**Health, Safety and Environmental Management in Petroleum and offshore Engineering**

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**Module No. # 01**

**Lecture No. # 2.1**

**Safety assurance and assessment (continued)**

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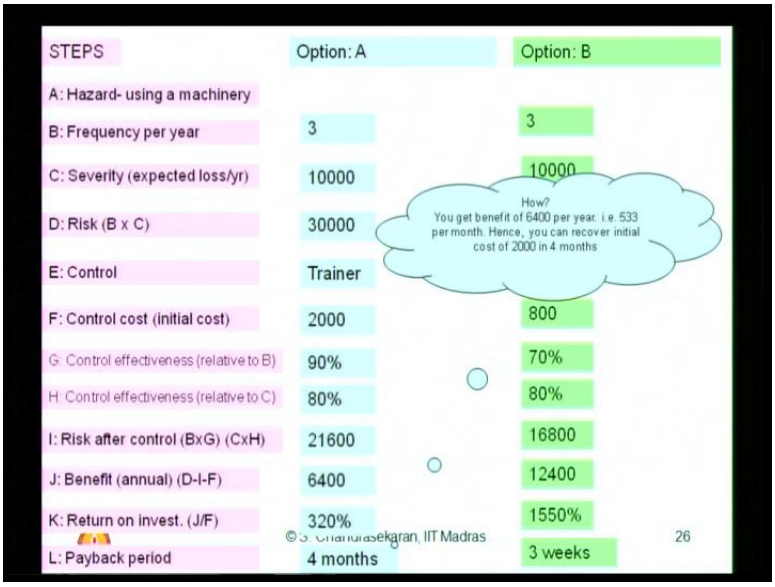


So, ladies and gentlemen, we saw two examples. Ultimately both examples were focusing on how to actually finance risk. The goal is, even if you invest on risk reduction, what would be your commitment towards finance, what would be the return, what would be the benefit you get annually from that risk reduction process, and of course, what would be the payback period of your investment?

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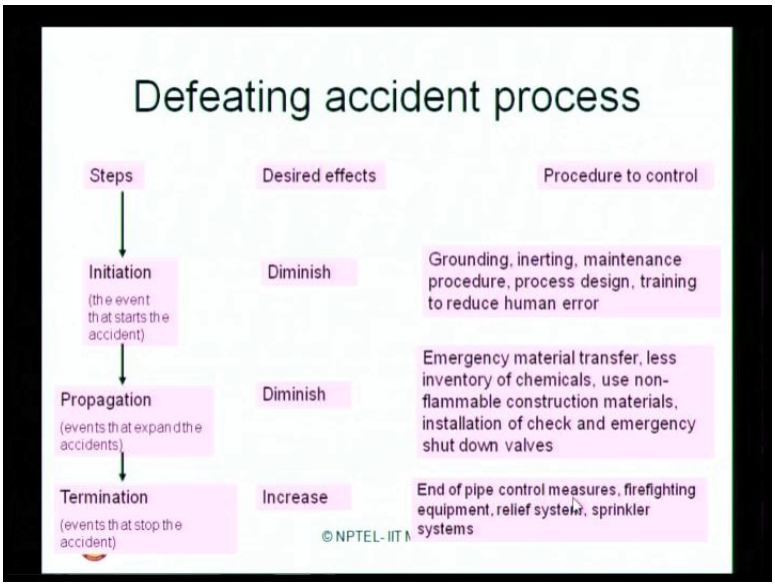


Now, we are interested in looking at a very simple phenomena of how to defeat an accident process, what are the steps involved in defeating an accident process, what are the desired effects and what would be the procedure to control them? The steps involved are initiation, propagation and termination. The event that starts the accident is what we call as an initiative accident, eventthat expands the accident is propagation and the event that stop the accident are called termination. The desired effects on the events that would start the accident should be diminishingand the procedure to control them may be grounding, inerting, maintenance, procedure, process design and training to reduce human error.

When you look at the propagation, you do not want those events to expand to result in an accident. Therefore the desired effect that I want on propagating events, should be diminishing. The procedures to control them are emergency material transfer, less inventory of chemicals to be stored in the working place, use of non-flammable construction materials, installation of check and emergency shutdown valves etc. And the events that stop the accident should be on the increasing side, that is the desired effect I want. And the procedure to control them would be end of pipe control measures, effective firefighting equipments, effective relief systems on board, effective sprinkler systems on board.

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After understanding how you would actually finance risk, what are the different methods? The fundamental question which you may get in mind is, is there anything like acceptable risk? In an offshore industry can I accept a risk, because risk is contemporary to safety? Whenever I say, I accept a risk, safety is a question. Ladies and gentlemen, it is very interesting to know that risk is acceptable to regulatory agency and also to public. According to United States EPA criteria, you have lifetime risk of 1 in million, that is 1 in 10 powers 6, and is defined as acceptable for carcinogens. For non carcinogens, acceptable risk is hazard index of less than 1. According to UK health and safety executive, acceptable fatality accident rate is 1.0. So, all international bodies basically specify an acceptable value of risk.

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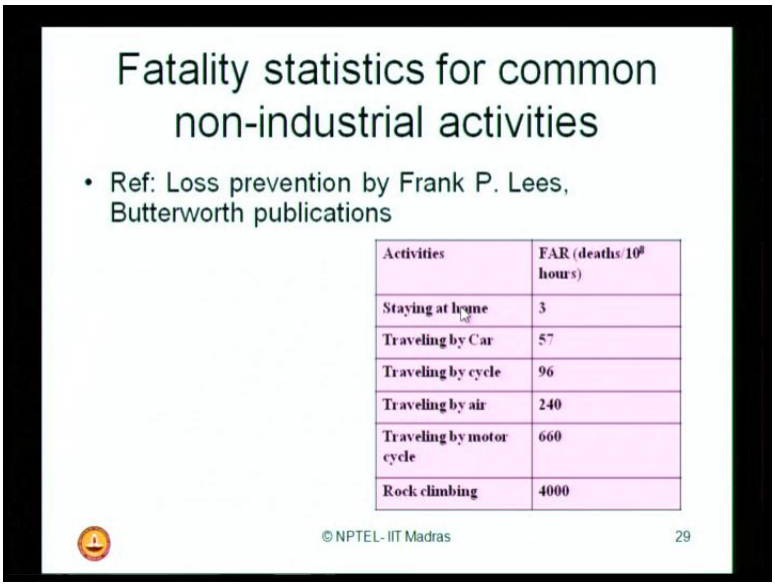


Look at the fatality statistics for common non-industrial activities. Before understanding, what would be such statistics for oil and petroleum industry, let us have a very common example of looking at non industrial activities. This is suggested by loss prevention given by Frank P. Lees, Butterworth publications reference.

