Health, Safety and Environmental Management in Offshore and Petroleum Engineering

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Module – 03
Accident modeling, risk assessment and management
Lecture – 16
Risk in Marine systems-II

Welcome friends to the sixteenth lecture on HSE Practices in Offshore Engineering under the mass piece of NPTEL course, IIT, Madras.

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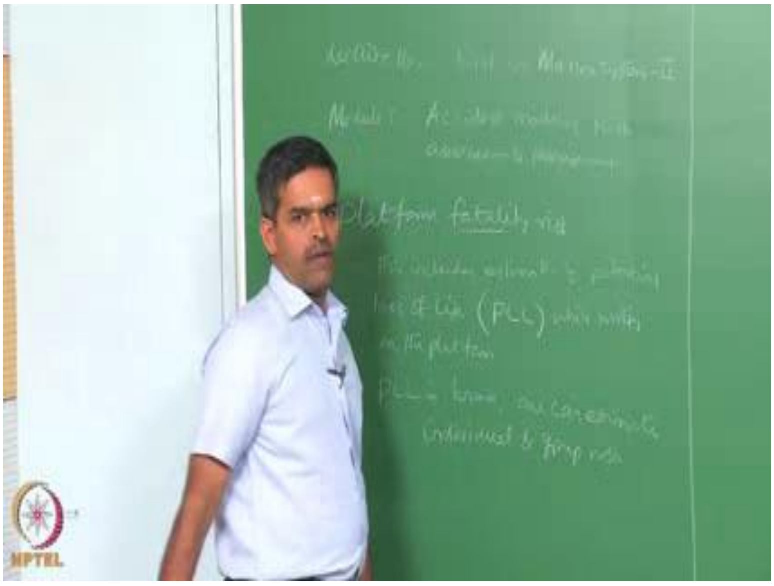

We are talking about the sixteenth lecture where we will discuss in continuation with the previous one, risks in marine system. We call this lecture number 2 in the same series. So, this lecture is a part of module 3 where we are focusing on accident modeling risk assessment and management. We already said in the last lecture that risks can be assessed in different manners out of which first one is what we call as platform fatality risk. This includes estimation of potential loss of life that is why it is called fatality.

So, we say potential loss of life while working on the platform, we call this as platform fatality risk. Once PLL value is known from this, one can estimate the individual and group risk which I will show you later. It is a PLL; potential loss of life which is also a number of fatalities per platform per year is given by PLL is equal to summation of n and summation of f, summation of j.

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F n j and C n j is equal to 1, where PLL actually refers to fatalities per platform per year f n j refers to the annual frequency of accidents, where n is the accident scenario number, where j refers to personal consequences and C n j is the expected number of fatalities for the known accident scenario, n is the total number of accident scenario number and which can be obtained.

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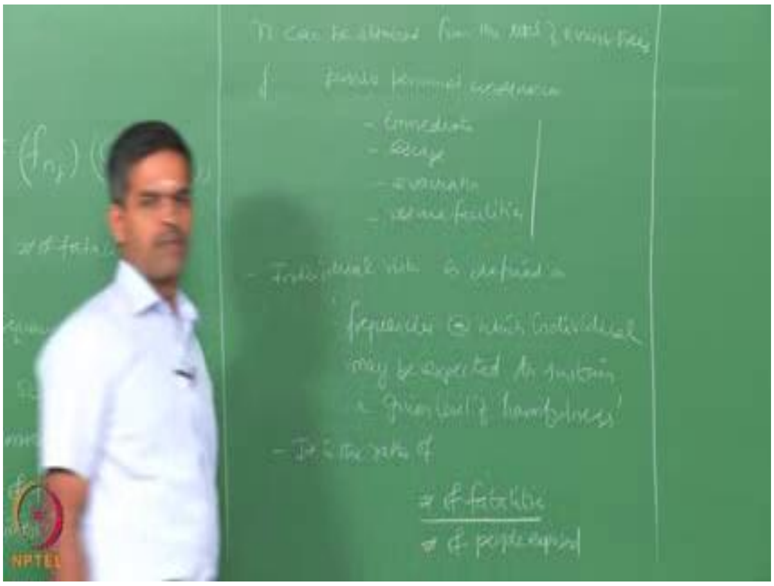

So, n can be obtained from the total of event trees which you will use to plot this j. Of course, it is the personal consequence which is arising from this accident.

What could be the possible personal consequences? It could be immediate, it can be an escape scenario, it can be an evacuation scenario, it can also be sometimes rescue facilities or it can be included in the j. So, once you know the platform fatality risk, we are interested also in individual or group risk individual risk can be defined as frequencies at which individual may be expected may be expected to sustain a given level of harmfulness that arise from the hazard. It is actually the ratio of mathematically; it is the ratio of fatalities to the number of people exposed individual risk is expressed.

