NPTEL

NPTEL ONLINE CERTIFICATION COURSE

Health, Safety & Environmental Management in Offshore and Petroleum engineering (HSE)

Module 1
Safety assurance and assessment
Lecture 12
Failure Mode and Effect Analysis

Welcome friends we are now heading towards the lecture 12 on module 1 well we are focusing on safety assurance and assessment in the course of health, safety and environmental management in offshore and petroleum engineering under the asepsis of NPTEL IIT Madras. I hope you have followed the 11 lectures earlier there are two tutorials which you must have submitted the third one is also on the pipeline.

Any doubts you have please post it to NPTEL discussion site so that your questions will be answered accordingly. Let us enjoy lecture 12 now, which will focus on failure mode effect analysis.

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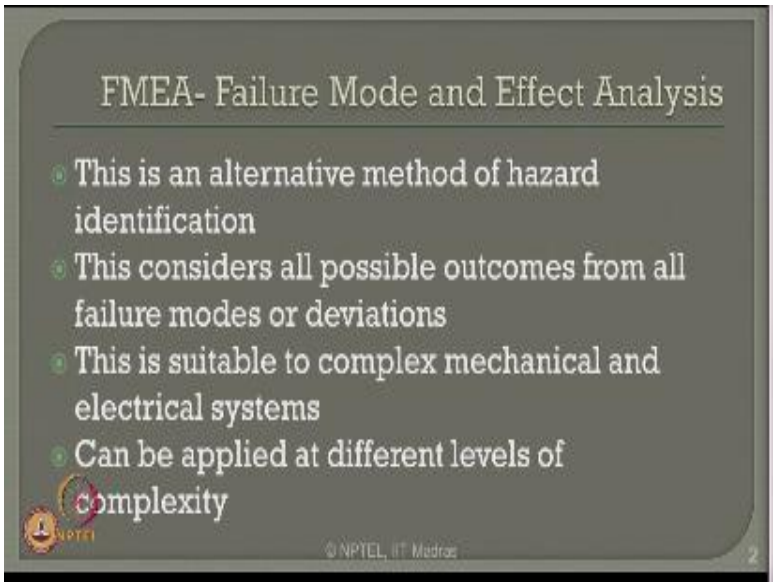

Failure mode effect analysis is one of the tool which is considered as an alternate method of hazard identification. This considers all possible outcomes from all failure modes or deviations. We already know dear friends what are the design intense and deviations in a given problem identified for either a machinery or a process situation. FMEA method is suitable to complex mechanical systems and electrical systems.

It can be applied at different levels of complexity of a given problem. Essentially this is one of the quantitative risk analysis on hazard identification tool which is applied to mechanical and electrical systems, whereas in the earlier couple of lectures we discussed about the hazard method which can be applied to the process management systems.

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FMEA is therefore a systematically identifiable tool to identify the consequences of a component level failure. We all know that mechanical system is a combination of different subsystems which we call as components. Now the overall system failure will occur or will be generally directed by the failure of different component levels. So it is important for us to do a micro level

analysis for a given complex system, because it is very difficult to analyze the complex system as a whole.

Therefore, we divide the complex system into component levels and FMEA is a very interesting tool which identifies the consequences of component level failure. It determines significance of each failure mode with regards to the systems overall performance. On the other hand if the system compress of different components we identify the failure of different components in a specific order or hierarchical manner where the consequences of failure of these systems are subsystems are components will affect the overall performance of the entire mechanical system.

So this study should be able to give you the consequences in hierarchy of failure modes or different failure modes of component levels in a given complex mechanical or electrical systems. This method is primarily used to study material and equipment failure.

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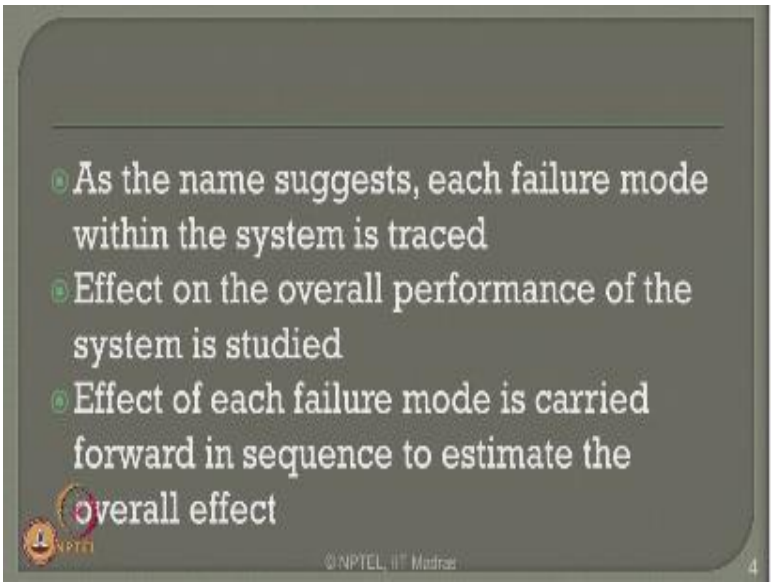

As the name of FMEA suggest each failure mode within the system is traced by this method. Effect of the failure of these items are components on the overall performance of the global system is not subsequently examined. So the entire outcome of the study is the significance of

failure of the components on the overall system, whereas the study focuses on the failure of the components part by part which leads to the successive overall failure of the entire complex system.

Each of the failure mode is carried forward in a sequential manner to estimate its overall effect on the performance of the given mechanical system.

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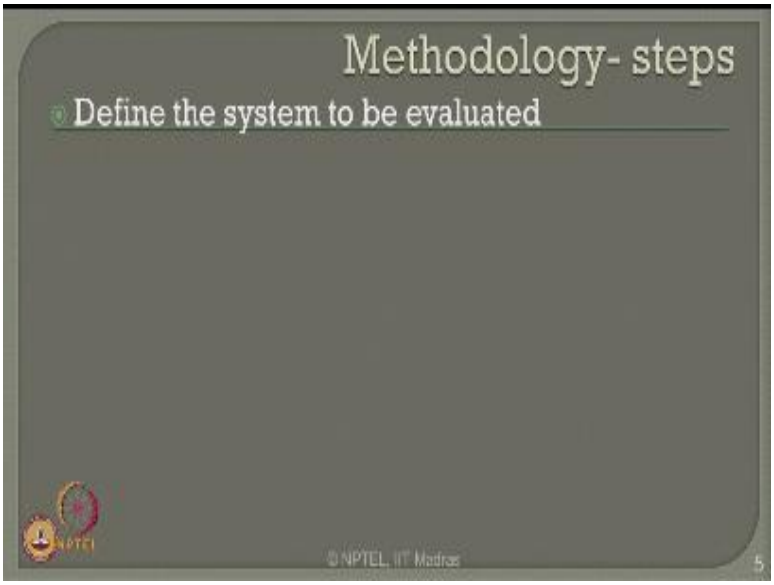

Let us quickly see what are the steps involved in conducting an FMEA for a mechanical system. First we have to define the system which needs to be evaluated. So this kind of study cannot be applied if the conceptual design of the system is not available. Usually for a successful FMEA one need to at least conduct a scaled model investigation of the system. Therefore, based on the experimental investigations one can then HAZOP at the different failure modes categorically and systematically.

Dear friends please understand HAZOP is a perceived level of failure for a given process system which is in anticipation. Whereas FMEA is a prescribed level of failure analysis for a given system where the system should physically exist not necessarily the photo type mode of the

system, but actually the scaled model of the system should be available to you. Therefore, the FMEA studies are generally conducted to pre analyze the failure mode of a given product before it is marketed or before it is even started production..

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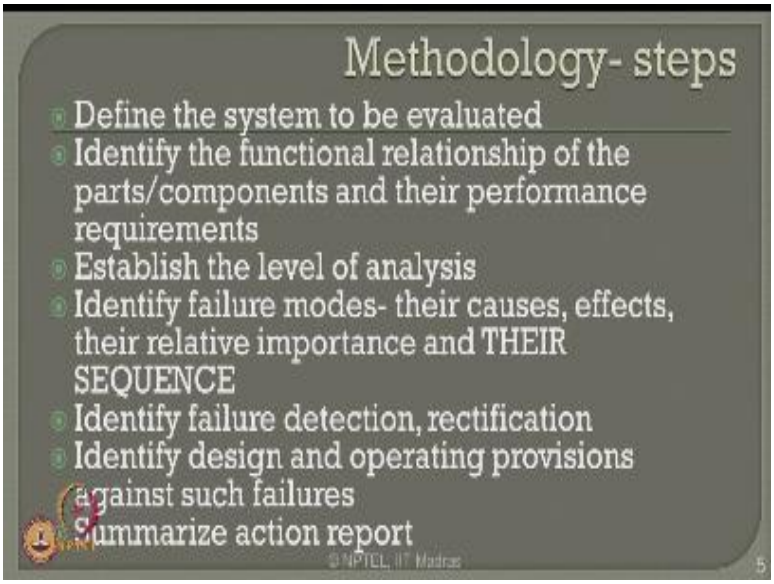

So first define the system which needs to be evaluated. Once the system is defined completely then after understanding the mechanical process of the system identify the functional relationship of different components present in the system and their performance requirements. Dear friends you will be able to now recollect that these are the design intense. Every component of a given mechanical or electrical system is designed with a specific intend. Let us try to capture the designed performance of every component at this specific stage which is the second step in FMEA analysis.