It is a simple table given by Frank saying that, interestingly, even staying at home can have an FAR of three deaths at 10 power 8 hours; travelling by car can create an FAR of 57, and rock climbing can be as high as 4000. These are all non industrial activities; therefore you will not see any of these numbers related to offshore and petroleum industry, we will talk about that in the coming slides. What I want to apprise from the slide is, there is an acceptable level of risk even when we stay at home, that is what Lee has suggested.

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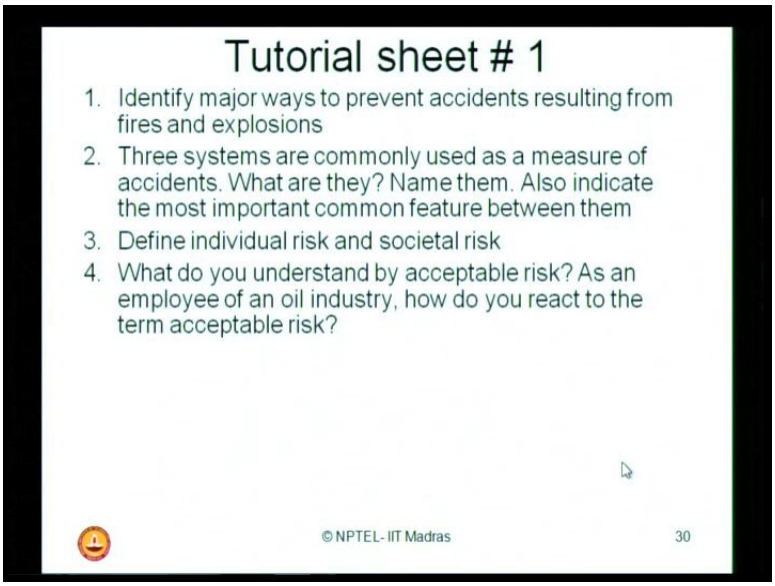


I would like to give you a tutorial sheet. Can you try to solve these questions which I am posting to you? Remember that the solution of this tutorial sheet is not presented in the presentation here. You have to write your feedback and request for the solution from NP-TEL at IIT, Madras.

Identify major ways to prevent accidents resulting from fire and explosions. There are three common systems use as a measure of accidents. Can you name them? Also indicate the most important common feature between the three methods. Can you define individual risk and societal risk? What do you understand by acceptable risk? As an employee of an oil industry, how do you react to a term ‘acceptable risk’?

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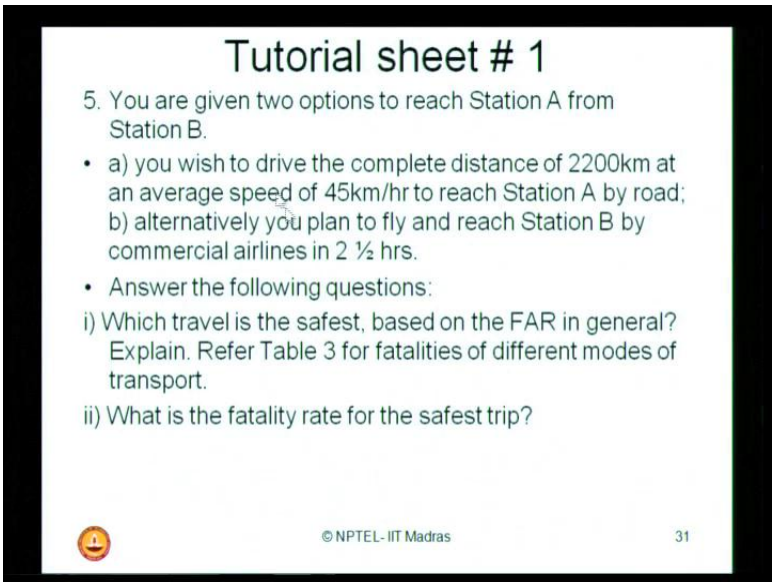


We also have some numerical questions for you. You are given two options to reach station A from station B. You wish to drive the complete distance of 2200 kilometers between A and B by an average speed of 45 kilometer an hour to reach the station by road; alternatively you are planning to fly and reach the station B by commercial airlines which will take just two and a half an hour.

Now, the questions are the following: Which travel is the safest? A travelling by road at a specific speed or traveling by airlines in a specific time; between these two, if you have got to travel which travel is the safest? Remember, you have to identify your answer based on fatality accident rate in general. I will show you Table 3 for different fatality accident rate for different modes of transport available in the presentation. You have to also find what is the fatality rate for the safest trip between these two?

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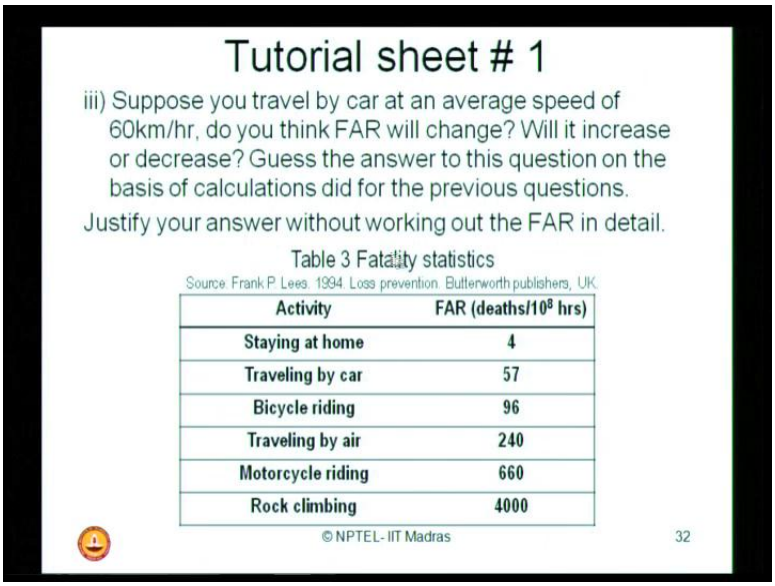


Now, the fatality statistics given for different travel by Frank Lee are the following. So, travelling by air has a fatality rate of 240, whereas travelling by a car has a rate of only 57. Remember travelling by cycle also has a fatality accident rate. Suppose you travel by a car at an average speed of 60 kilometers an hour, do you think that FAR will change? Because the earlier example said you are to travel by 45 kilometer an hour, do you think by increasing the speed of the car the fatality accident rate will change? If you feel it is changing, will it increase or decrease? Guess the answer; do not try to work it out again. You should also justify your answer without working out the FAR in detail.

