Risk and Reliability of Offshore structures
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Module - 03
Risk assessment and Reliability applications
Lecture -10
FMEA – II

Friends, welcome to the 10th Lecture in Module 3.

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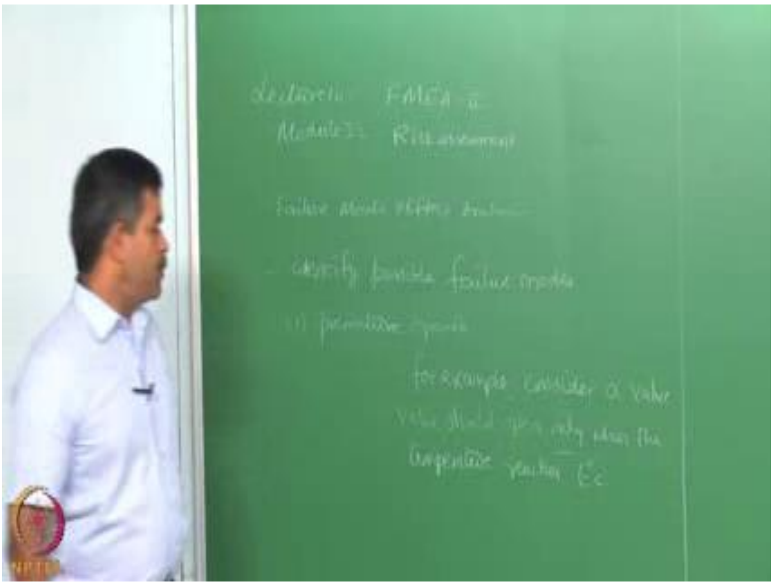

In this lecture we will continue the discussion with FMEA. This is lecture in Module 3, where we are focusing on risk assessment and reliability applications. We already said that failure mode effect analysis identifies the consequences of various failure modes in mechanical, electrical or structural systems. And try to tell me what would be the consequences of these failure modes on the overall performance of the system what we call effects.

We all know that mechanical, electrical and structural systems generally fail in multiple modes. So the first and for most job in FMEA is to analyze or to find out or essentially to identify these failure modes and for each one of these modes we should be in the position to understand the consequences of that failure mode on the performance of a chosen system what we call effects. If you are able to prioritize these effects in terms of that consequences and effects on the overall performance of a chosen system then we will able to really identify the most venerable component or the most important part or element in a given structural system or a mechanical electrical system. Therefore, we can even refine the study with what we call as FMECA, where the term C stands for criticality analysis as well**.**

So, the foremost issue here is to identify the possible failure modes. One should be able to identify possible failure modes. Let us see what these possible failure modes which can generally occur are in a given system to understand the preamble of this whole problem. If you having enough experience in expertise in a given subject domain of mechanical design or electrical design or structural design etcetera, these failure modes what we will be discussing now may be very elementary for you to really understand.

However, you want to really start an FMEA analysis for a specific problem or for a chosen system, it is better let us try to understand what are general very generic failure modes then of course this failure modes need to be modified as the case maybe or as a chosen system maybe in a specific example. So, let us say first could be what we call as a premature operation. That is one of the very common failure mode which generally occurs in mechanical or electrical electronic systems.

What you understand with a premature operation. For example, let us take a wall in a given process system or a process line. The condition is the wall should open only when the temperature reaches a specific value, but there can be a possibility that the wall may open premature even before the temperature in the process line reaches this particular value t 0. So, this is what we call as Spurious Operation.

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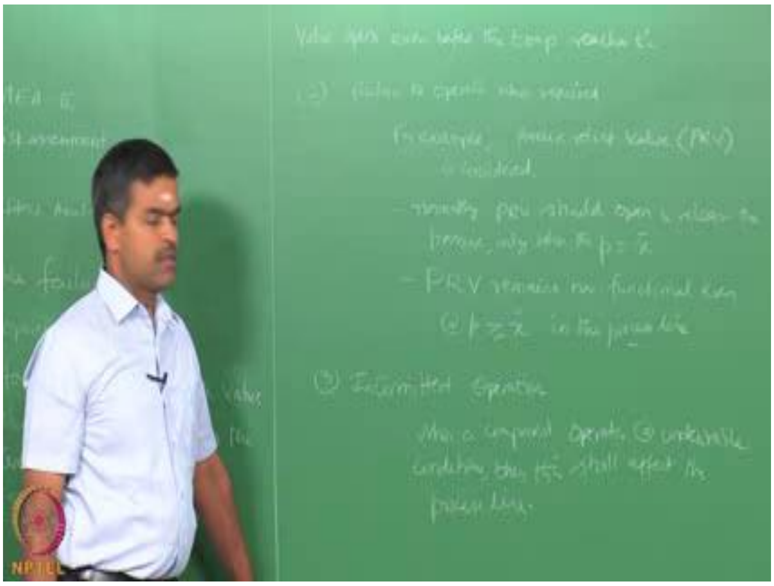