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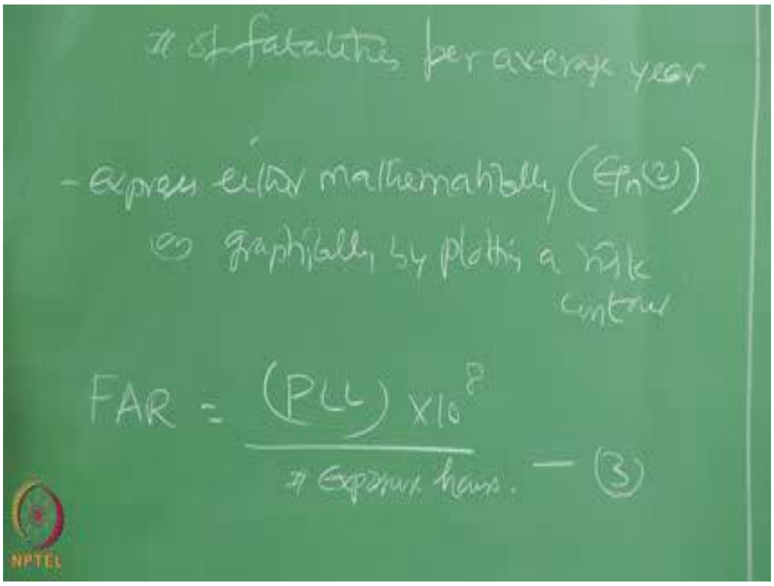

Generally, in terms of number of fatalities per average per year number of fatalities, per average you can express this either mathematically as given by the equation or graphically by plotting a risk contour. So, fatality extent rate, if you know the PLL can be estimated as PLL into 10 power of 8 divided by the number of exposure, ask equation number 3, we call this as equation number 2. So, you can express this mathematically like expressed in equation 2 or by plotting a simple contour like when you express the risk. A typical contour plotted for expressing individual risk is shown in the screen now, for a given plant which has been studied and investigated at IIT, Madras.

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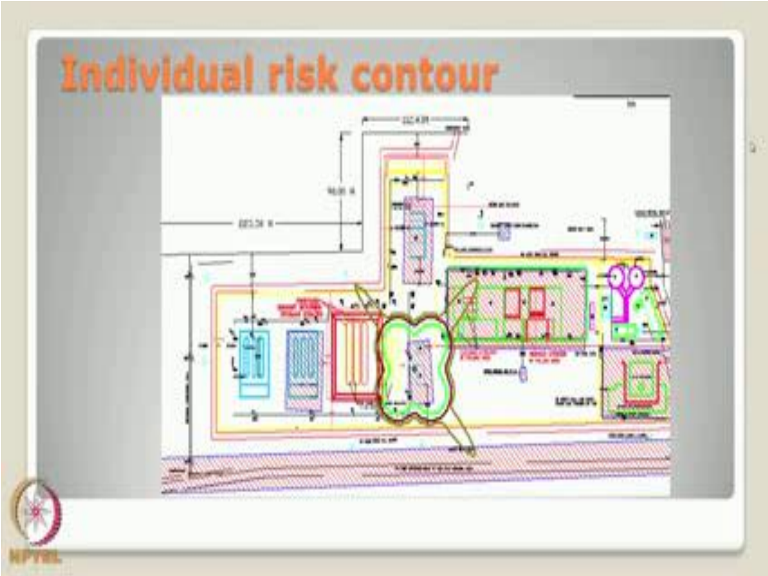

You can see here, the green lines indicate the contour extension of the individual risk of a plant working on board for personnel. The next aspect could be the societal risk.

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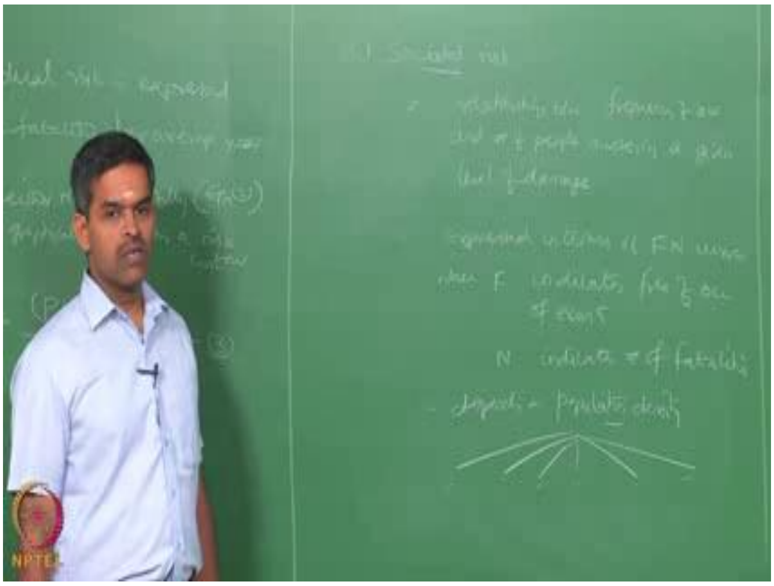