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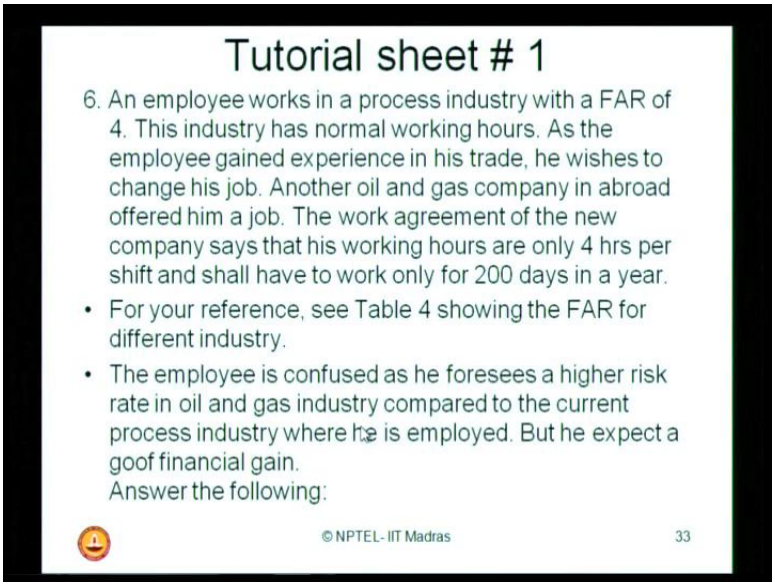

I have a nother question for you - question number 6. An employee works in the process industry with an FAR of 4.0. This industry has normal working hours. As the employee gained experience in this tray, he wishes to change his job. Another oil and gas company in abroad offered him a job. The work agreement between the employee and the company says that his working hours are only 4 hours per shift and shall have to work only for 200 days in a year. This is a part of the work agreement shown to the employee by the company in advance. Now, the process industry and the oil and gas industry have different FAR(s); for the process industry the FAR is 4; for oil and a gas industry I have a table which is given to you.

With reference to that table, you have  to suggest the following. Now the employee is confused. Why?  Because the FAR ratio for oil and gas industry is much more than the process industry. The employee is confused because he foresees a higher risk in oil and gas industry compared to the current process industry where he is employed. But he expects a financial gain by shifting his job.

Now answer the following. Let us try to read the problem again and understand. An employee works in a process industry. The FAR is 4. He wants to shift his job from this industry to oil and gas company. The FAR for oil and gas company is much more than 4. I have a table in which I have shown you what is the FAR for oil and gas company. But the working hours of this company is scheduled in the agreement. He has to work only for 4 hours per shift and has to only work only for 200 days in a year. The employee is confused, because the FAR ratio or the FAR number given for oil and gas company is much more and he foresees a higher risk.

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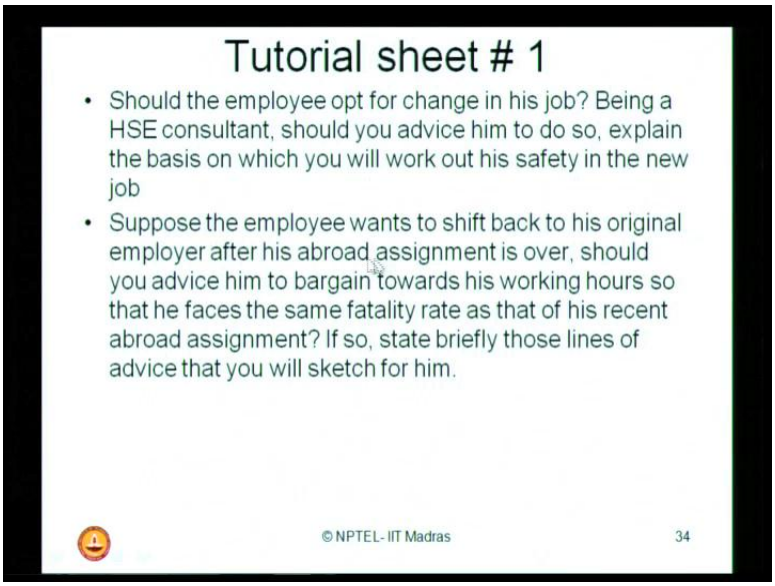


Now the employee opts for a change in his job. Should he change the job? You must advise him as an HSE consultant. Explain the basis on which you will work out a safety in the new job. Suppose employee wants to shift back to original employer after his abroad assignment is over, can you advise him to bargain towards his working hours, so that he faces the same fatality rate as that of recent abroad assignment? If so, state briefly those lines of advice that you will sketch for him. Now, this part is very interesting, the employee changes from FAR - 4 to an oil gas industry, as an HSE consultant you advise him accordingly. But suddenly after working for some years in the oil and gas industry, the employee wants to get back to the previous job. Now, you have got to advice him again accordingly, as to what bargain should he do? He can now do a bargain because he is more experienced.

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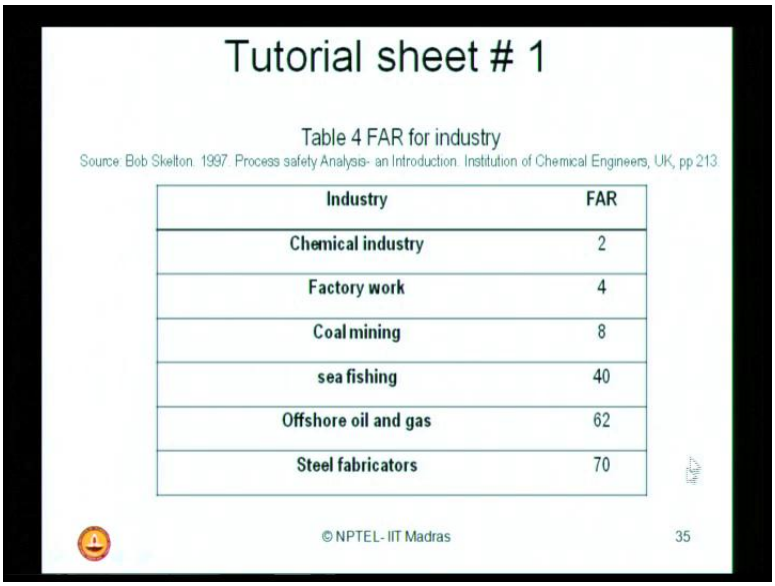


This is a very interesting table given for you; taken from Bob Skeleton to 1997. Each industry has a different FAR(s). For example, the employee is now working in a factory, which is having an FAR of 4. The employee wants to shift from a factory to an oil and gas industry, which is having an FAR is 62. And that is the worry what the employees is having, because this FAR is now moving 15 times ahead. As an HSE consultant, tell him should he shift from this job or not.

