette smoking has a risk in one in two hundred.

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A motor vehicle accident has risk of 1 in 10 power 4.

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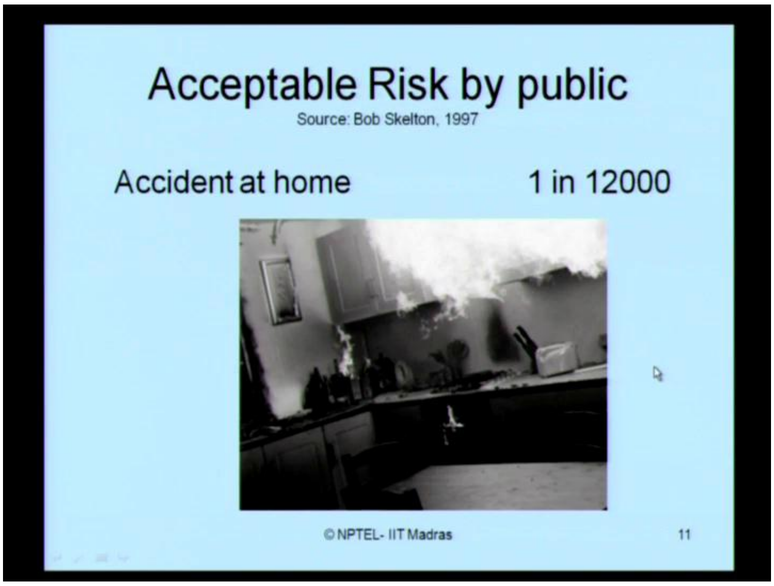

Even if you stay at home you can have a risk of 1 in 12000 remember that. So, acceptability of risk is not a very unique feature in offshore and oil industry. Even if you have residing at home can have an accident and that can also be an acceptable level of risk referred in the standard literature.

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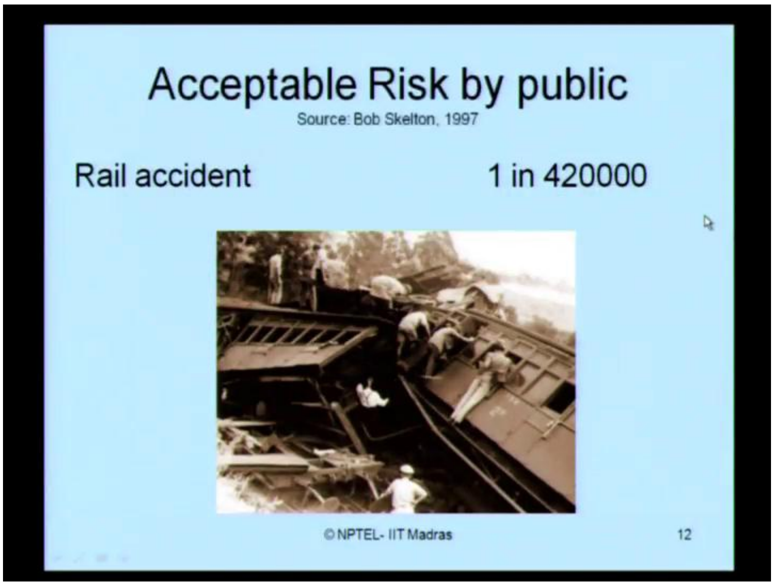

And you are travelling in the rail can have an rail accident and that can also be an acceptable level of 1 in forty two ten power four. So, different events, different scenarios have been a quantified by international regulatory agencies and they arrive at the figure what we called as an acceptable level of risk. Ladies and gentlemen, risk is having an acceptable level in all simple events to consider events in offshore and oil industry. So, we have got a look at that level of acceptance which we must understand that risk cannot be completely mitigated. If the risk is beyond an acceptable level then one will talk about the assessment and evaluation, reduction and mitigation or reduction of the consequence of the risk. If the risk is within the acceptable level, then one has got to leave with the risk as for as offshore and oil industry is concerned.