Societal risk is defined as the relationship between the frequency and number of people suffering that accident, given level of damage it is expressed in terms of f m curves, where f indicates the frequency of occurrence of events and n indicates the number of fatalities. A typical f m curve which is plotted for an example study is now available on the screen which is indicating or method of indicating a societal risk. You can see different lines of blue, yellow and red, yellow indicates the acceptable risk blue indicates the risk under control and red of course, indicates unacceptable level value of risk.

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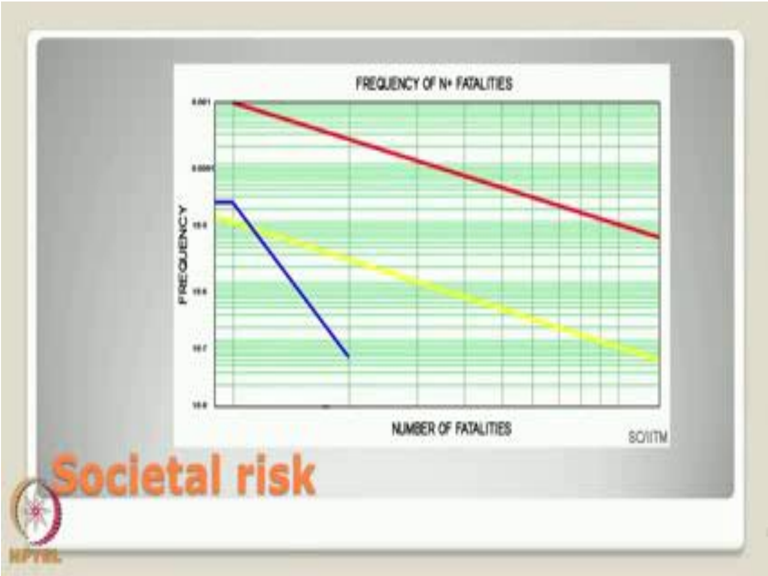

So, we have plotted for the societal risk of course, a societal risk is important to compute and it is also dependent on the density of population strongly depends on population density. In fact, in the last lecture we discussed that the population can be also segmented in different groups and one can account the FIR for different groups individually because the exposure hours of different groups like office, production, drilling, etcetera may not be same, may not be uniform. So, one can also work out the individual risk or fatality accident rate depending upon different groups of people which is also one of the form of societal risk.

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Societal risk can also calculated mathematically as NEDF given under the operation situation is actually the number or people or number of persons exposed to the damage scenario or to the accidental consequences while the plant is in operation. Interestingly, the count which is used to count the number of persons exposed the count will also include the conditions that are responsible for accidents that is important.

The conditions that are responsible for accidents, I mean this has included indirectly because depending upon the number of people exposed to the accident sequences, the count will also include the conditions which are responsible for accidents like wind, speed and direction. Type of accident that is a fire, is it an explosion? Is it a toxic chemical release, etcetera? Interestingly, a societal risk is given by double integral of n x y p d x y given o d x y given o d x equation 4, where n x y is the number of population per cell or grid consider for the analysis p d x y given o is the probability of population present in the grid during operation.

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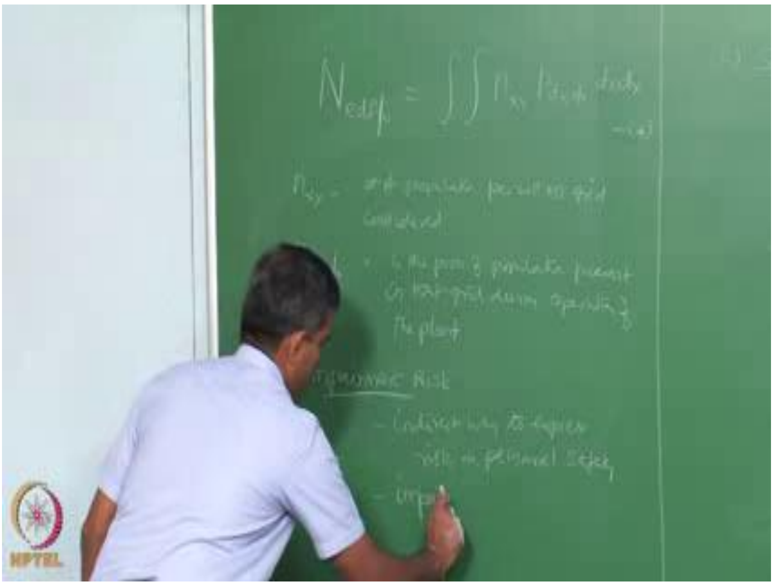