If the wall opens even before the temperature reaches t degree Celsius. This can referred as a failure mode related to premature operation. The second failure mode to be again common in mechanical electrical electronic systems, failure to operate when required; let us say for example, a pressure relief valve PRV is considered in a process line. Generally this wall should open and release pressure only when the pressure inside the vessel reaches a specific special value which is x bar.

So, normally PRV should open and release the pressure only when the pressure reaches a specific value let us say x bar. Let us say in the process line by mistake have a chance of the accident pressure has reached specific value which is x bar, we expect that the pressure relief valve should open and release the pressure, but the pressure relief valve is not able to open. The pressure relief valve remains non functional even at pressure greater or equal to x bar in process of line. If that situation happens then we can call this kind of a failure mode as failure to operate when in demand.

The third kind of failure mode can be intermittent operation. Let us say a specific component of the process line is suppose not to operate at a given value of temperature and pressure, but still that components remains functional physically. This may lead to unusual intervention to the whole process, then a component operates at undesirable conditions then this shall affect the process line. This is what we consider as intermittent operation.

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The other failure mode which is again common to mechanical electrical electronic systems could be failed to cease operation. For example let us consider temperature sensor. It is designed to indicate drop of temperature below a specific value, and then shall remain functional until the temperature is increased to that value let us say the temperature value is about let say t 1 degree Celsius. If the temperature drops below t 1 then the sensor should indicate either by (Refer Time: 10:25) or by a led depending upon on the design of your control panel.

It should remain in the state of this operation until temperature raises t 1 degree Celsius, unfortunately when the temperature reaches t 1 the alarm should stop and led should put off, but if the sensor is continue to shows the alarm or the led glowing then I can say that it is fail to cease the operation when the operation is not required. It means there are certain items or components which are designed in a mechanical process or electronic systems which are desire to operate only on certain conditions, when the conditions are violated they should cease of the operation, but if they fail to cease of this operation and they continue to remain in operation even though the conditions are not satisfied then we can say that the failure mode is referring to fail the cease operation.

So, more or less these failure modes are highly generic that when you want to derive a failure mode for a specific activity or a member in a given system one should apply the expertise and experience gain as a designer or as a plant engineer as a production or manufacturing in charge who will be able to list out a better failure modes in a sequential manner and the look in to the effects of that failure modes on the overall failure of the system.

Please understand that these failure modes are not to be confused with a vibration modes or modes of failure of the structural problem where we talk about model failure frequencies etcetera. These modes are nothing but physical phenomenon which needs to be understood as the failure of a given system, because of the failure of a component of the system or series of components of a system or a multiple failure of same component etcetera and their consequences on the overall performance of the whole system. So, they are nothing to do with the structural failure phenomena which otherwise also has a similar terminology like failure modes.

So, one can also have similar kind of failure modes or highly generic in nature. For example loss of output, I have a sensor which suppose to give me an output on a specific value but the sensor is fail to give me the output even though the value is desirable to release an output, so I can say loss of output. So, all the above are different failure modes they need to be considered in a familiar.