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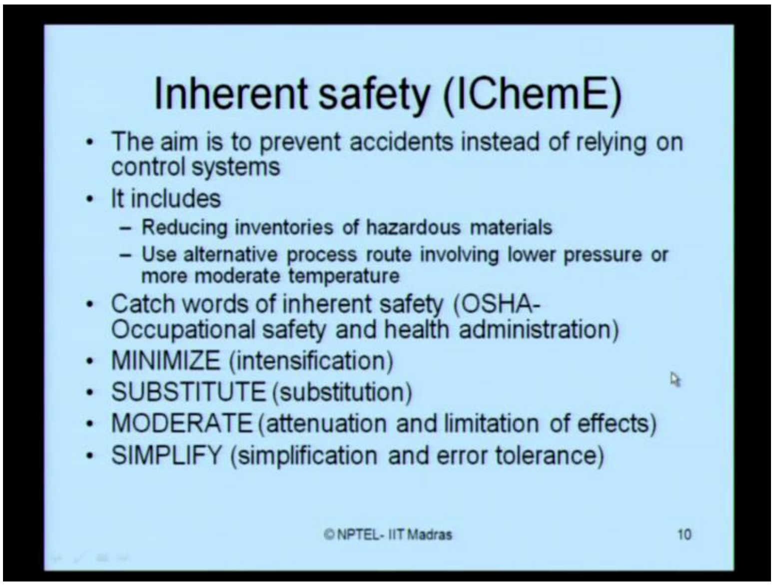

The moment you talk about risk acceptance, then parallely we spoke about safety and now there is something called inherent safety discussed by institute of chemical engineers. The main objective of this particular safety standard is that to prevent accidents instead of relying on control systems. Now this statement is very interesting do not try to create a risky environment and control it by using some electronic, or electrical or mechanical systems. Instead of that address that scenario itself to prevent accidents instead of relying upon or investing on more and more control systems. So, the whole standard has a main objective towards this direction. So, this includes reducing the inventories on hazard materials. For example, if a process has hazardous material which is involved as a bi product or as a source product, keep on reducing the inventory of stock of these hazardous materials in the process plant area itself or on the shop floor at least.

Alternatively use a different process route involving lower pressure or more moderate temperature. For example, if you have process industry is operating at a specific pressure and temperature, which is relatively high and dangerous if there would have been a (( )) then you can always try for an alternative process route, so that the temperature and the pressure can be in a moderate region. So, look at the design aspect, look at the process methodology instead of investing on controls systems to check whether the pressure is being maintained and temperature is being controlled. Now the catch words of inherent safety as defined by occupational safety and health administration are the following minimize the accident, substitute, moderate, simplify. OSHA defined certain keywords, which are acceptable and very short bullet points related to industrial safety, which we just now saw.

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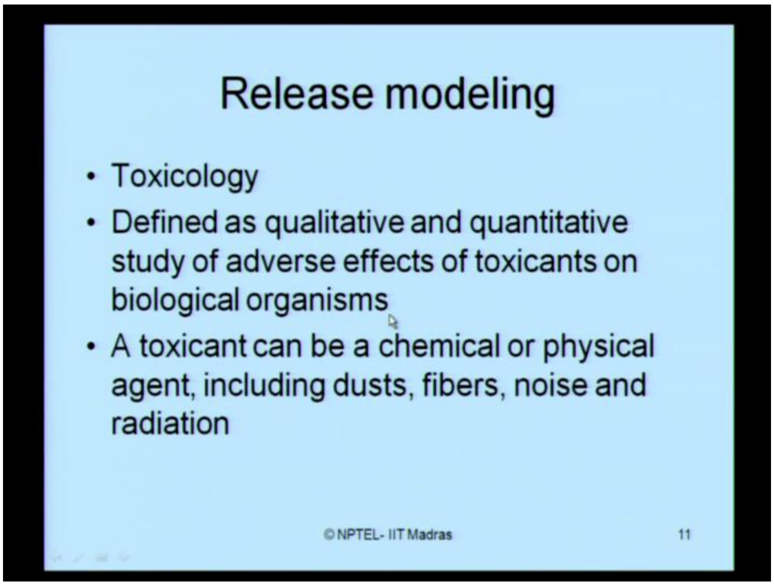

Now, ladies and gentlemen, we discuss something about what we call as release modeling. So, we saw about something on accidents, how safety is important; these two parallely go with what we call as risk. We have also seen what an acceptable level of risk is, surprisingly the acceptable level is also available in public life therefore, a very expensive infrastructure industry like oil and gas should be allowed to have an acceptable level of risk, but off course one can understand that risk acceptance is a subjective issue. Therefore, international body international forward come forward to define these acceptable levels and industrial safety levels, so that a process industry is bound is mandatory to keep the safety standards in the prescribed levels of this international standards.