The next interesting risk which is also estimated in marine systems is impairment risk. Impairment risk is an indirect way of expressing risk that is crucial for personnel safety. It is an indirect way to express risk on personnel safety impairment frequencies are calculated for main safety functions on the base of physical modeling are calculated on the basis of physical modeling of the accident scenario.

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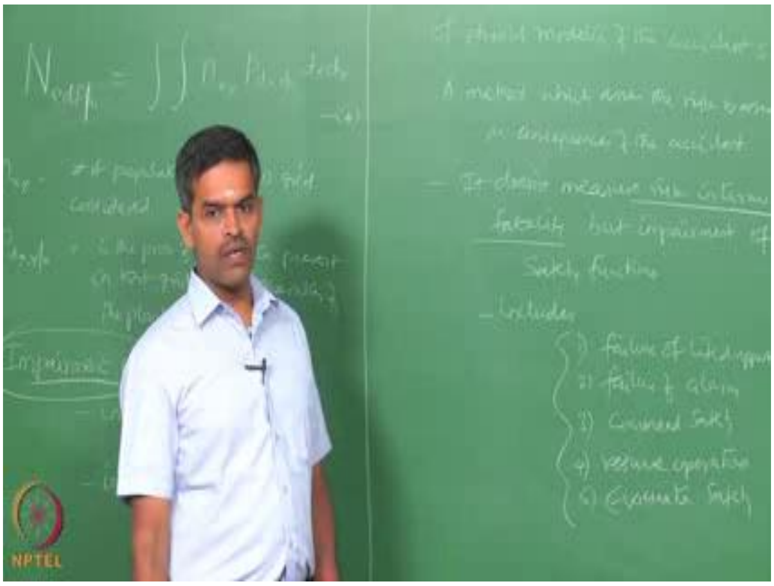

Impairment risk is actually a method which can assess based on the consequence of the accident method, which assess the risk purely based on consequences of the accident That is called impairment, it does not measure in terms of fatality, it does not measure risk in terms of fatality, but impairment of safety functions.

What are the functions has failed, during the accident. According to UK legislation's the impairment of safety includes life support, let us say failure of life support systems, failure of alarm command safety, failure of rescue operations, failure of evacuation safety etcetera. So, interestingly friends this is the only kind or risk assessment which does not include fatality. It purely looks at the failure of the safety functions in a given system frequency of impairment risk is given by that is frequency of impairment risk is given by summation of n safety functions.

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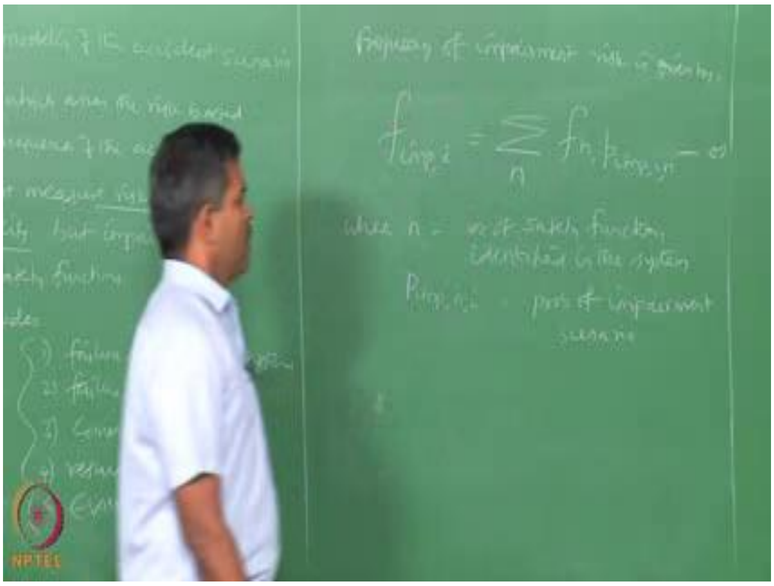

F n of p impairment and here equation 5, where n is a number of safety functions identified in the given system and p impairment n i is the probability of impairment scenario. The next kind of assessment of risk on marine system modeling is on environmental risk.