Once you do this then establish the level of analysis, what kind of analysis you wish to do. Once you design the level of analysis which has come to the next slide, identify a different failure modes, you have what anticipate the failure modes, it is very difficult as we all understand to anticipate the failure mode for a mechanical system if the working model of the system is not available.

It is because of this reason I told you in the beginning there is essential first we have got to make a scale working model of the system for which we need to do an FMEA study. So from the experimental investigations of a scaled model of the system let us then subsequently identify different failure modes their causes if the failure is materialized then their consequences are what we call effects of this failure on the overall performance of the entire system.

Most importantly dear friends please note it is not only necessarily that we should know what are the causes and effects the most important feature of FMEA is the sequence of failure under the given set of components which component fails first, which components follows the failure of the first component and so on. So this is the only study which gives you categorically the sequence of failure as you saw in the HAZOP they are not intervened completely whereas in FMEA which is a qualitative method of risk analysis are hazard identification.

It is essentially interesting that this method of analysis gives you most importantly or should enable you to identify the sequence of failure. So dear friends define the system, identify the relationship functionally between the components and their performance requirements, therefore it is a design intend here, establish the level of analysis which you wish to perform then identify different failure modes, their causes and their effects and most importantly their sequence of failure in which we say their relative importance in a given overall assembly.

Once this is done then we are through with identifying the failure detection and subsequently the rectification methods or mechanisms. Then identify the design and operating provisions against such failures. So it is a very interesting pack of risk analysis which tells you what are all the sequences of failure that are envisage in a given model. Now it is very clear that you have a question in your mind, how we can envisage a failure mode for a mechanical system, if the mechanical system is not in operation.

It is an interesting question that is why I told you in the beginning for performing FMEA it is mandatory that you should have a working model. Preferably the photo type model, but since these models are very expensive people generally construct scaled models of these prototypes

and then based on the working mode failures they identify the sequence of failure and then if the failure are envisage properly during exponential investigation then you can identify any modification the design and the operational provisions.

So that these failure modes can be avoided or can be eliminated or mitigated completely. So that the product outcome after FMEA will be more or less a failure fool proof design. Then you try to summarize your action report and give a recommendation to the manufacturer that what recommendations you suggest as an FMEA team to modify the design or to modify the operational conditions of a given mechanical or electrical system. Therefore, the failure is minimized.

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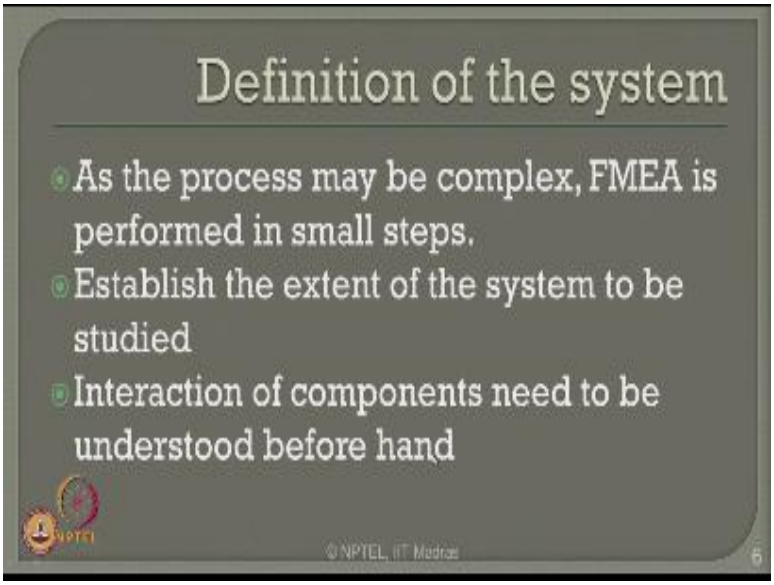

Let us talk about slightly appropriate manner of definition of the given system. As the process may be complex, FMEA generally is performed in smaller steps. So FMEA is generally performed at component level. Therefore, FMEA is one of the studies which addresses component level failure. It establishes the extend of the system to be studied. The whole system obviously cannot be studied at one shot, you divide them into segments and keep them

understanding and identifying and then doing failure analysis of different segments or components of a given overall system.

Most importantly dear friends it is necessary that we must link the interaction of different components and we must understand them before hand with ever one can easily find out the sequence of full mode in a given system.

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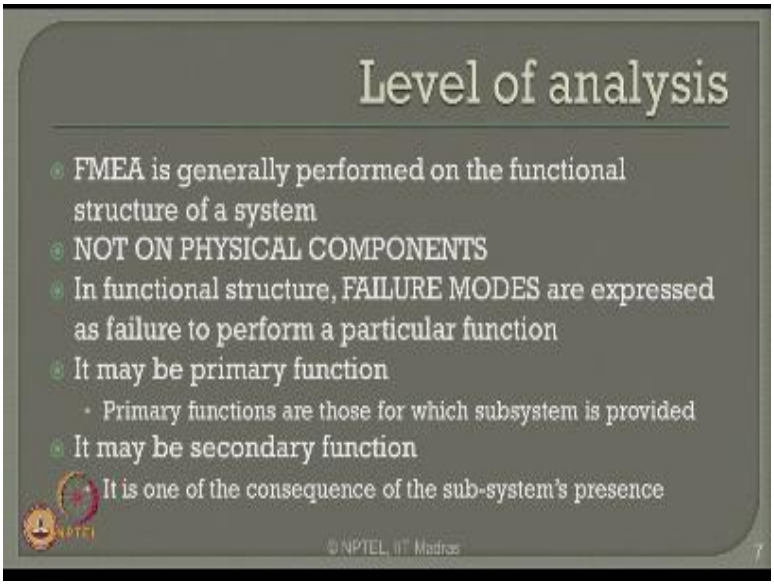

Now there is a question in line what do you understand by level of analysis. FMEA is generally performed on the functional structure of a given system. It is not on the physical components please understand component level analysis means components while working. Therefore, we need to have a working scaled are prototype model of a given mechanical system, if you really wanted to perform an FMEA on a given system.

So FMEA does not focus on the physical components, but the functional structure of a given mechanical system. In the functional structure of a given system failure modes are expressed as failure to perform a particular function. Now ladies and gentlemen you will be able to integrate

this statement specifically this particular statement with the top on HAZOP study which is a qualitative risk analysis where this is nothing, but the deviation in a given system.

So the first part of FMEA spoke about design intend, the second part of FMEA is speaking about the deviation which is addressed as level of analysis. Therefore, there is no principle difference between qualitative and quantitative risk methods of analysis. In qualitative we speak about perceived failures whereas in quantitative we speak about identified failures. Now when we talk about the level of analysis it maybe a primary function, primary function are those for which subsystem is provided or it can be a secondary function which is one of the consequence of the subsystems presence.

So this is where the level of analysis means. The level of analysis can be applied to a primary function or a secondary function which is a derived function of the presence of the subsystem which is a primary function.