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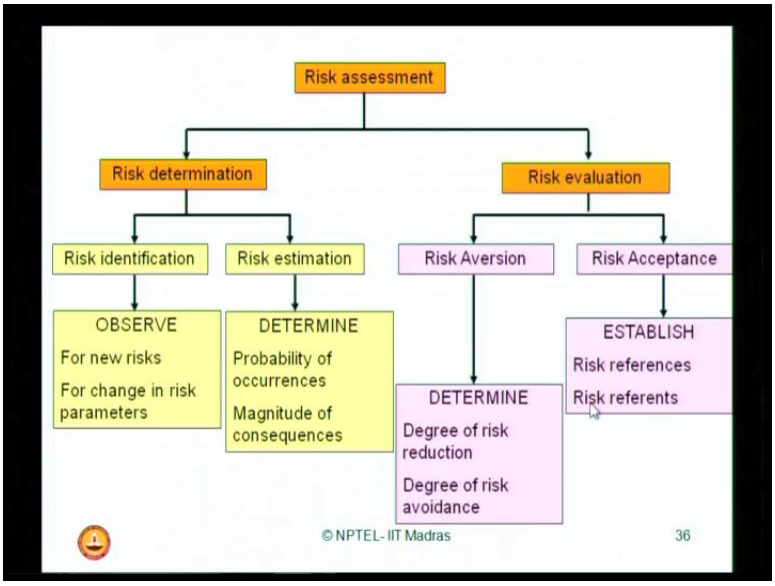

The solutions for these tutorial sheets are available on request. You have to write to NP-TEL at IIT, Madras and request the solutions along with a feedback for the problems.

Let us look further beyond; I am interested to do what I called as risk assessment. It has two categories, risk determination and risk evaluation. What do you mean by risk determination? It has got two branches – first, identify the risk and second, estimate; both of them are together called as risk determination. In identification, I will observe for new risks or for change in risk parameters already existing. In estimation, I will determine the probability of occurrence of risk and magnitude of the consequences, if the risk occurs. Whereas in risk evaluation, I will look for risk aversion or risk acceptance. In risk aversion, I will determine the degree of reduction and the degree of risk avoidance, whereas in this risk acceptance, I will establish the risk references and risk referents.

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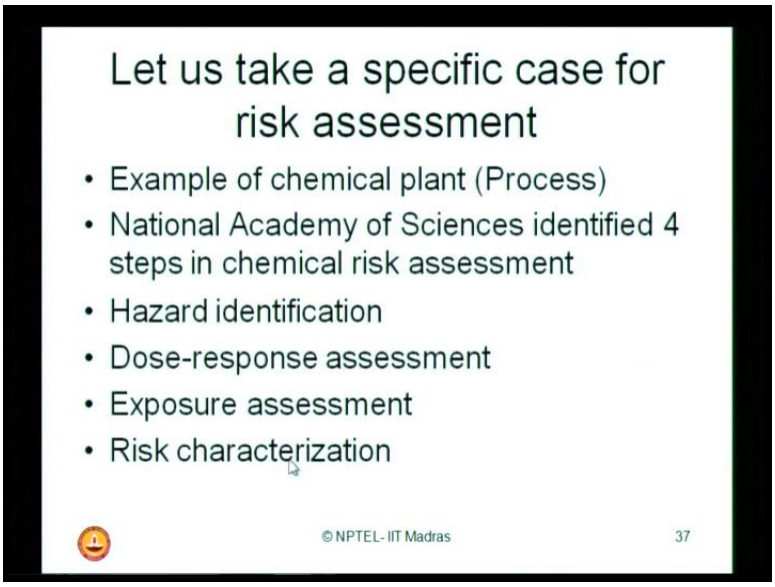


Let us take a specific case for risk assessment. We will now consider a chemical plant, which I call as a process industry. The National Academy of Sciences identified four steps in chemical risk assessment. I have a separate module where I will explain in detail how to do a chemical risk assessment. In summary, National Academy has identified four steps - hazard identification, dose-response assessment, exposure assessment, and risk characterization.

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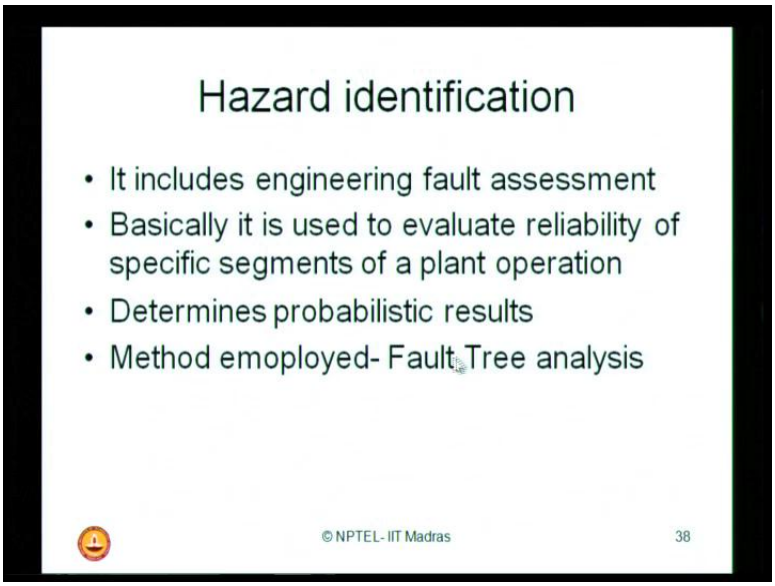


What do you understand by hazard identification? This includes engineering fault assessment. Basically, it is used to evaluate reliability of specific segments of a plant in operation. It determines probabilistic results. The method employed is what we called as fault tree analysis.

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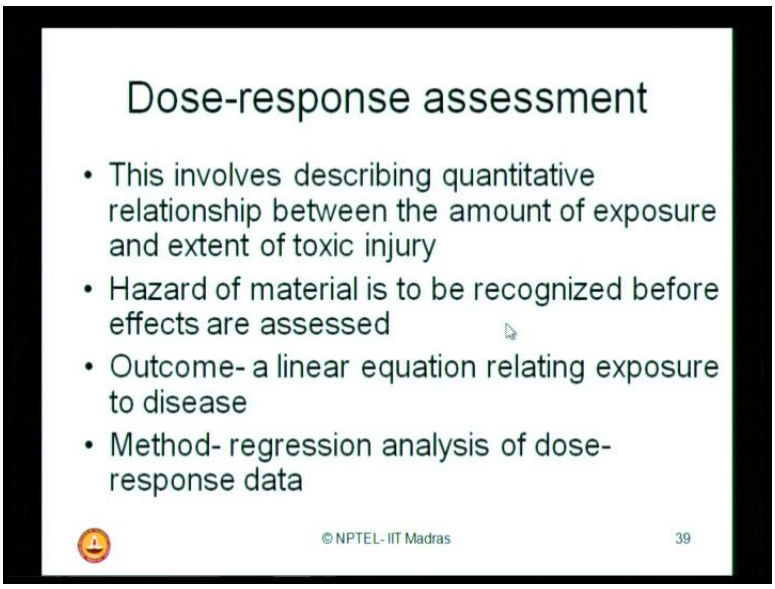


The dose-response assessment: This involves describing quantitative relationship between the amount of exposure and extent of toxic injury. Hazard of material is to be

recognized before effects are assessed. Outcome will be a linear equation relating exposure to disease. And the method used is regression analysis of dose-response data.