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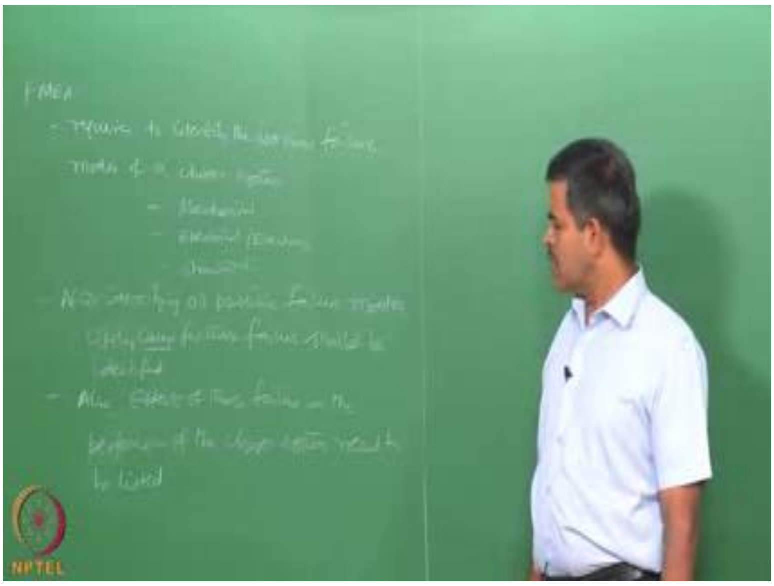

It means the FMEA essentially require to identify the various failure modes of a chosen system. Preferably the chosen system and the mechanical, electrical, or electronic, it can be even structures. I will show you a FMEA later for a structural problem of an offshore structure in the next lecture, so you will be able to easily understand how I am organizing or diagnosing the failure modes for a structural problem which will pick up an offshore structure and do FMEA for that.

Now the after identifying the failure modes what should we do. Let us say all possible failure modes let us see after identifying all possible failure modes. The likely cause for this failure should be identified. So, one should be also able to identify the causes for these failures, subsequently also effects of this failure on the performance of the source and system needs to be listed. So, friends can we look at these two points.

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These two points emphasize that FMEA requires a primitive study conducted what we call as cause effect study. Again is the subclass within FMEA which is very important to proceed with the FMEA because causes and effects of different failure modes are very important even for FMEA. People also do only cause effect study using what we call preparing a cause effect diagram. So, one can easily that to have a successful FMEA study one should first prepare cause effect study or do a cause effect analysis.

So, it is very important that we need know what the cause is and effect of each failure mode of the component and also for the one should also know the sequential effect of the failure, either in terms of its occurrence or in terms of its consequence, either way one should be able to sequentially. So, what we are trying to do is here is simulate to Frank Morgan logical risk analysis we are trying to rank the failure modes. So, what is the advantage of ranking the failure mode? Once you know the ranking of the failure mode the failure mode which gets the top rank will be identified as the most critical failure mode then the component will be redesigned so as to reduce or avoid this failure mode.

So, FMEA study can always lead to changes and modification of the design by an iterative procedure. So one can also have what we call design FMEA. Design FMEA leads to interestingly recommendations and modifications suggested on the original design based on which certain components or the arrangement of those components material, size, shape, specification, etcetera can be changed, modified, remove, or add it in the given system line so that the consequential effect on this failure on the overall system can be reduced or very good if they can be completely avoided. That is what we call as design FMEA.

Obviously, an offshore structures when you are try to innovate a new platform geometry which is essentially formed dominated structures, we already remembered this in the first module structure lectures or their enough references available in this particular website of this course please read those text books and the research papers to really know what is formed dominated design of offshore structures.

As a very bit summary we can say that the platform geometry of offshore structures starting from the fixed it has become now completely floating. We also have complaint system which allows and admits large displacement in terms of horizontal plane like. surges way and your motions and very limited displacement in terms of heave and rotations in terms of let us say roll and pitch. So, TLP's are one classical examples of campaign offshore structures which are essentially envisaged for the (Refer Time: 20:17) exploration where this kind of highbred combination of degree of freedom or in build in the design itself.

So, when one attempts such innovative designs, for example triceratops, for example; floating, storage, offshore, regasification unit FRS used etcetera which are very recent generated forms which are used for ultra deep waters. One need to actually know the failure modes of the components and the design effect of these components can be changed in the design stage itself. So, design FMEA is very powerful in terms of its application in structural reliability in terms of risk assessment on FMEA or using FMEA.