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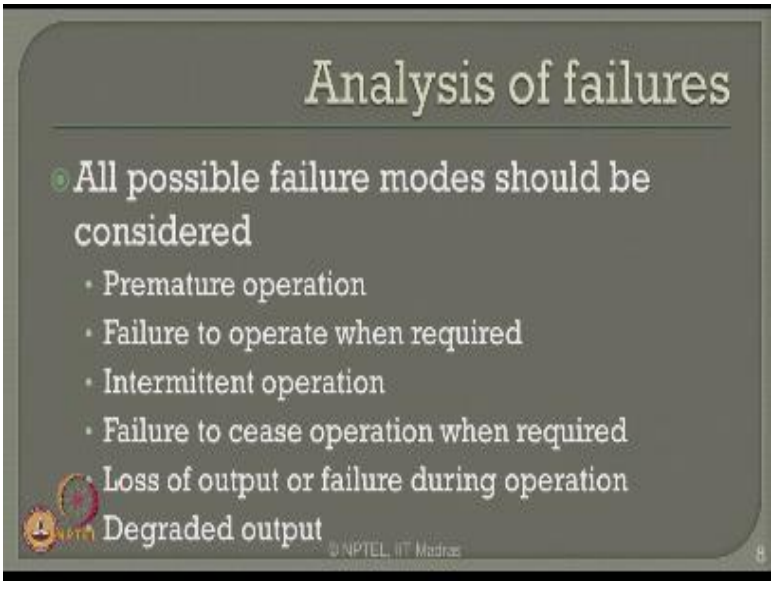

When we talked about analysis of the failure modes one should identify all possible failure modes in a given mechanical or electrical system. What are the possible failure modes which we

can always identify in a given system, following a value brief list of the possible failure modes. The system can have a premature operation, the system can result in failure to operate when required, for example a valve, the valve should open or close at a specific temperature, pressure or flow of volume.

If the valve does not close at a specific operational conditions, then it is identified as failure to operate when required. Sometimes the valve failures will intermittent operation, failure to cease the operation when required. For example, the valve should close that does not close. Loss of output or failure during operation maybe senses, awareness, alarm should work when there is a remark, so loss of output or failure of an alarm during operation or it works but not satisfactory what we call degraded output these are possible failure modes of a given mechanical or electrical systems for which the components leading to or responsible for such failures are identified in a method called FMEA.

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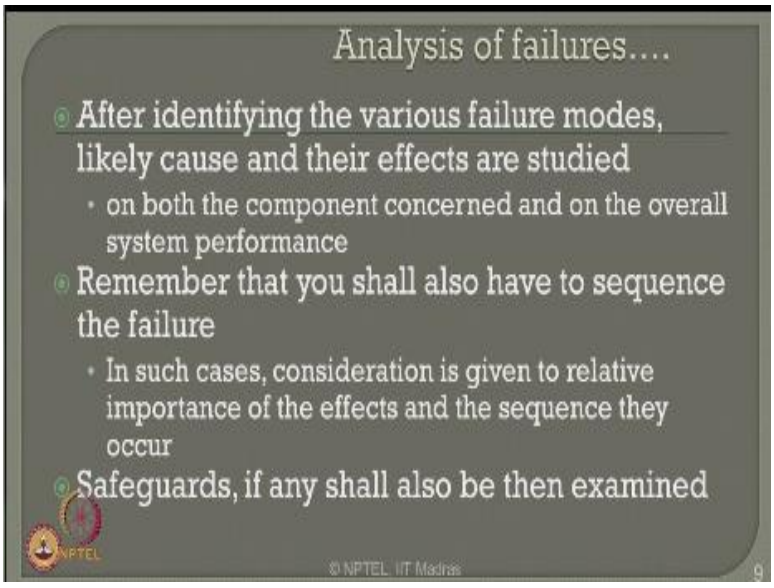

After identifying the various failure modes then the likely cause the reasons for the failure and if at all to fail what will be the consequences now dear friends we will know that FMEA is purely a risk analysis method because it also tell me the probability are failure modes in addition to that it

also gives me the consequences or the effects of this failure modes and we know that risk is generally the product of these two.

So FMEA is one of the cognitive risk method which analysis risk in a given mechanical on electrical system with a focus to the subsystem or the components in a given global system it essentially focus on the components concerned and the consequence of the failure on an overall performance of a given system please note that if you all have the consequence completely addressed only when you know the sequence of failure in such cases consideration generally given the relative importance of the effects.

And the sequence they occur so importantly it had to grad them in terms of which component will fail first which component fail first which component will fail next therefore you grade the failure and that will give the importance of the component in a give system so in a FMEA study as an output you can easily identify the most critical or the vital component of a given mechanical system.

If you want to provide any safe guard to avoid or to prevent the consequences of failure of the component then one can also talk about safe guards which we already provide in the design if any when should we also examine and see and check whether these safe guards are capable of mitigating or minimizing the effects of failure.

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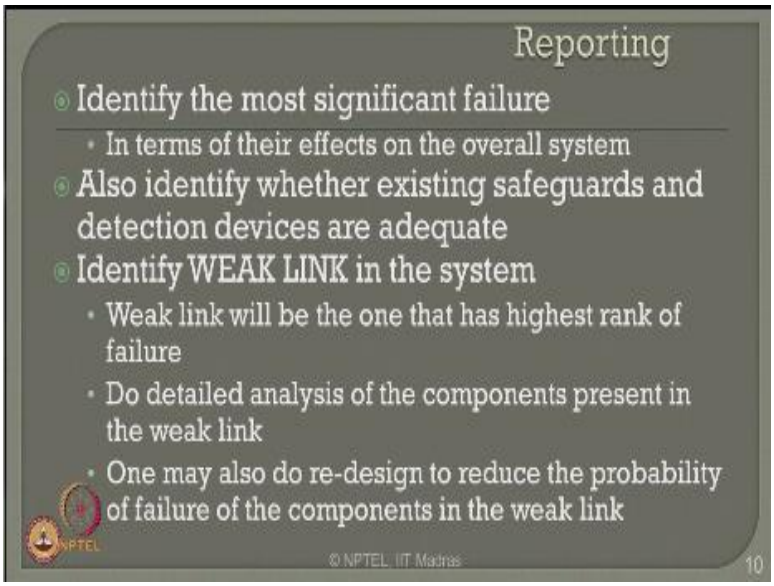

Once we do the analysis the most important part of the analysis is how will document it how ill report the result of the given analysis identify the most significant failure in term of the effects in the overall system also indentify whether the existing safeguards and detection devices are adequate enough to perceive this damage is in advance most importantly drear friends try to identify the weakest possible link in the given system now the question comes what do you mean by weak link in a given system week link will be the one that has got the highest rank of failure the one have a question where are we ranking the failure we already said that the components which are identified for the causes and consequences are also subsequently arranged in terms of the merit order.

So this merit order arrangement will tell which is the most vital or the critical component which as the most serious consequence the failure on the overall system therefore we are trying to rank the failure in a specific order especially and preferably in a descending order the highest component which as they got the maximum consequence of failure will get the highest risk rank as we also saw in Morgan's analysis so that would be the weakest link in a given mechanical system.

So identify the weak link the given system then do detail analysis of the components of that system which is present in the weak link weak link may not essentially be only one component it can serious of components for which they have got to do a detail analysis especially and particularly in detail if so then one may also redesign the entire weak link to reduce the probability of failure of this components in a given weal link so essentially an interestingly dear friends FMEA identifies the weakest possible links are components in a given system enables you to redesign the system therefore the probability of failure of the components in a given system are minimized if the components are failure or minimized the success of overall working of the system is always reacted to it is maximum probability.

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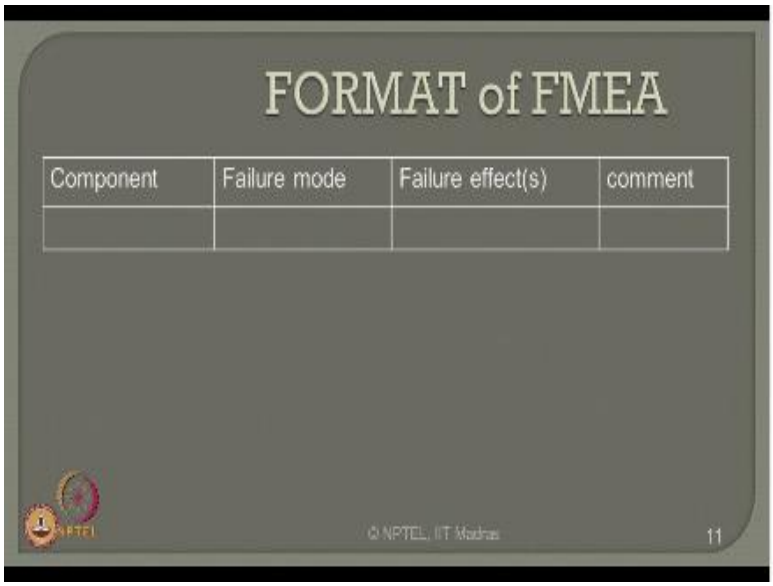

Now one will interestingly like to move what would be the format of reporting and FMEA study, the format appears like this in a tabular column you must identify the component the perceived failure mode of the component in working not the physical condition the effects of the consequences of this failure on the overall performance is against system please understand dear friends the failure effects is the consequence of failure of the component on the overall system it is not the consequence of failure the component alone in locally.