We will talk about release modeling, the moment we understand the term release, which may be in air, which may be in environment, which may be in water, may be liquid and may be in gaseous format. We talk about immediately, what is called as toxicology. Now toxicology is a term, which is defined as qualitative and quantitative study of adverse effects of toxicants on biological organisms. The term toxicology deals with qualitative and quantitative study on adverse effects of toxicants on biological organisms. You may wonder, how this toxicology or toxic agents will enter into the body of biological organisms like human being, what would be the qualitative acceptable level of these toxicants if they enter in human body, how do you quantify them as a number, because adverse effects is a subjective issue, how these effects are quantified? It will be very interesting to know that the subjective issues like adverse effects on human health has been given a number that is how the release modeling or mathematical modeling of this kind of toxicology is very interesting in HSE.

Now, let us first to define what is a toxicant now toxicant can be a chemical or a physical agent not necessarily the toxicant is an term always related to chemical only. It can be a physical agent like simply dust, fibers, noise, radiation etcetera all are called as toxicants. All of them should be defined qualitatively and quantitatively for their adverse effects on the biological organisms like human beings.

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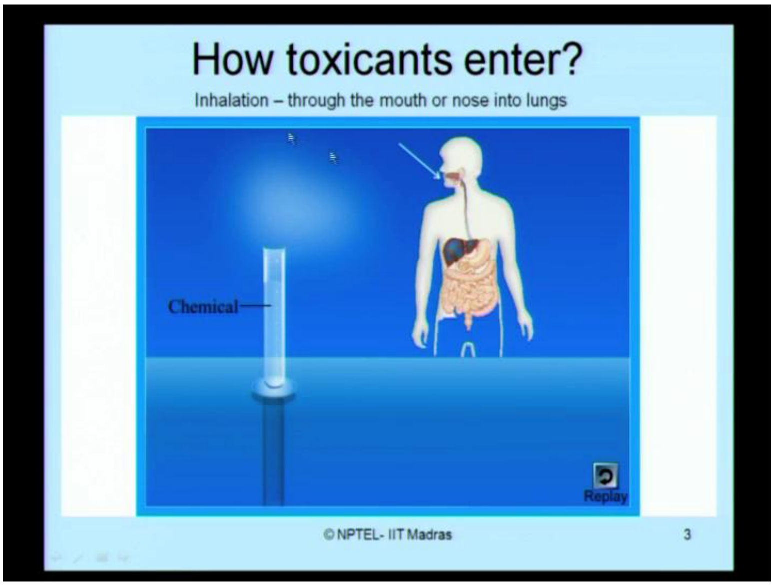

Now, the question fundamentally asked after understanding this is, what is a toxicant? After understanding, the broader interest of the domain of toxicology, we will ask a question actually, how these toxicants enter in human body? Ladies and gentlemen, let us now look at how actually the toxicants enter into human body. There are many ways by which they can enter inside one is what we see here, if a chemical is being released, it can enter through the mouth and get in the stomach of human body - that is what we call as ingestion. The other way of this is if the chemical is released it can get through the mouth or the nose into the lungs that is what we call as inhalation.

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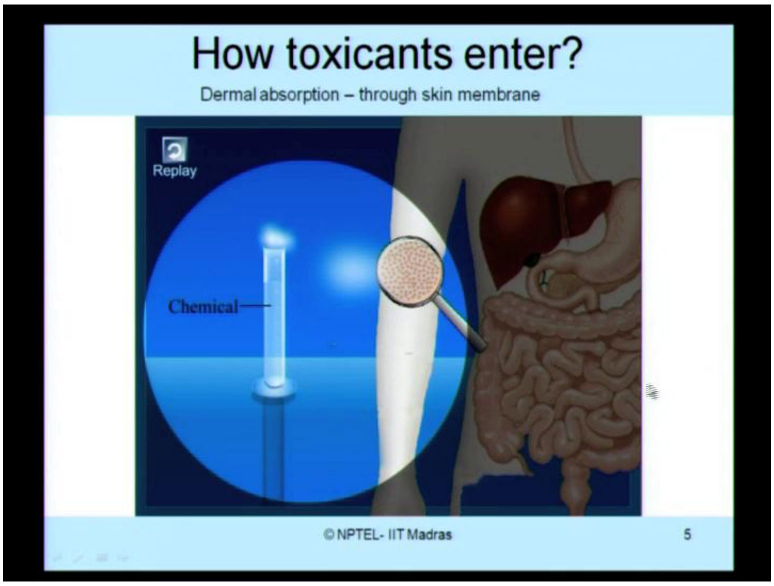

The third process by which a toxicant can enter can be through the cuts in the skin, and the fourth method by which can enter can be through the skin membrane itself what we call as dermal absorption. So, there are four means by which a toxicant can enter into human body.