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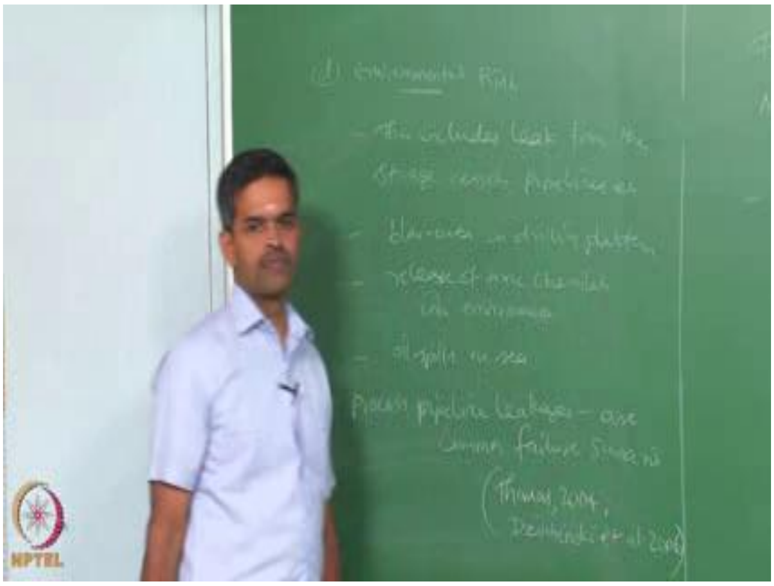

This includes leakage from the storage vessels, pipelines, etcetera. It also includes blowout accidents on drilling platforms. It also includes release of toxic chemicals into environment it of course, includes oil spills on sea process pipeline leakages are one of the most devastation and common accidents in oil gas industries process pipeline leakages are very common or one of the, let us say common failure scenarios in offshore industries as suggested by Thomas, 2004 and et al, 2006 this can result in a worse consequences in a given scenario. So, one has got to aim at estimating this kind of risk, where will be a very important estimate to know the environmental impact caused with the oil and gas industries.

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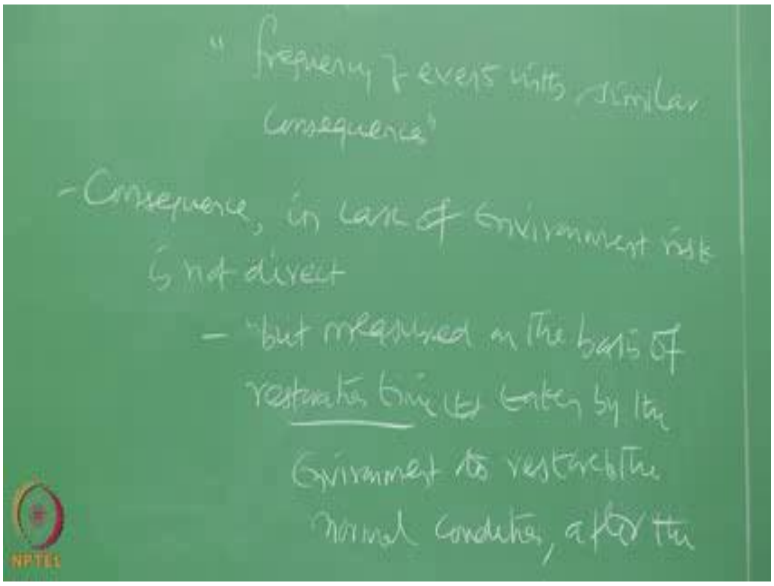

In such cases, risk to environment is expressed as that is the environmental risk is expressed as the expected value of spilled amount of oil or frequency of events with similar consequences. Interestingly, consequence in case of environmental risk is not direct, but measured on the basis of restoration, time t taken by the environment to restore to the normal condition after the incident.

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Interestingly, it is the time taken to recover. Let say from the oil spill to be very specific because environmental risk essentially is computed or framed to compute the consequences caused by the oil spill, as said by Weber et al 1992. So, therefore, the expected value of spilled amount maybe of oil, it is given by q is equal to the quantity expected amount summation of all the events, which is f n multiply q, where f n is the frequency of accident scenario, q n is the quantity of spill and n is the scenario. As I keep on insisting and as we all agree now and understand risk has a very major component towards economic perspective. Therefore one is also interested to know.