So FMEA connects the component failure to a system failure, it integrates from segments or parts to the whole ultimately one can give also the respective comments related to whether these failure effects can be minimized mitigated or can be controlled by either he designing the weakest link in a given system or by inducing node advance features in the design so that the component that will fail out can be easily prohibited or prevented in a given system therefore the overall performance of a given mechanical system can be assure to the highest probability of success.

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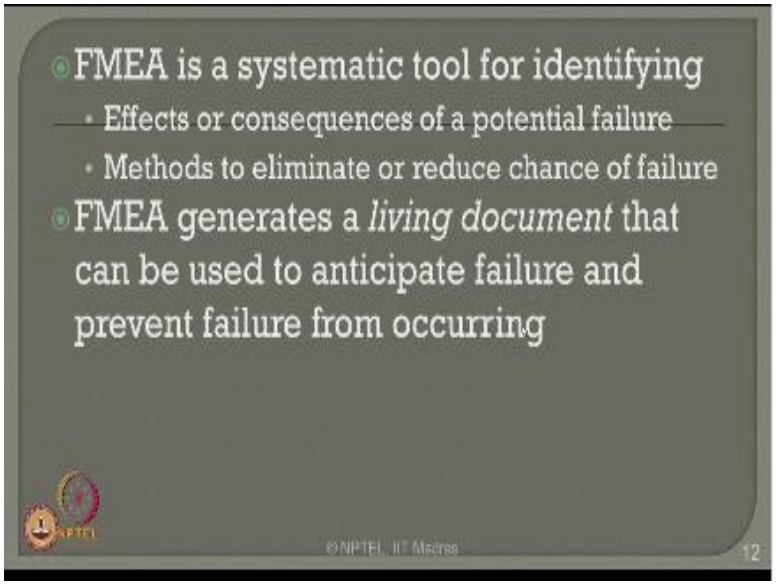

FMEA is therefore a systematic tool for identifying the effects or consequences of a potential failure, methods to eliminate or reduce the chance of failure of an overall system because you are able to understand clearly the failure of components of a given system. FMEA therefore generates a living document now one can ask me a question why FMEA is called a living document?

It is called as a living document because FMEA is one of the QRA methods which is trying to identify the failure when the model is working that is why we call living document which can be

used anticipate the failure modes and therefore one can either re-design or try to prevent this failure from occurrence one highest possible extent.

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Having understood some brief idea about how FMEA is going to be done, how they will be reported, what are the merits of FMEA, what are the intrinsic comments an FMEA can give to a designer so that the overall success probability of a mechanical system can be achieved having said this now the fundamental question in designers mind is went to use an FMEA is it mandatory or is it optional?

FMEA if it is used before the design it will be very useful because you are scaled model working can be easily corrected by some design features some of the end development of the product can be more or less successful so when used before the design it is always constructed to be extremely useful, it should be used before the final design of any product is released, the objective of FMEA please understand friends these on failure prevention and not on detection.

Failure detection is only an observation you need not have to have your working model to detect the failure what we are understanding here from FMEA is how to prevent the failure if the failure

is in messaged to occur or definite to occur in a given mechanical or electrical system, so failure prevention is the motive and failure detection is not the motive. FMEA is consider as a standard procedure which is used in development of new products.

Therefore it is very useful for design and development of new products before they are launched in a commercial market.

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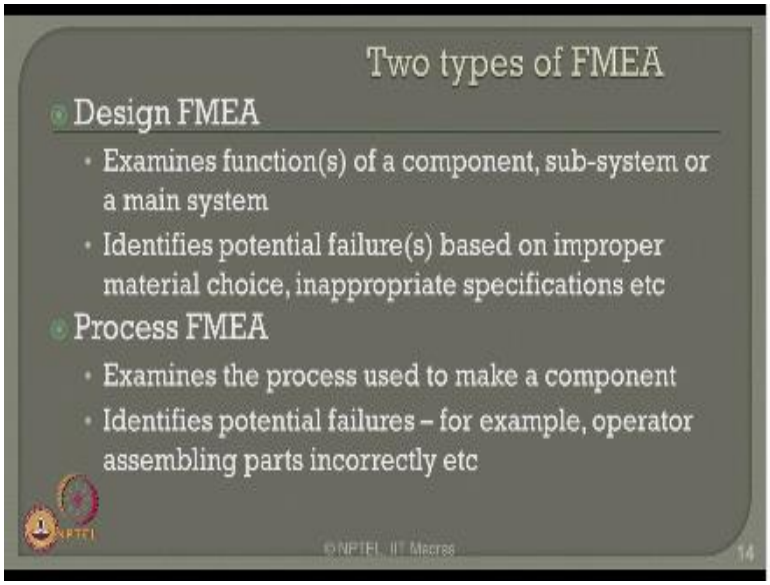

There are two types of FMEA which a literature governs and decides in a given system one is what is called design FMEA other is called process FMEA, design FMEA examines the function of a component, sub system or a given main system it identifies the potential failures based on improper material choice in appropriate specification etc. Whereas the process FMEA examines the process used to make a component identifies the potential failures in terms of operator assembling parts incorrectly etc.

So one talks about work man ship, one talks about the design, put together is the development of a good product as a mechanical engineer we all understand that FMEA become very vital for

development of a new mechanical on electrical product if you really want to ensure that the successful operation of the product is 100%.

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As in the case of HAZOP analysis where primary and secondary key words are important, FMEA also have certain key words based on which is reporting is carried out. Let us see now what are the key words of failure mode an effective analysis keys words generally convey the basic and secondary functions, basic function is about what the product does? Secondary function is about what the process does? Failure mode is talking about the physical description of a failure. Failure effects talk about the consequence of failure on people on equipment on economy extra. Failure cause refers to the cause of such failures.

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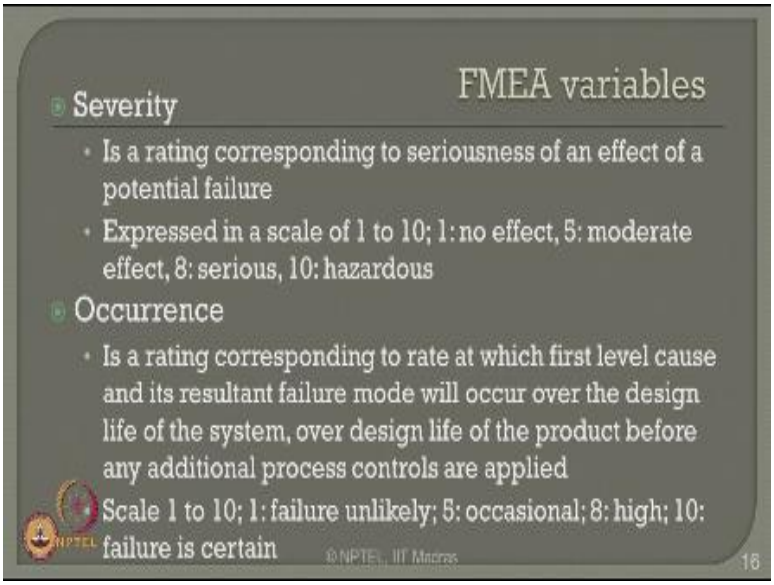

There are different variables available in FMEA study the most important variable which is seen in the literature is considered as severity, severity is a rating corresponding to seriousness of an effect on a potential failure. If at all the failure occurs in a component if that failure is going to significantly cause a consequence under overall performs of the whole system what would be the rating of that seriousness in a given system.

When the moments are rating you must understand that I am trying to quantify the consequence in terms of a number therefore you are scale it is generally therefore expressed in a scale of 1 to 10, where 1 means the failure of this component has no effect on the overall system at all, whereas a scale of 10 out of 10 will tell me that failure of this component is going to be most hazardous for the failure of the entire mechanical system.

So in a scale of 10 a number of 1 to 10 varying from 1 can be no effect for example 5 can be moderator effect, 8 can indicate serious and 10 can be most hazardous. In the next important variable in a FEMA study is occurrence. Occurrence is a rating corresponding to the rate at which first level cause and its resultant failure mode will occur so it will tell me which is the first component is going to fail. So where the failure initiate is shown from this key word are the variable called occurrence, then it will occur in the overall design life of the system.

The overall design life of the product before any additional process controls are applied. Again the moment I say rating I need to again express this in a scale of 1 to 10, 1 means failure is unlikely it means it will not occur at all whereas in case of 10 it is considered that the occurrence of failure of this particular component is for certain. So any point varying from 1 to 10 like 1 indicates unlikely failure, 5 indicates occasional failure, 8 indicates high failure whereas a scale of 10 on 10 indicates the failure is 100% certain.