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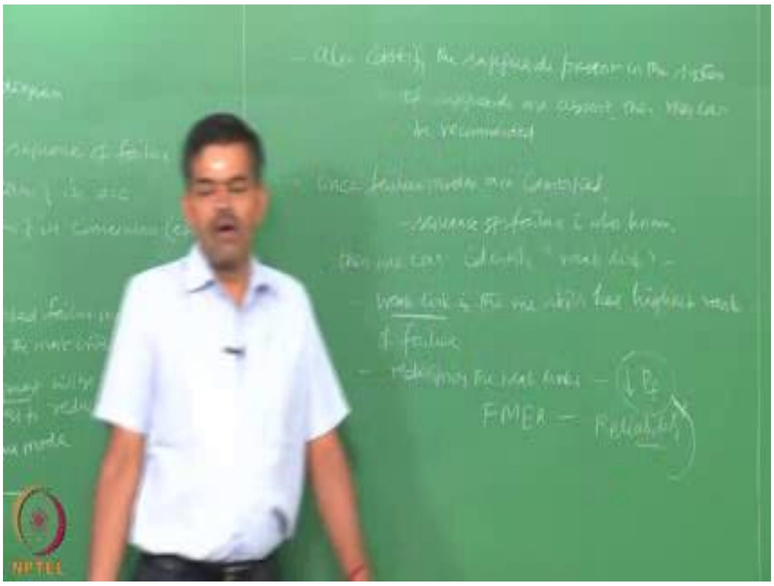

Subsequently, FMEA should also identify the safeguards present in the system which are designed to reduce or to mitigate the effects of these failure modes. If the safe guards are absent then they can be recommended through FMEA studies. Among the scientific failure modes select the most significant failure mode either with respect to its occurrence or order of occurrence or respect to its effects on the overall system. For example, if there are different failure modes amongst the failure modes rank them relatively with one another and then identify which of the modes have a significant effect over the other and therefore it affects the overall performance of a given system.

Such modes need to be considered and checked whether they have safeguard enough to mitigate these kinds of effects or not if they are not then these safe guards should be recommended as an outcome of an FMEA study. As the failure mode is considered identify what we call as a weak link. Once failure modes are identified and sequence of failure is known then one can identify the weak link in a given system.

Weak link is the one which has the heights rank of failure. For those weak links one need to carry out detail analysis separately. So, this will help us to reengineering the whole system by avoiding the weak links in a given system which can then reduce the overall probability of failure of a given system. So, redesigning the weak links can lead to reduction in probability of failure therefore FMEA study is a part of reliability, though it is a risk assessment method. However, it helps us to reduce the probability of failure and we all known reliability is focusing on probability of failure as such.

Let us quickly see what are the silent merits or advantages of an FMEA.

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As we all know the system is able to identify the analysis; can identify various possible failure modes and their sequence that is very important. This gives me the most critical component what we call as the weak link. So, it helps me to redesign the system to avoid the failure so that I can decrease the probability of failure of a given system. This can be used as one of the interesting design tools. It also talks about the effects, so effects or let us say cause effects of the system helps to diagnose the overall system through the behavior of the components.

So that is we can say it is a bisectional mode of understanding the overall mechanical systems, part by part component by component in terms of its overall effect on the system that is very interesting diagnosing tool. So, it can be a useful diagnosis tool.

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FMEA can also identify the components which require periodic maintenance. So, tell me a tool for service and maintenance requirement. It can be useful to schedule the service and maintain of a plant also. So, one can say it can be useful in improving the overall performance of the system, so we are bothered about improving production of the system. Since, the cause effect diagram or the cause effect analysis is a powerful diagnosis tools FMEA is a powerful tool to assess safety of the system. It can be used as a safety diagnosis tool as well. So, there are many advantages by which one can simply keep on listing the merits of FMEA.

And FMEA can be used at two stages; one is what we call design FMEA; one is what is called process FMEA. Process FMEA will talk about the changes modifications that can be suggested for maintenance and service requirements. Design FMEA can be useful for redesigning reengineering the whole system in terms of reducing the probability of the failure and guaranteeing a better and safe performance on the whole system. So, design FMEA is very a useful tool as far as innovative formed dominated offshore structural designs are concerned. FMEA is generally reported in simple tabular form.