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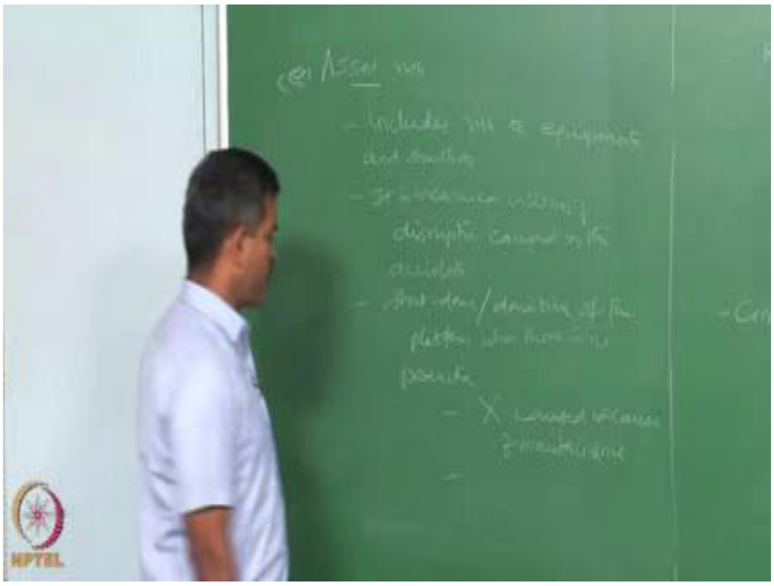

How to compute the asset risk, asset risk includes risk to equipments and structures because it is measured in terms of disruption caused by the accidents. So, indirectly are more or less, it is shutdown or the down time of the platform when there is no production. Please understand this should not include the down time caused because of maintenance, it is only the down time caused maintenance.

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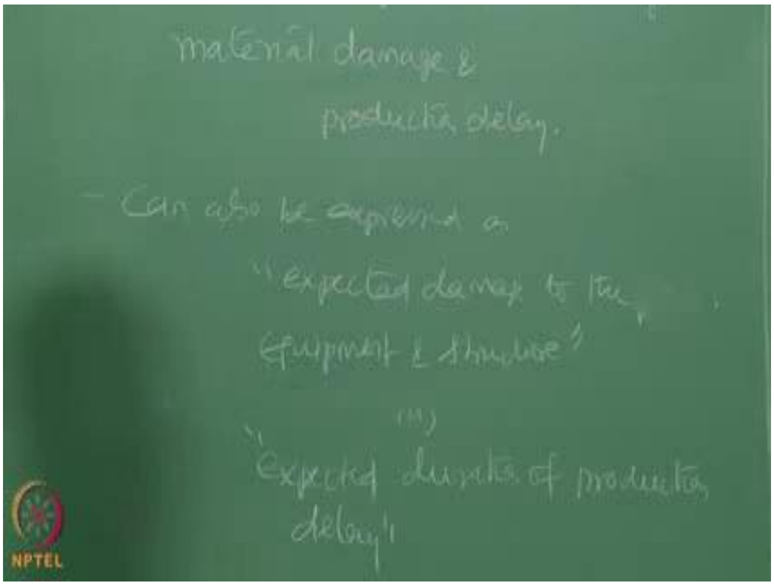

So, asset risk is expressed in terms of material damage and production delay. Asset risk can be also expressed as expected damage to the structure and equipment, etcetera or expected duration of production delay, the expected value of damage to equipments and structure per year is given by d is equal to summation of n f n d n, where f n is the frequency of occurrence and d n is the damage at every incident.

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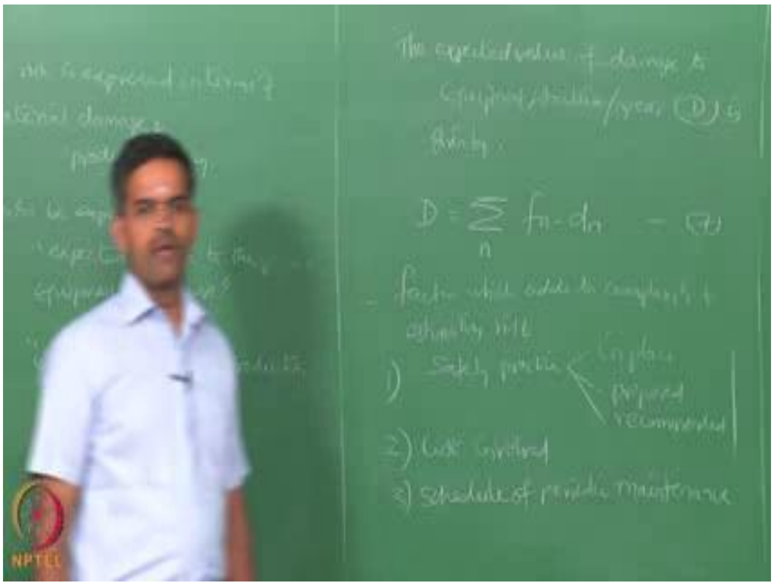