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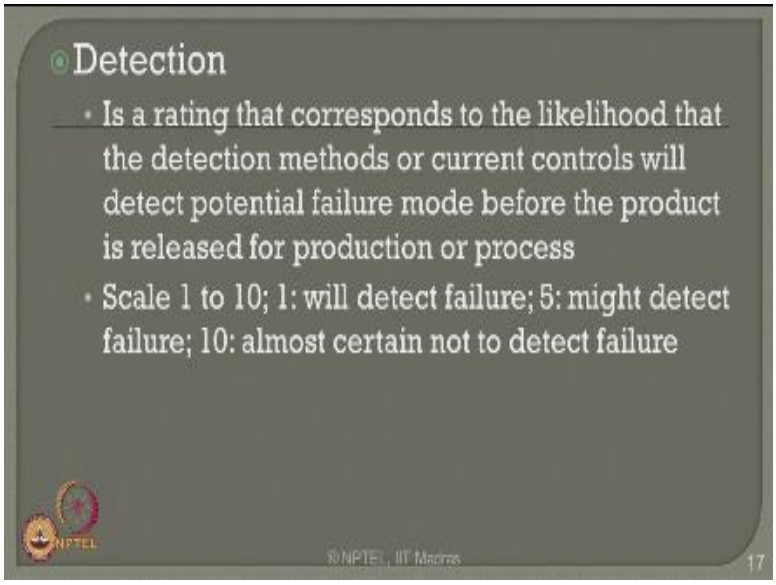

The next variable is detection, detection is again a rating that corresponds to the likelihood that the detection methods or current controls will detect the potential failure mode before the product is released for production or process. So detection is an observation of different mechanisms available in a given system which is capable of detecting the failure in advance or can visualize a failure when the failure is about to be initiated. Again is expressed in a scale of 1 to 10 where 1 means it will detect the failure, whereas 10 means almost certain not to detect the failure so is in compliment part of the discussion.

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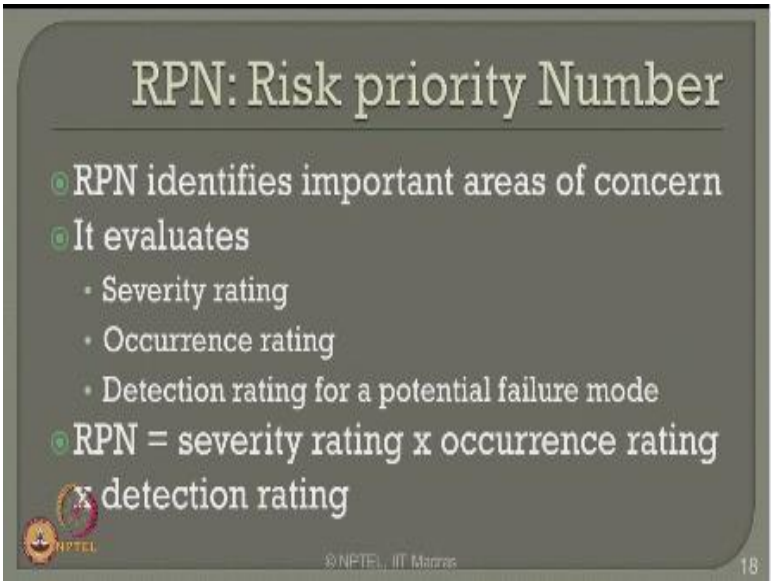

So three variables severity, occurrence and detection when they are multiple together will give me a number call risk priority number expressed as RPN. RPN identifies the important areas of concern. For example, in a given system or mechanical product or an electrical product the components are analyzed in detail and when able to get a RPN of every component the component is got the highest RPN that is the risk priority number is the most critical component we should be addressed in a design are a component should be design for the overall performance of the product which is the end development of the state.

So risk priority number identifies the important areas of concern it evaluates severity rating, occurrence rating and detection rating of a potential failure mode. Therefore, RPN is nothing but the product of all the three put together.

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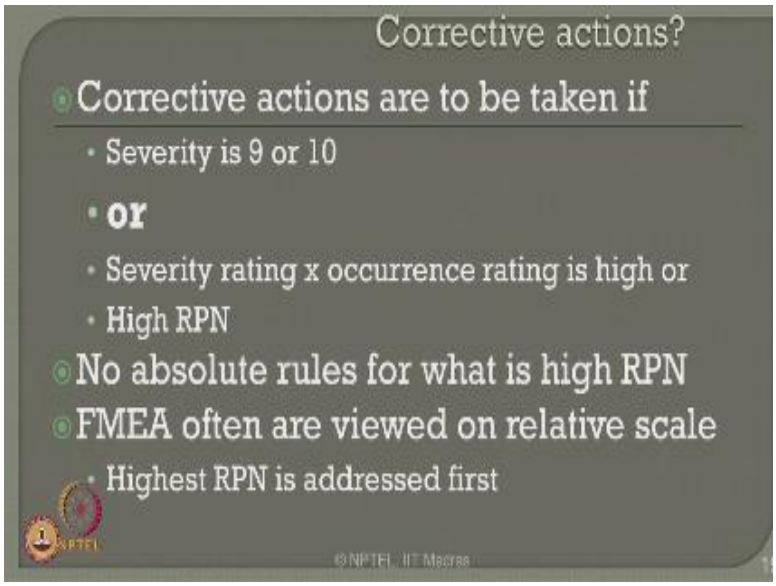

So the actions core of RPN can be poison they got spin is scale and each one of them subsequently once you know the RPN is given for a specific set of components in a given mechanical system then lot of corrective actions either available in a given system or suggested by the familiar authorities corrective action are to be taken if the severity is in a scale of nine or ten or severity rating multiply by occurrence they are taking this high or we have highest RPN number.

If anyone of them is true when I given analysis then one should take corrective actions RPN generally is a confusing term because RPN does not have any absolute waves what is meant by an highest RPN, RPN only give you the relative ranking between the components in a given system therefore FMEA often or view on relatives scale highest RPN is addressed first.

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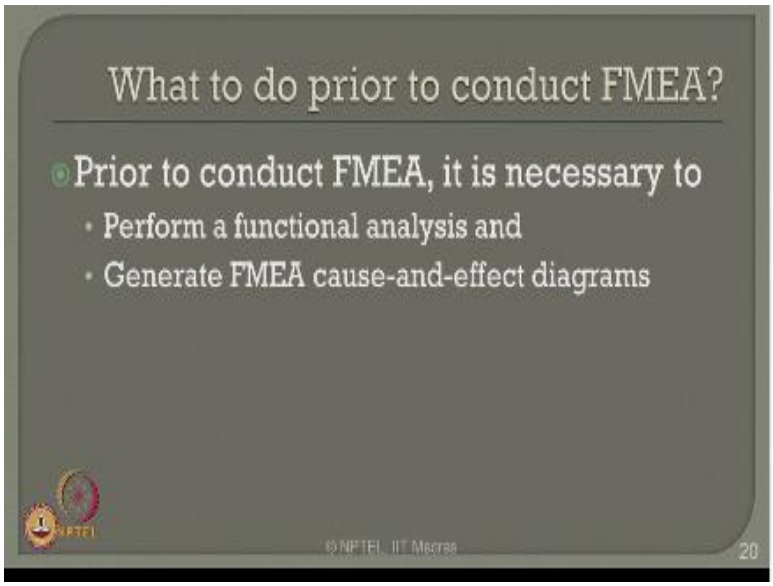

Whatever part to conduct FMEA what to do prior to connect FMEA prior to connect FMEA is necessary to perform a function analysis and then generated FMEA cause and effect diagram.

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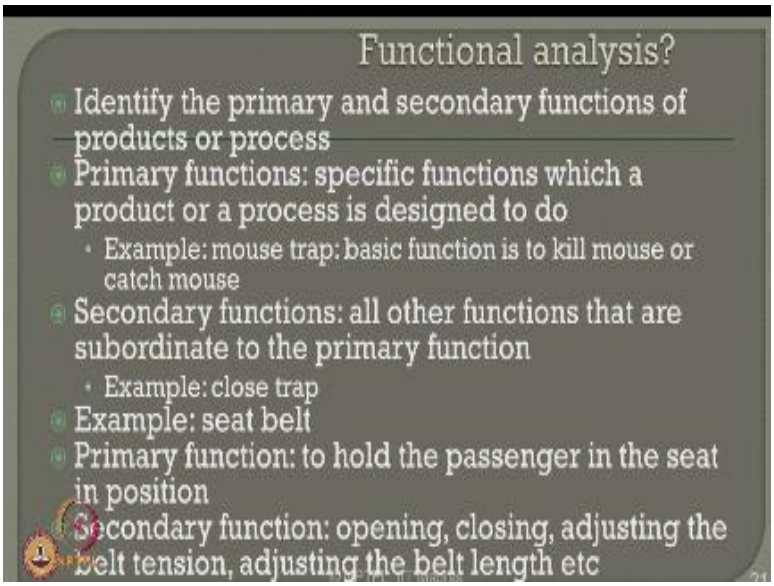

Let us talk about the functional analysis functional analysis is done to identified the primary and secondary functions of a given product are a process primary functions have a specific functions which their product or a process is design to do for example a mouse trap the basic functions the mouse trap is to kill the mouse or to catch the mouse secondary functions are based functions that has subordinate to the primary function for example closing or opening with trap is one about secondary function of given mouse trap.