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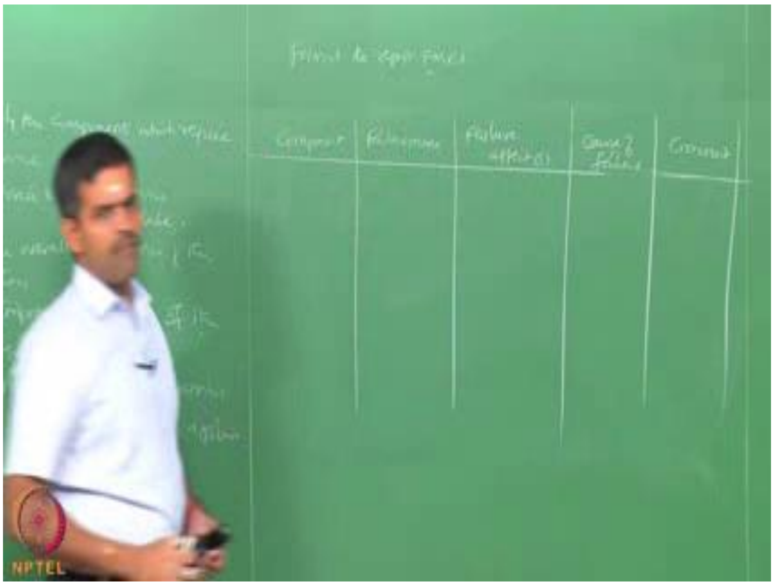

So, what is the format to report FMEA? So, one need to identify the failure mode of the component, one need to also identify the failure effects, and then one has to comment about the cause and failure etcetera. So, one need to also identify before the comments let us say cause of failure and then that is FMEA which is essentially qualitative. But interestingly risk analysis need to quantify this in terms of numbers as I said risk is a term associated to economy.

So, economics will always deal with the numbers; qualitative statements, comparative statements will not be powerfully used in terms of economic perspective. In terms of scientific and engineering perspective one can relatively understand the importance, but when you want really projected to an let us say audit format of any company one should also convert this qualitative issues of analysis to quantify them. So, to quantify them we need to always introduce risk in the whole picture. Now you see there is no risk coming here, we are only doing cause effect analysis of the whole system. So, it looks as if that FMEA is focusing on cause effect. It is true FMEA is focuses on cause effect, but this should always give me out the risk priorities because I have to categorize the risk priority of this particular thing.

FMEA applications can be a design stage; can be also a process stage. FMEA has got many key words related to a describing the function component, the basic function of every component, the failure modes, then the causes of the failure, then the effects of those failure on the overall performance system, and then identifying this failure system in terms of order of consequences or order of occurrence. Subsequently, I want to convert the whole study into prioritizing them in terms of risk, what we call risk priority number.

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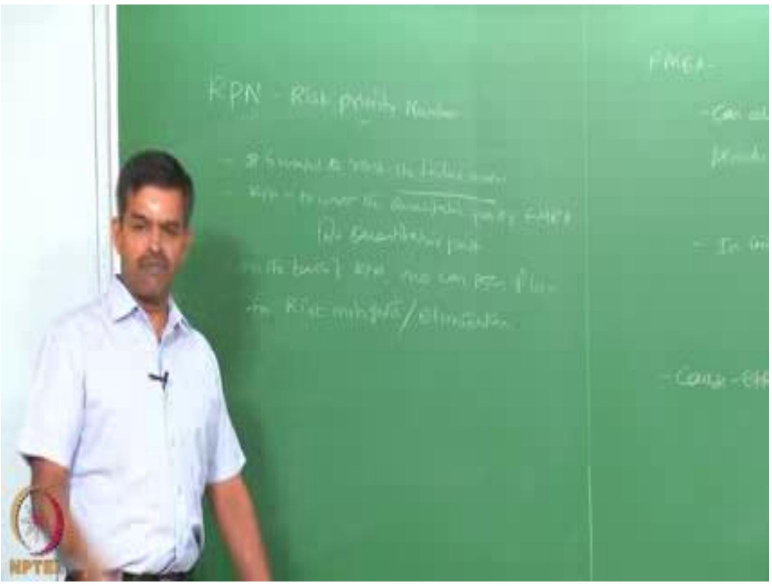

Risk priority number is actually a product of three variables. Risk priority is going to prioritize is useful to rank the failure modes. Risk priority number is useful to convert the qualitative part of FMEA into quantitative part. The qualitative part is the cause effect diagram or the cost effect analysis, the quantitative part is actually the number which is given by the risk priority number. So, on the basis of this priority number, if you know this priority number for the given system one can plan for risk mitigation or risk elimination one can then plan for (Refer Time: 33:38) for risk mitigation or risk elimination if possible.