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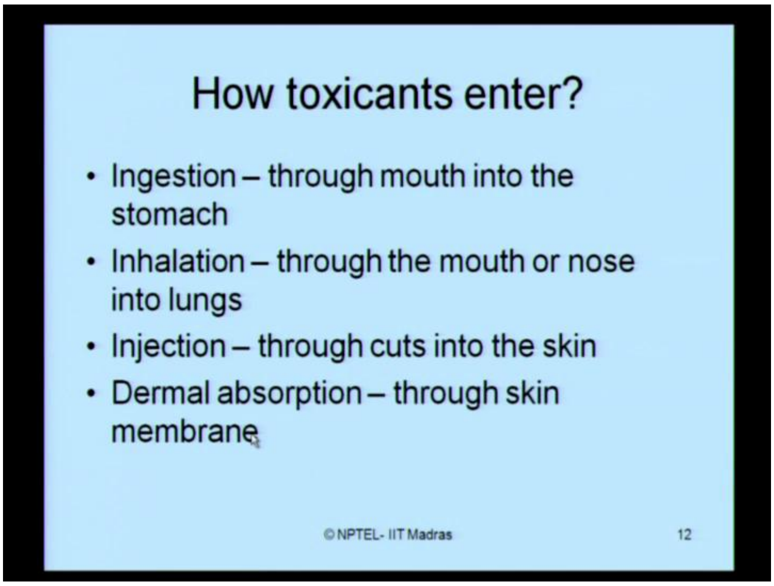

So, toxicants find way by these four techniques or four methods by which they can penetrate into human body.

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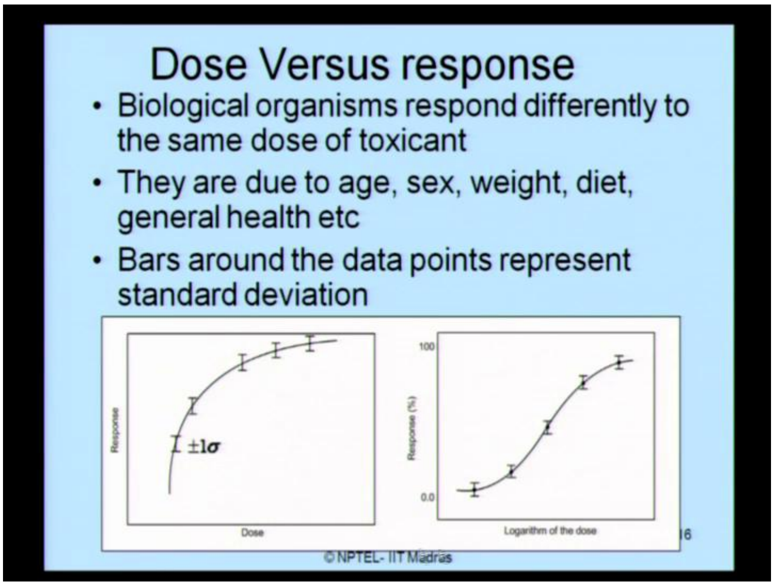

If you look at the dose versus response chart as plotted below. The biological organisms respond differently to the same dose of toxicant, and there are many factors which influence this. There may be due to the age, there may be due to the sex, the weight the diet, and the general health condition what a human being or the biological organism possess, when they are exposed to the dosage. If we look at this curve here, if we try to plot the doses versus response, and if we try to get these points as the standard deviation issues along the line. I can plot the dose versus response in this format or I can also plot them in the logarithm format while keeping the response in a percentage format.