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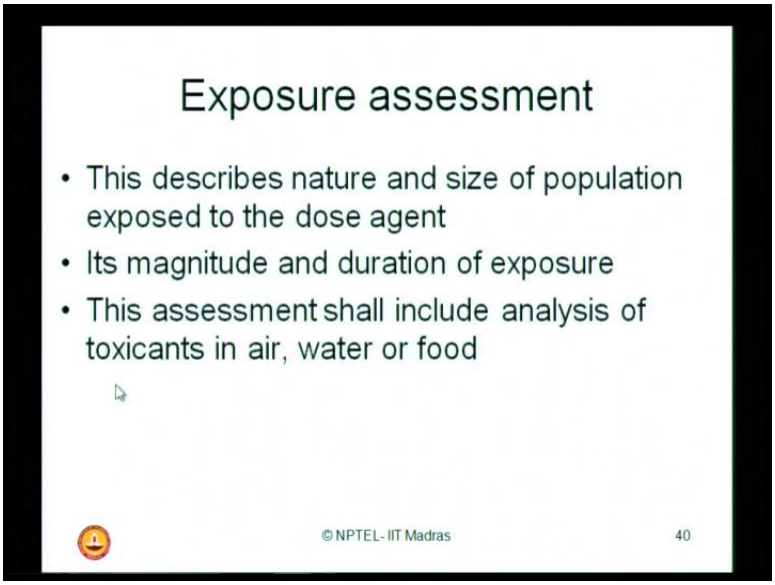


The exposure assessment describes nature and size of population exposed to the dose agent; its magnitude and duration of exposure. This assessment shall include analysis of toxicants in air, water or food.

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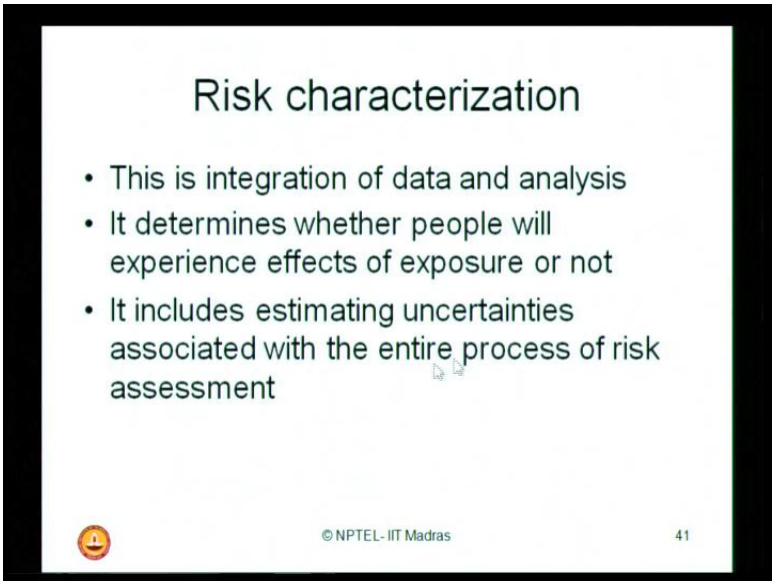

And finally, the risk characterization is an integration of data and analysis. This determines whether people will experience effects of exposure or not. It includes estimating uncertainties associated with the entire process of risk assessment.

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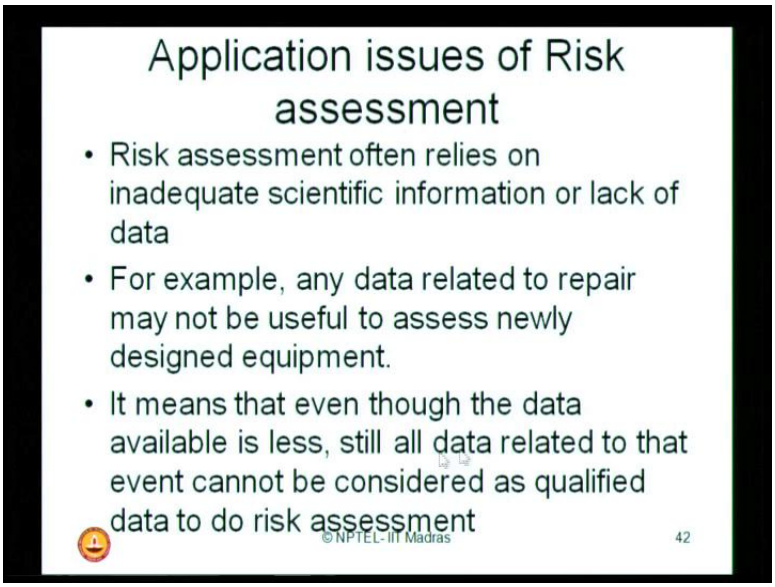


Now, let us look at some application issues of risk assessment. Risk assessment often relies on inadequate scientific information or lack of data – that is a very serious note, as you do not have sufficient scientific information to assist risk, especially on oil and gas industry. For example, any data related to repair may not be useful to assess newly designed equipment. Already we have shortage of data. Even within the data, there was a data related to repair which cannot be used for design. It means that even though the data available is less, still all data related to that cannot be considered as qualified data to do risk assessment. Then what do we do?