So, interestingly calculation of risk is very difficult as if the probability of event is known, but the severity may not be known or vice versa. So, there are many factors which add to this complexity. So, what are the factors which add to the complexity of estimating risk? One, it can be safety practices in place proposed or recommended. So, should be assessing risk before the recommended practices or prior to the recommended practices; secondly, cost involved in correcting these errors; Third schedule of maintenance.

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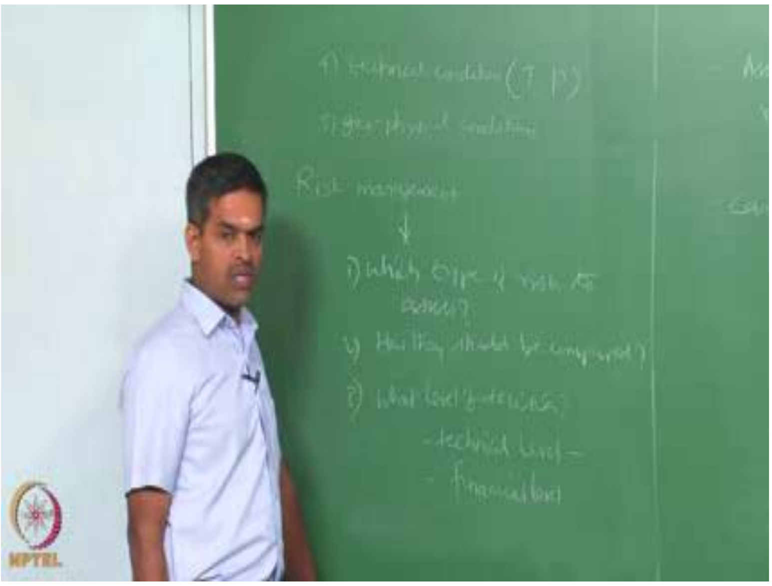

Technical conditions right operated in temperature, pressure, etcetera 0 physical conditions all these will add complexity to actually estimate risk in a proper manner. Therefore, most of the decisions of risk estimates include one or more of these constructors which are considered.

Hence, an important part of risk management is to decide which type of risk is to assess. So, risk management essentially focuses on which type of risk to assess. There are many types of risk; we saw how they should be compared? I mean do you want to compare them globally? Do you want to compare them internally? You want to compare them within the company, you want to compare them geographically and what level of decision in sense are you going to take the technical level decision or financially technical level means you can always bypass the line of production. You can always replace or update the equipments; you can always provide more ventilation to the space areas of operation. You can always decrease the number of working hours of exposure all these are technical issues.

However, when you want to really update control mechanisms and add certain trust components to improve the control mechanisms and safety which will also have financial implications, looking into these complexities one lands up in doing probabilistic risk assessment.

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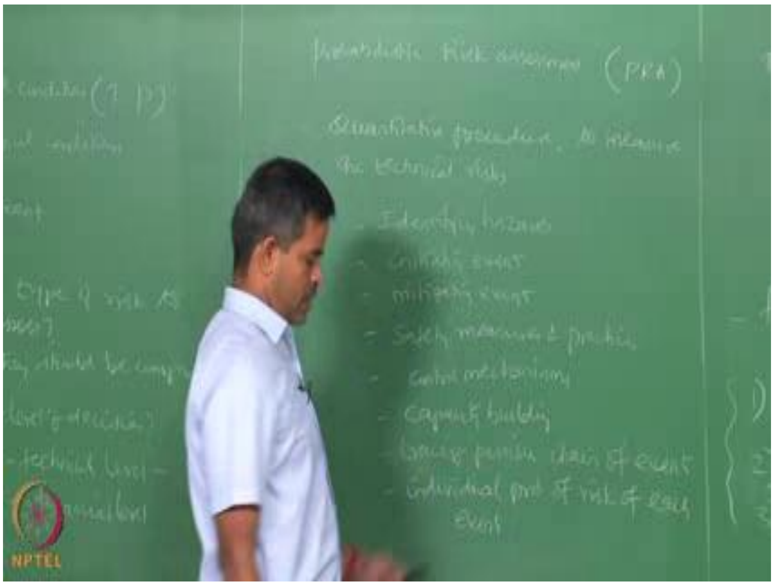

This is actually a quantitative procedure to measure the technical risk involved in the given system. This procedure includes identifying hazards, initiating events, mitigating events, safety measures and practices control mechanisms, capacity building facing possible chain of events responsible for the accident working out individual probabilities of risk of each event, etcetera.