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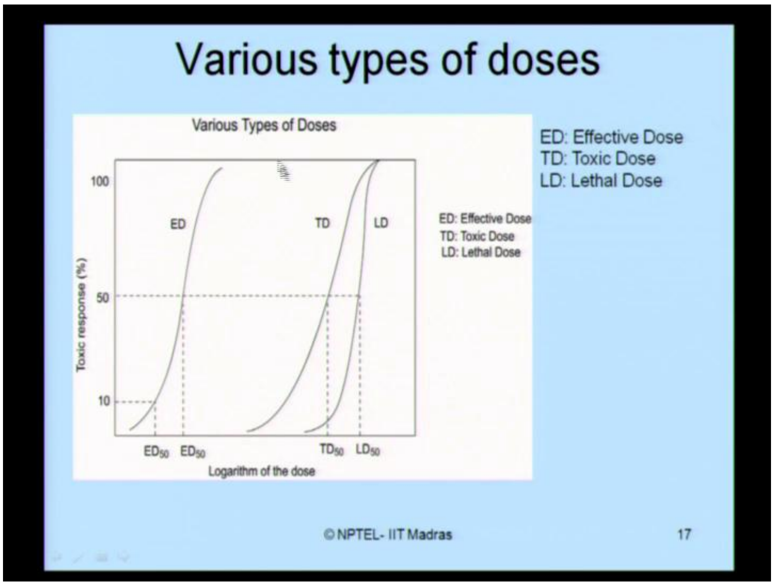

If you look at various types of doses available in the literature then we have something called ED, TD and LD. ED is what we called as an effective dose, TD is what we called as toxic dose, LD is what we call as lethal dose. So, if I plot then dose versus response in logarithm scale in x axis and percentage of toxic response in y axis. I can call something call ED 50 value, it means that I look at the ED curve on the logarithmic versus toxic response percentage for effective dose the value corresponding to 50 percent of toxic response it what we call as an ED 50.

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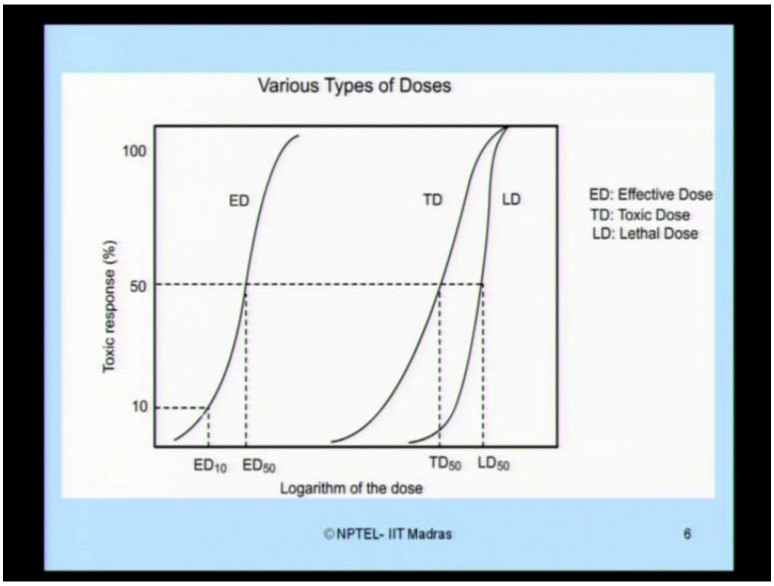

The value corresponds to 10 percent of response is what we call as ED 10, the value corresponds to toxic dose or at 50 is what we call as steady fifty and the lethal dose at 50 is what we call as LD 50.

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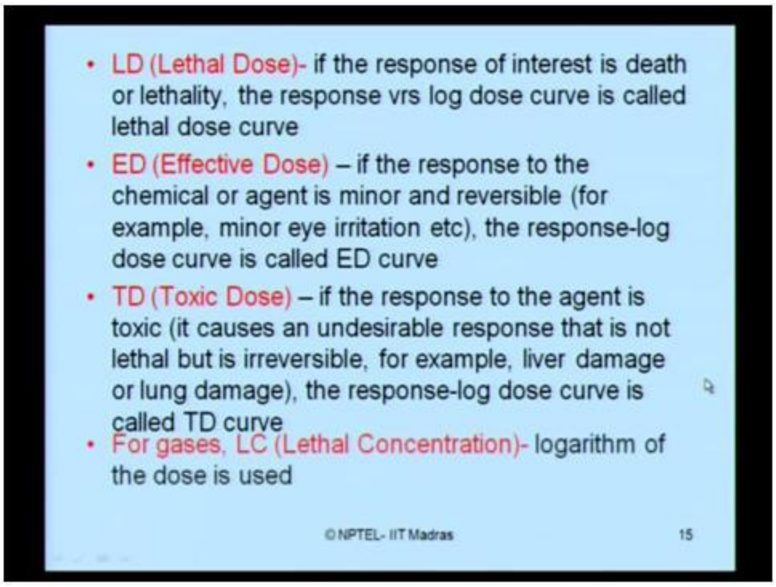