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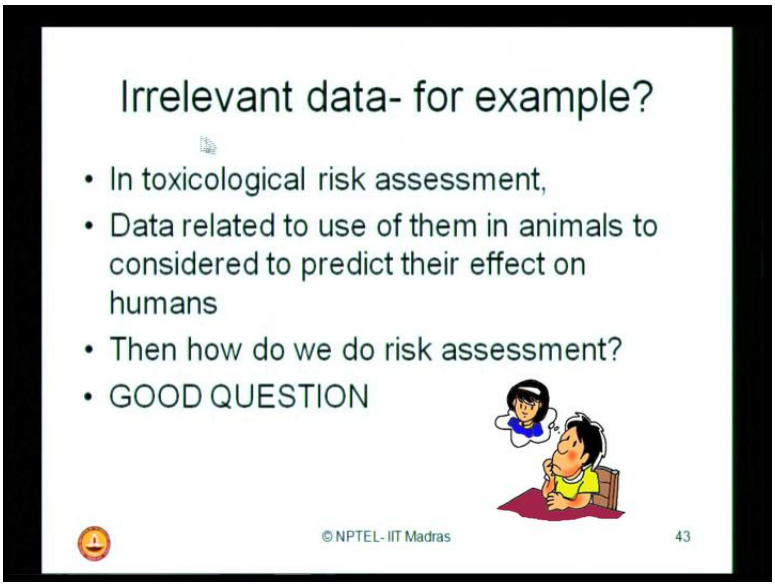


Suppose, for example, we have enormous amount of irrelevant data then what do we do? I can give you a specific code in toxicological risk assessment. Generally the data related to use of them in animals is considered to predict their effect on human beings. Now, one can say that the effect of toxicants on animals can be different to that of toxicants on human beings. So, one can also say, it is an irrelevant data. Then do we do risk assessment? It is a good question.

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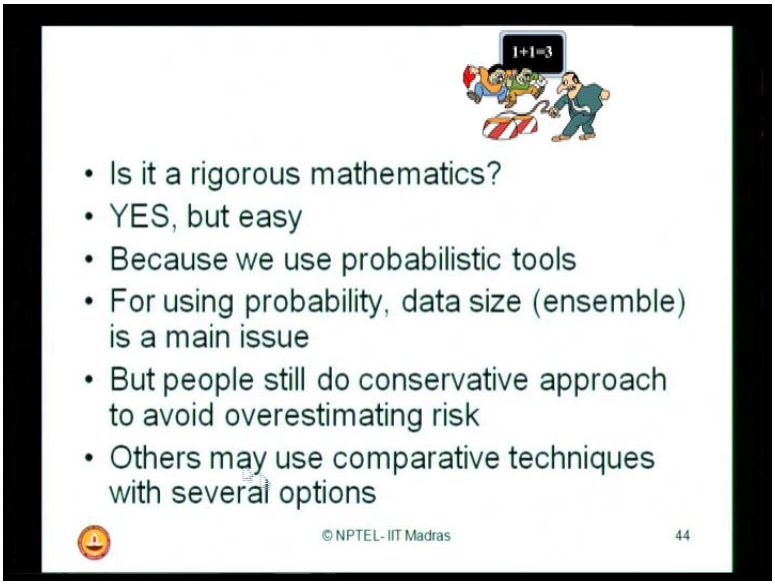

Do you think that risk assessment is going to be a rigorous mathematics? The answer is yes, but it is simple and easy because we use probabilistic tools to do that. For using probability; obviously, the data size what we call as ensemble, is the main issue. But people still do conservative approach to avoid overestimating risk. Others may use comparative techniques with several options, which will be discussed in different modules in the coming lectures.

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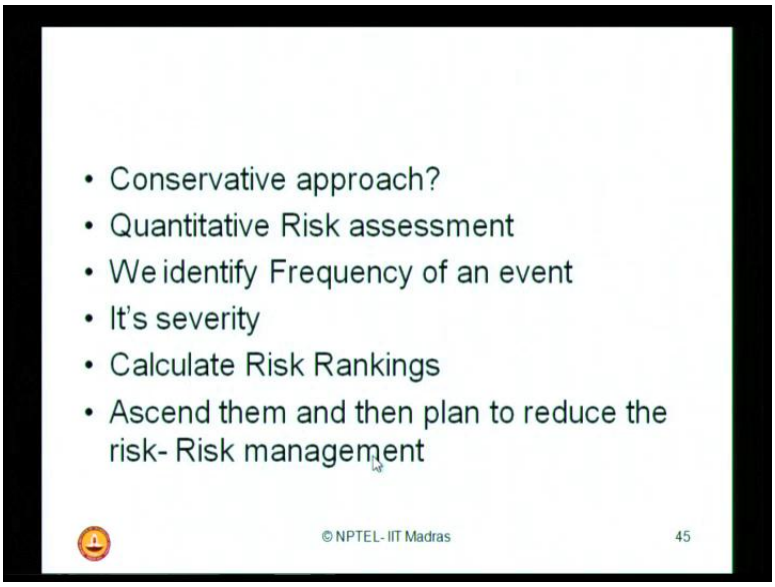


Why the approach is called a conservative approach? Then what is quantitative risk assessment? In quantitative risk assessment, we identify frequency of an event, its severity, then calculate risk rankings, then ascend them and plan to reduce the risk and this is what we address as risk management. We saw an example of a, b, c, d sections of a plan given by Morgan analysis.

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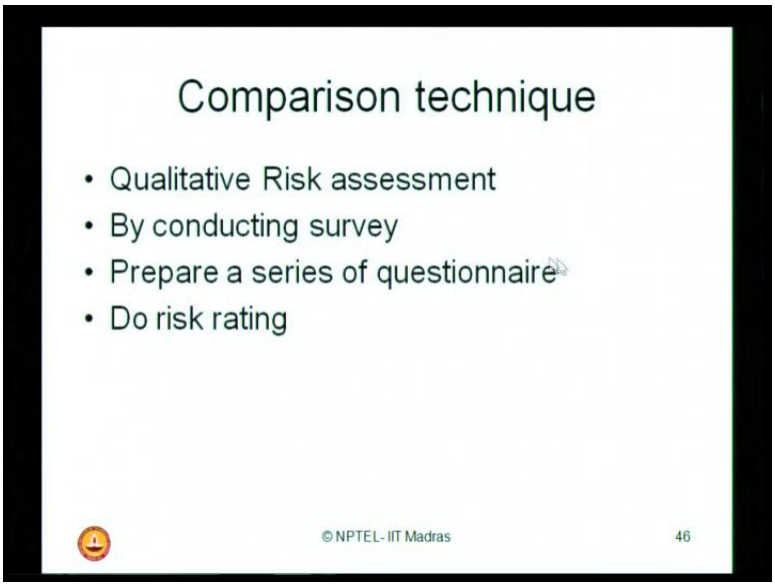


We can also use what is called comparison technique. This is what we called as qualitative risk assessment - this is done by conducting a survey. You prepare a series of questionnaire, then do risk rating. You try to understand the plant a's risk compared to plan b, form series of questions, and see whether plant a is relatively safe compared to b. That is what we call as qualitative risk assessment.