We talk about a seat belt in a given automobile vehicle the primary function of seat belt to hold a passenger in the seat in position the secondary function is opening of the belt closing of the belt adjusting the belt tension adjusting the belt length etc. So every component you can easily identify the primary a secondary functions now we do analysis on their own functions in a primary or secondary more.

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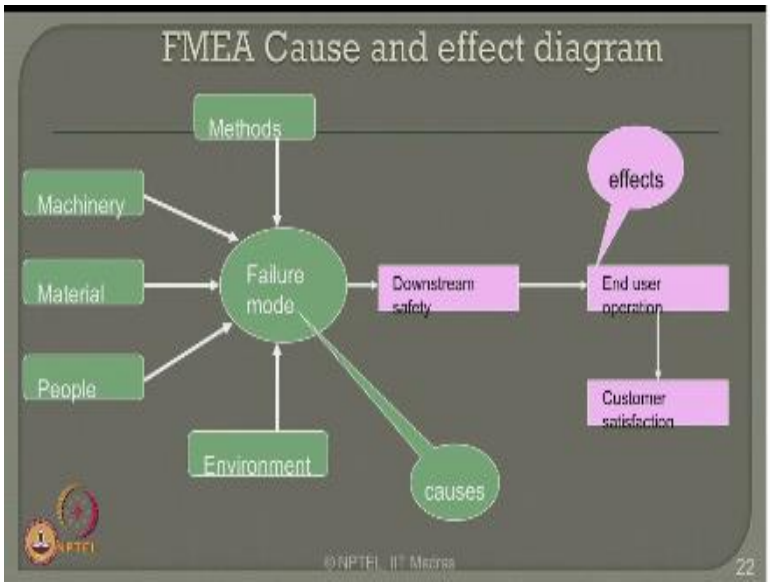

What do we understand the cause and effect diagram FMEA a cause an effect diagram indicated about the failure notes with comprises of the methods the machinery the material the people the environment all put together can result in the failure modes what we identify as the failure modes of a given system arising from the components once it is identified then it can lead to downstream safety then it can result in end your operation and ultimately the design product should have the high level customer satisfaction.

Now we call this has causes and we call these as effects so put together is what we called as cause and effect diagram so after you do FMEA you must also bridge the causes and effects in an mode what we call as cause an effect diagram.

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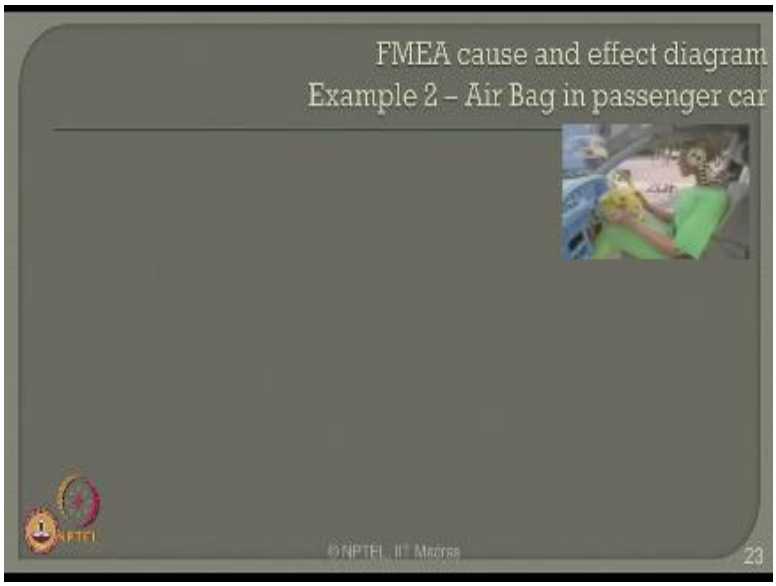

There is state solve an FMEA sheet for a given case study which is an example two which is an air bag in a passenger car as I said to perform a FMEA one should first understand the working model of given product what is see quick video how a seat belt in a given car is adjusted and how and air bag in a given system works for it safety.

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When this quickly see this video this is one or air bag design system which is done from automobile vehicle then the vehicle hits you will almost the see the person hitting this steering will already protected therefore it does not cause an injury if he does it that is neck bone actually damages severely result in damage fatal accident so how to understand this particular design let us quickly see how one can do the failure more affect analysis of a given had the act system for a passenger car.

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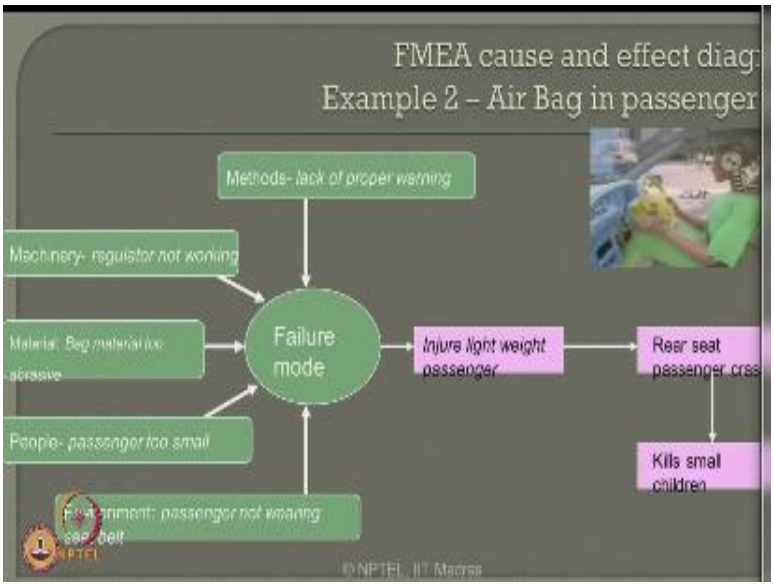

Let us getting back to do a FMEA for air bag in a passenger car what are the methods by which I can identify the failure one is lack of proper warning it arise from the understanding of the system it can be a machinery failure the regulator which as to involve the air bag is not working properly it can be a material the air bag can be very highly addressee material it can be the people if the passenger is too small maybe a child under aged person there is not case cannot so cause a failure.

The final one can be a environment that is the passenger is not wearing a seatbelt at all were is he has to be in position to make it safe, so these are all different failure modes in a given problem whereas the consequences or the effects of the failure can be it will injure the light weight passenger it can also cause crush to the rear seat passenger can also result in killing a small children because the passenger need to have a specific geometric configuration if he have product himself from a serious abrasion of accidents.

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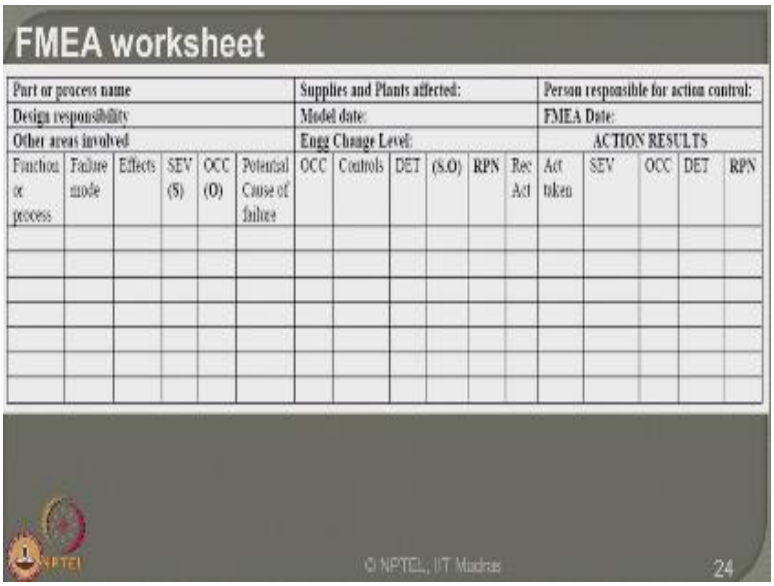

So failures and cause let us talk about me a worksheet this is a details spread sheet of an FMEA we talks about the part of the process name in a suppliers idea and identification the person responsible for action control which date FMEA is performed what is model date because experience date we conducted what is the design responsibility what are the areas involved which now correct in measures.