If the response of the interest is death or lethality, the response versus log dose curve is called lethal dose curve. On the other hand, it is that dose to be response is death, when you are exposed to this dose on the other hand ultimately the end will be fatal. There is something call effective dose, if the response to the chemical or agent physical agent is very minor, but reversible. For example, you get minor eye irritation, when you are exposed to specific chemical or a physical agent like dust etcetera. Then the response to the log dose curve is what we called as effective dose curve or ED. So, if you are exposed to a dose which I refer as effective dose then it means, the dose will cause a response on the human body, which could be very minor and that can be reversible. If you have got a toxic dose then the response to the agent cause an undesirable response, but the undesirable response is not lethal, but it is irreversible - for example, it causes a permanent damage to a liver or a lung of human body. So, if that kind of dosage response is expressed as log dose curve, its is what we called as a TD curve.

So, we have seen the LD curve ED curve and TD curve in the previous slide. So, if you have got a dose, which causes irreversible an undesirable response that dose is what we call as toxic dose. If you have a dose which causes a very minor and reversible response to any chemical or physical agent exposed like eye irritation etcetera we can call that dose as an effective dose. If you are exposed to a dose, which may be from a chemical or a physical agent, which causes death we called that dose as a lethal dose.

So, ladies and gentlemen, it is very easy for you to actually quantify or rank, which kind of dose is more severe.

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Yes, you are right. Lethal dose is the extremely severe case, toxic dose follows that and effective dose is a mild kind of dose, which one can sustain. Remember all these dosage are defined based upon what is the response on human health. If the response is fatal, if the response is reversible and very minor, if the response is undesirable and causes irreversible damages, then the doses are different. These are for may be chemical or physical agent if you have got a gas released models then we discussed what we called as lethal concentration for gases.

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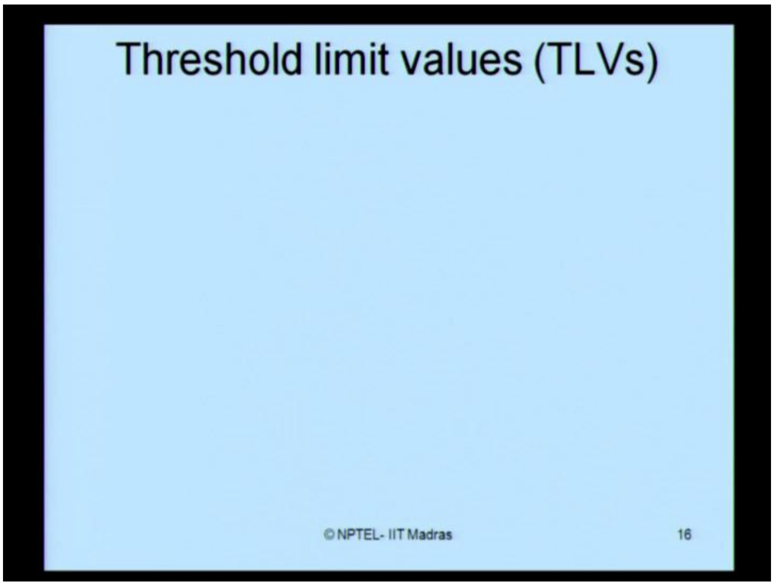

So, now we have understood, what the different kinds of dosage are by which you can define depending on how, what kind of effect they cause on biological organisms. Now all these dosage should be defined for the upper limit of the value of exposure, because I want to define here ordinary dosage, which may not cause an irreversible damage, which may cause a minor irritation. If you prolong expose a human being, even to that level of doses as ED then that may also resultant a permanent damage. For example, he may lose his eyes, it may cause a permanent problem in his lung or respiratory system. So, there should be a threshold value, there should be a limit - upper limit value for all these dosage level to which a human being should be exposed on a process plant or a shaft flow. We will discuss that subsequently in the coming lecture.

Thank you.