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Probability risk assessment is always done through reliability, analysis. Reliability actually addresses prevention of the system from failure therefore; reliability is also a part of risk assessment. When the system becomes complex, it is very difficult to account for various combination of failures because there are lot of uncertainties involved in this. Therefore, methods like fault tree analysis event tree analysis is developed to facilitate these complexities, so that they can be addressed in a more or lesser closed form solution.

Once we understand the complexities in estimating risk or in assessing risk then come interestingly, how to manage them. So, risk management actually is managing risk that are frequently occurring that has or that have high degree of frequency, higher order in real time practice. It is really rather difficult to manage this kind of risk, but by conducting probabilistic risk assessment in which all these factors will be included in the study, one will be able to make out really the risks which are very frequently reoccurring and that should be prioritized. That was also addressed and advocated by Bonvinci et al, in 1998. Therefore, friends it is important for oil and gas industry to understand how to manage such risks that arise from both process and the plant design.

Unfortunately, for technical analysis perceptions and decisions related to risk are very complex, they even appear irrational. It is therefore, important to understand that risk is not quantified in absolute terms, please understand this risk is not quantified in absolute terms. It is always quantified only in relative terms within the given system, what is the level of risk event. So, this will help you in relative terms. This will help you actually to prioritize risk to have risk ranking in the given various scenarios therefore, the question now comes, what is called risk preference?

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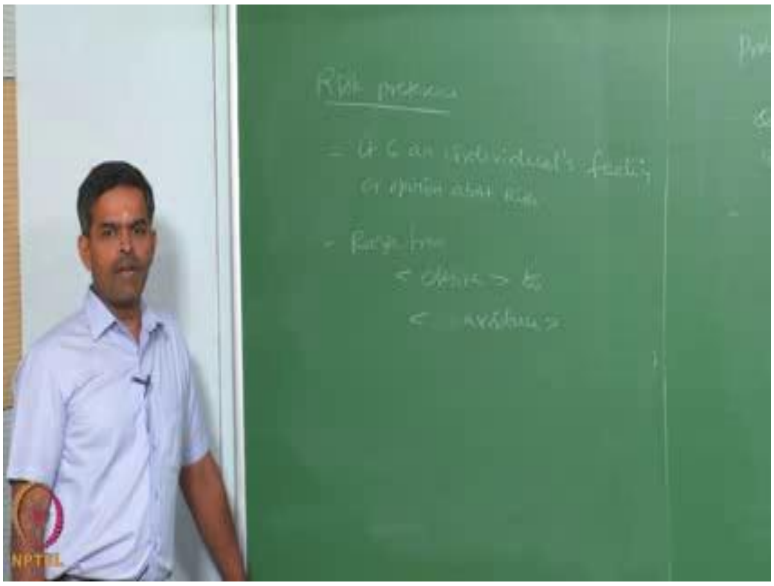

Risk preference is an individual’s feeling or opinion about risk like any preference, this preference can also range from desire to unavoidance. It can range from desire to avoidance; the trouble is most people actually seem to exhibit both the type of risk preferences parallel. So, friends risk management becomes complex because risk assessment is complex. There are varieties of risk when you assessed in a given platform which are envisaged by marine systems.

So, one in interested to know what kind of risk we are going to assess and based on that one has to manage them as an, actually one can simply say risk assessment which compromises on management is only on relative terms, but not on absolute terms because when you assess risk on relative terms then you can always prioritize and rank the risk of different various scenarios present in the given system for your convenience.

Therefore, you know the scenario or the event or the concept or the hazard which has got the maximum number or the highest rank will be attempted first. Therefore, step by step gradually one can reduce the consequences caused by the risk then of course, one can plan to then completely mitigate them from it is presence all together in the working plant

So, friends in this lecture we discussed about various type of risk assessment techniques, the equations and the variables present in the equation complexities which lead to assessing these variables and therefore, assessing risk and then in a nutshell, how do we converge them towards risk management. So, finally, we should look at set of lectures on safety practices which are very useful, both in design and operation. Before we conclude that how one can do effective risk management because we all know risk is always higher when safety norms are violated. So, can we improvise safety both in the design and operation stages, so that hazards are minimized therefore, risk management becomes very effective which we will see in the next lecture.

Thank you very much.