What is the engineering change recommended different levels of analysis what are action results. So what is the function of the process what are the failure modes what are a consequences what is the severity occurrence of these two which will give you the potential cause of the follow what are the occurrence after you make the engineering change what is the control you are inserting or recommending in the engineering change.

What is the reduction possibility of these control mechanism therefore what is the product of severity and occurrence now after the occurrence revised. Original occurrences is different after you making the changes the occurrences going to be further different now the product of severity and occurrence in reduction now will give you the risk priority number then you can always say for the recommended action.

Once a recommended action is there after you take actions please list what action you have taken after taken this actions what is the severity occurrence and deduction which are changed from that of the original severity occurrence and reduction. Therefore what is the new risk priority number, so the sheet gives me a compliance of comparison of the risk before the design the risk after the deduction or after the recommendation and if the actions there are completely perform what would be the changes in the risk priority number for various components.

So this is a compressive worksheet of an FMEA study which can be done now let us fill up this worksheet for the passenger car in a air back failure.

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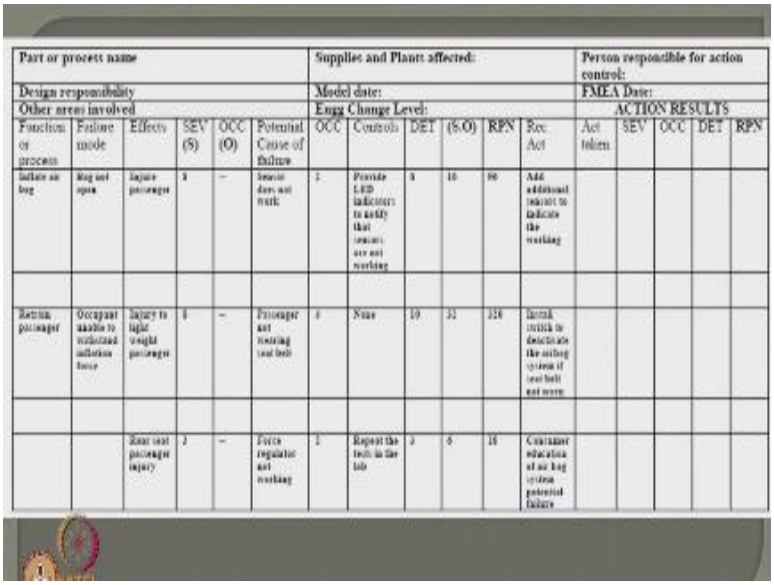

Let us quickly see you one of the functions of the components infraction of an alba the failure mode maybe are that is not opening the effects could be it can injure the passenger. The injury can be very high therefore the severity of this failure can be laid on 10 point scale of course occurrence of this is not deductive in the beginning the potential cause can be the fills us which would sends the opening of the air bag is not working.

Now you make a recommendation correct the senses provide everyday indicators will notified that inside not working therefore now the occurrence is improve from nothing or 0 or 1 to 2 therefore you did deduction because LED is available on the panel board to show since is on hard working therefore it is detectable therefore the severity in the occurrence which we now the product of use to which is 60 multiply the reaction this priority number as become 96.

Now you recommended a action saying add additional senses to indicate that that is not opening. Once we recommendation of in place we can again work out the severity occurrence and reduction get a new risk priority number. Dear friends it is very comfortable and easy and very comprehensive to prepare a FMEA for any new product which is C working therefore it givers you a interesting idea about every components.

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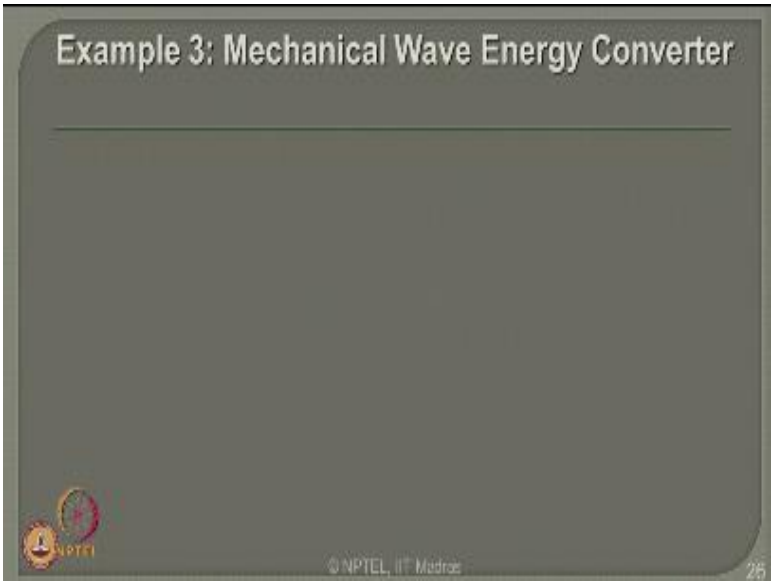

So let us also take one more example which is a mechanical wave energy converter designed, analyzed, developed and pattern type at IIT Madras.

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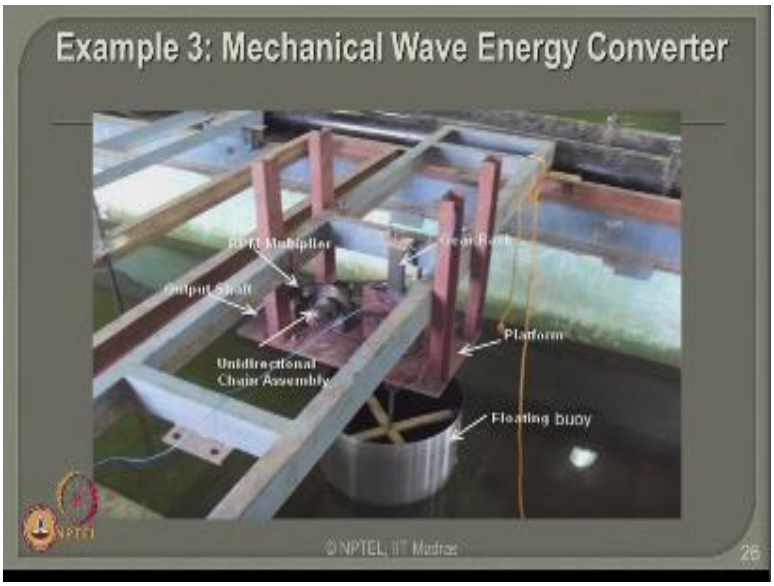

This is a device which a scaled model of 1:10 of the prototype which is designed for wave energy converter. The mechanical system is the different components a given at system, a platform on which this will be mounted, a floating body, a unidirectional change assembly, an output shaft and an RPM multiplier. Now let us try to understand the working of this particular model before we do a FMEA for this particular study.

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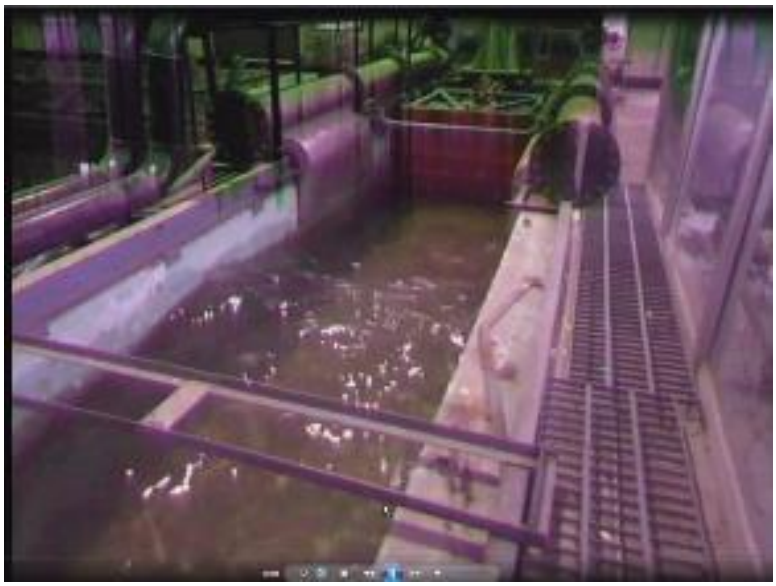

We say this models have scaled model which is placed in the wave flown of ocean department of IIT Madras. You can see that the lever is working up and forth which initiates the rotation of the gear which is connected to the output shaft, which converts the mechanical working of the device to an electrical energy. So the electrical energy is generated from the mechanical working of the components therefore we call this as mechanical wave energy converter.