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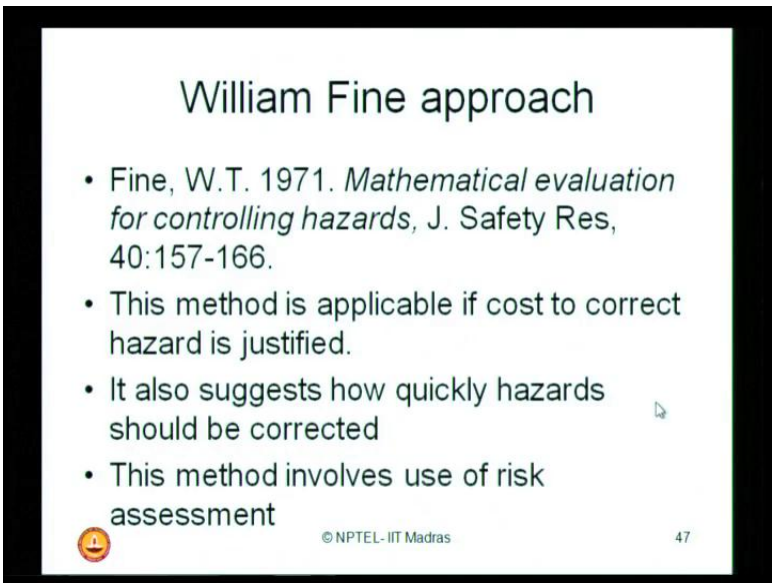


Now, William Fine has given a very good approach for doing this. The reference is given in system safety journal 1971. This method is applicable if cost to correct hazard is

justified. Remember that in oil and petroleum industry, if you are not able to justify the investment towards risk reduction or hazard investigation, then no industry will approve your methods of risk reduction at all. William Fine has given a very interesting method to estimate the justification of such investments. This also suggests how quickly hazards should be corrected. This method involves use of risk assessment.

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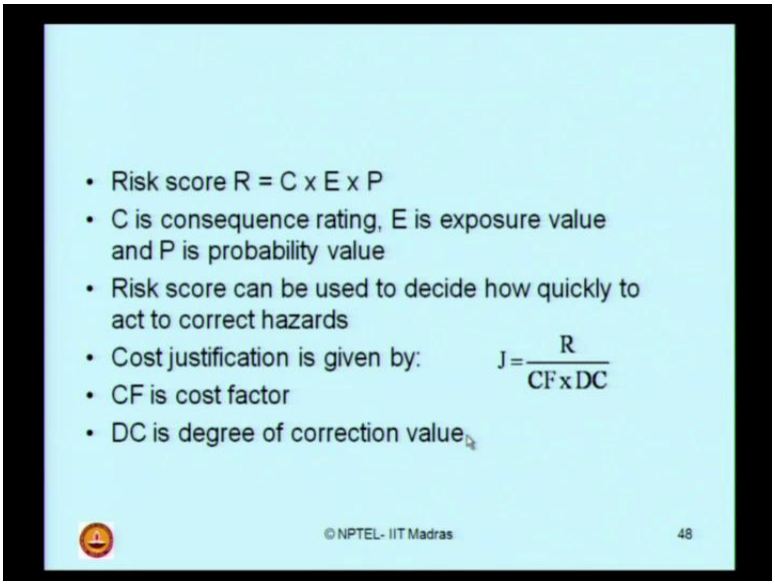


Now, let us see how to estimate risk score R. The risk score R is actually a product of C, E and P; C is the consequence of rating, E is the exposure value, and P is the probability value. Now, risk score can be used to decide how quickly to act to correct the hazards. The cost justification is then given by a simple equation which is R dividedby CF and multiplied by DC. R is the risk score which I have already estimated and CF is the cost factor and DC is the degree of the correction value.

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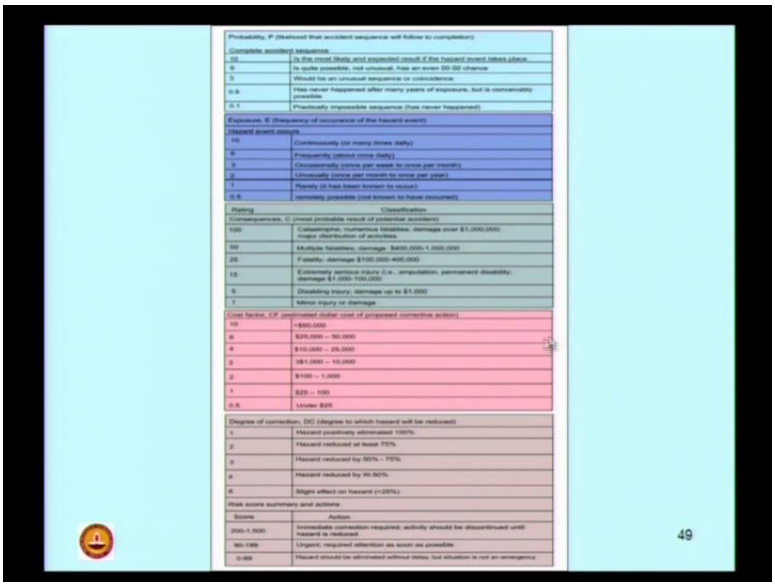


Now look at this figure. So that we can easily estimate the probability, that is likelihood that accident sequence will follow to the completion. Now, the complete accident sequence can be given a number. For example, if the accident is most likely an expected result - if the hazard event takes place, I give this rank as 10. If practically impossible sequence, I can give the value as 0.1. Look at the exposure part, it is basically covering up the frequency of occurrence of the hazard event. If it is going to continuously occur, then I can give a score of 10. If it is going to remotely occur, I can give a score of 0.5.

Look at the rating of the consequences; for example, see in your calculation of analysis. If the consequence is going to be catastrophic, numerous fatalities are going to be expected, and the laws are going to be more than 100000 US dollars, I can give the number as 100. If it is going to cost only a minor injury, then the consequence rank or rating can be simply 1. Look at the cost factor, if the estimated dollar cost of the purposed corrective action is going to exceed 50000 US dollars, I give a cost factor number as 10, if it is less than 25 US dollars I can make the cost factors as 0.5.

Look at the degree of correction, which is required if, the hazard positively eliminated 100 percent. Look and give the rank as 1 or the value as 1. If the slight effect on hazard is going to occur and is less than 25 percent, keep this score as 6. If the risk score is obtained between 200 to 1500 then you must recommend immediate correction action, so that the activity should be completely discontinued until the hazard is reduced. If a risk

score is lying between 90 to 199, then required attention should be given as soon as possible. If of course, the risk score is coming less than or between 0 and 89, then hazards should be eliminated without delay, but situation is not very emergency.