Then this can result in even modifying the whole system in terms of its design or the process line whichever results in improved safety of the whole system. We will talk about the risk priority numbers later where we take up an example and show how risk priority number can be easily identified for a given system.

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Please pay attention to the flow chart given on the screen now which is called FMEA road map. For FMEA we already know that the first step is to define the system. The system can have functional components identify all those functional components and the failure modes of those components also define the relationship of these components in the overall behavior of the system, then identify or monitor different failure modes in terms of the effect of the failure modes. And also identify the causes for these failure modes. Once you identify the effects identify its severity, detectability and occurrence. So, now there are 3 components here.

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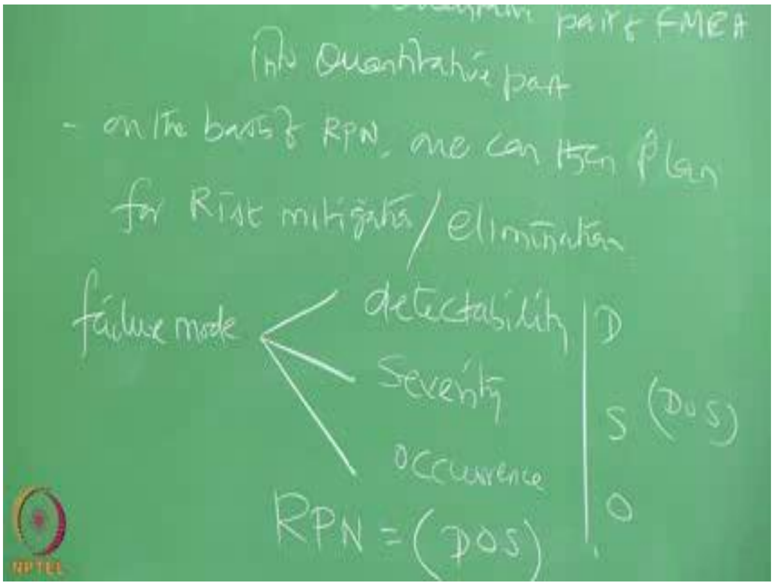

If you identify the failure mode for each failure mode try to identify 3 components; detectability is that failure modes detectable maybe using a sensor, maybe using an alarm, maybe using led, or maybe physically seen. For example, the tire of the vehicle is deflated. So that is the failure mode which can be detected easily one can see physically the tire is deflated in a given car therefore the car cannot move. So, is the failure mode detectable?

What is the severity of this failure mode, how severity it is in terms of affecting the overall performance, and what is the frequency of occurrence on this failure mode? We can say D S O or let us say DSO just to have a format in terms of understand. So, detectability rate of occurrence or frequency of occurrence how frequently this failure mode can occur in given system if at all it occurs what would be the severity. So, once you know these three RPN is nothing but the product of DOS in terms of numbers.

Now, the question comes how you will actually quantify detectability, severity, and occurrence in terms of a number we will talk about that. But please pay attention to the flow chart now on the screen back again. So, for each failure modes and effects try to identify the severity detectability and rate of occurrence or frequency occurrence. Once you know this evaluate the controls available in the system then identify the RPM number the risk priority number, then identify the action which you want to recommend for this particular study or for this particular system.

So, FMEA is a very useful study which can be applicable to mechanical, electrical, electronic systems, it can also be applied to structural systems where we call design FMEA. FMEA is able to identify the priority of failure modes in a given system and then the effects of these failure modes and the causes. Once you know the effects and the causes and the failure modes you can always arrange them, rank them based upon risk priority number. Risk priority number depends on 3 variables; the severity, the detectability, and the frequency of rate of occurrence of that particular failure mode.

So, if I am able to convert these 3 variables in terms of a number or a numeric character I can always identify the risk in terms of a number. Once I have the number I can always rank the risk so which will always indirectly rank the severity of the effect cause by a failure on a given system which will always tell me the criticality of this specific component in the given system. Therefore, FMEA which is focusing essentially on cause and effect diagram is slowly getting converted to cause effect and criticality analysis where we talk about FMECA.

In the next lecture we will talk about design FMEA conducted an offshore structure which is the form dominated innovative system which is quite recent in ultra deepwater exploration developments.

Thank you very much.