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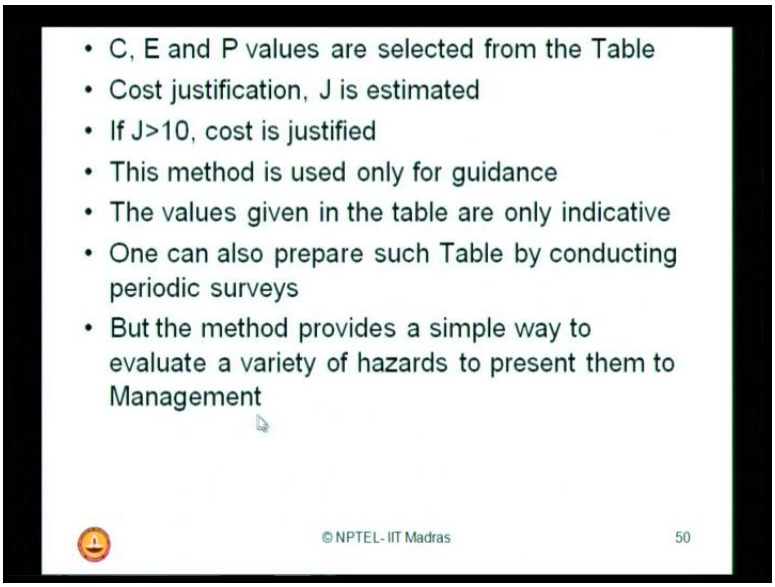


So, C, E and P values are selected from the table just now shown to you. Cost justification is then estimated from a simple equation given to you. If the justification is coming to be more than 10, then the cost involvement is justified. This method is used only for guidance. The values given in the table are only indicative. You can also prepare table of your own choice. One can also prepare such table by conducting a periodic survey. But interestingly the method provides a simple way to evaluate the variety of hazards to present them to the management.

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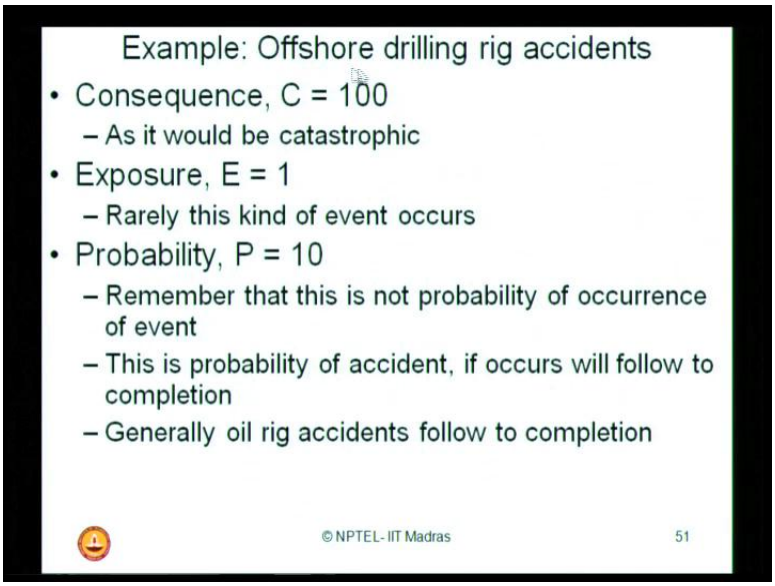


I will take an example of offshore drilling rig accident. The consequence of such accidents are hundred because when such accidents occur, it becomes catastrophic. Therefore C is 100; the exposure is 1, because rarely this kind of event occurs. The probability of this accident is 10, because, remember that this is not the probability of occurrence of event, it is the probability of accident if it occurs we will follow to completion. Generally all oil rig accidents follow to completion.

Therefore I have given this P number as 10.

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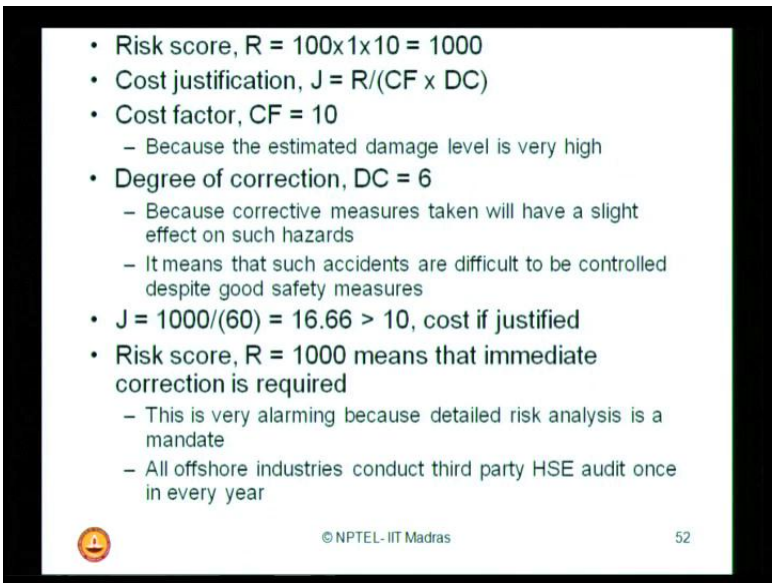

Now ladies and gentlemen, you can easily estimate the product of these three, which we call as risk score which is going to be 1000 for this problem. Now, let us work out cost justification. This is simply given by the equation, R divided by CF into DC. I look for cause factor from the table back again, I put the value 10 here, because the estimated damage level, if at all in any such rig accident, is very high. I also look at the degree of correction put the DC value as 6. You may wonder, I am giving this very high value because the correcting measures taken will have very slight effect on such hazards because all oil rig accidents are really accidents in a strict sense.

Whatever corrective measures you take accident still do occur. The corrective measures have very light effect on controlling the hazard mitigation. Therefore I use 6 as my DC, now I can easily work out the cost justification, which comes to be 1000 divided by 60, which is a product of CF and DC 16.66. Therefore, any mitigation methods suggested to reduce such accidents is more than 10; therefore the cost involved is justified.

Look at the risk scores R which is 1000 - this falls between a value of 250 and 1500; it means immediate correction of such accidents are required. This is very alarming because, detailed risk analysis is a mandate for such cases. All offshore industries conduct third party HSE audits once in every year.

So, ladies and gentlemen, we had a very explicit presentation on telling you how to assess risk using different techniques. We have solved three examples for you; I have left one tutorial sheet for you, which is having some objective questions, subjective questions in theory, and some example problems to be solved. The answers for tutorial sheets are available to you by request writing to NP-TEL at IIT madras. Kindly give your feedback about the presentation and the lectures what you have heard so far. And if you require any additional value to be added to presentation or to this lecture, kindly suggest your feedback with your affiliation to NP-TEL at IIT madras. In the next lecture, we are going to look into much more in detail about the risk analysis measurements and methods.

Thank you very much.