The vital component present this converter is a float which is made to move up and down by the wave action, this up and down motion is converted in an assembly mechanism by a gear and a rotor which is then connected to the output shaft where electric generator is clubbed or compared to the output shaft which connects the bulb therefore the electrical energy is generated.

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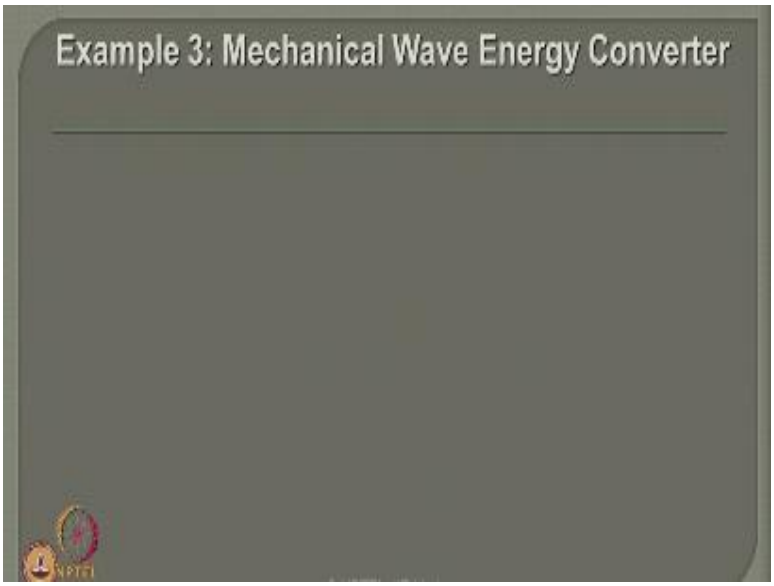

Having understood this.

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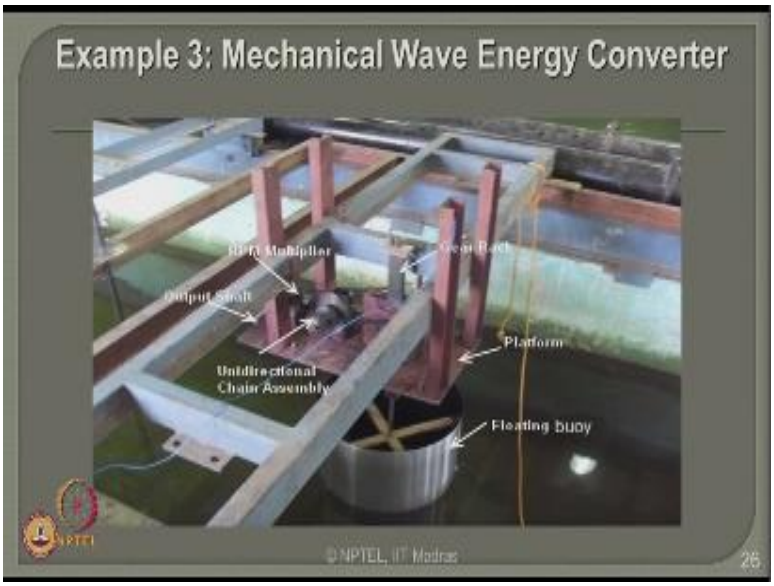

Let us now try to see how an FMEA report can be prepared for working or component of failure of this particular system.

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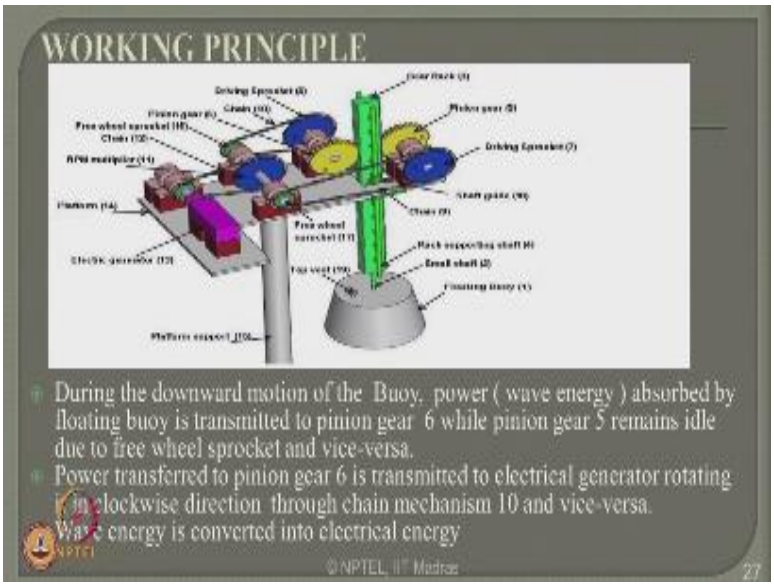

These are different components available in a given mechanism which we just now saw. It is interesting to note that during the downward motion of the buoy, the wave energy absorbed by the floating body is transmitted to pinion gear 6 while pinion gear 5 remains idle. On the other hand when the valve moves in the upward direction 5 is moved and 6 is released. So by the pinion flow motion or up angle motion of the buoy the gear is activated and the power is generated by a connecting shaft to the generator.

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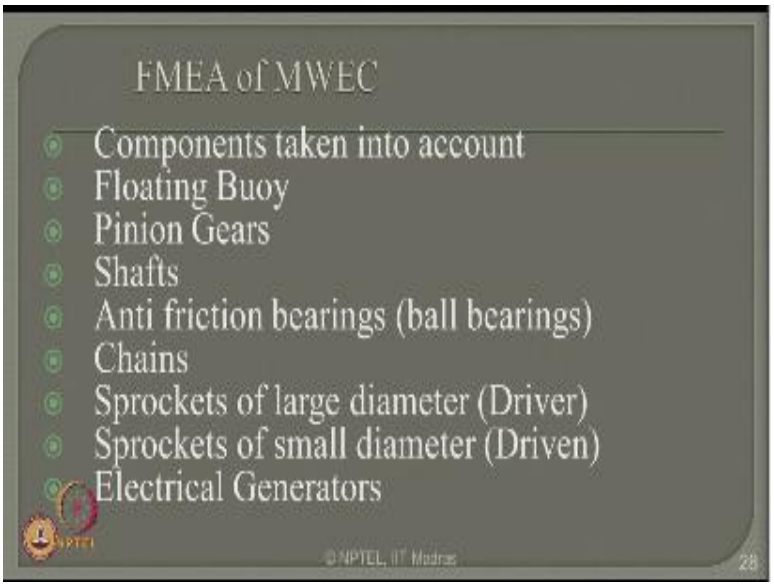

So what are the components you must consider while letting the FMEA for this physical problem, the floating buoy, the pinion gears, the shafts, the anti friction bearings, the chains, the sprockets, and of course the electric generators.

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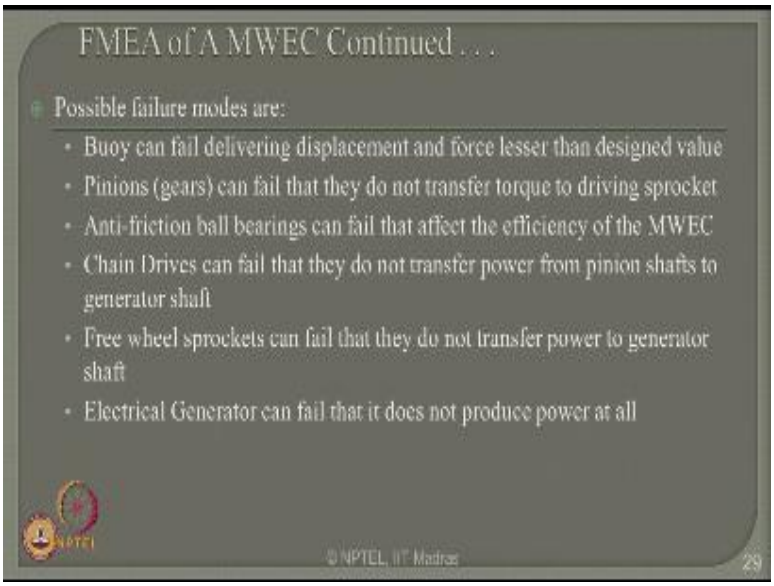

What are the possible failure modes one can identify the buoy can fail, the buoy may not move at all, the pinion gears can fail, the anti friction ball bearings can fail, the chain drives can fail, the free wheels sprockets can fail, therefore they did not transfer color for generator shaft or the electrical generator can fail because that does not decide in a RPM to produce power.

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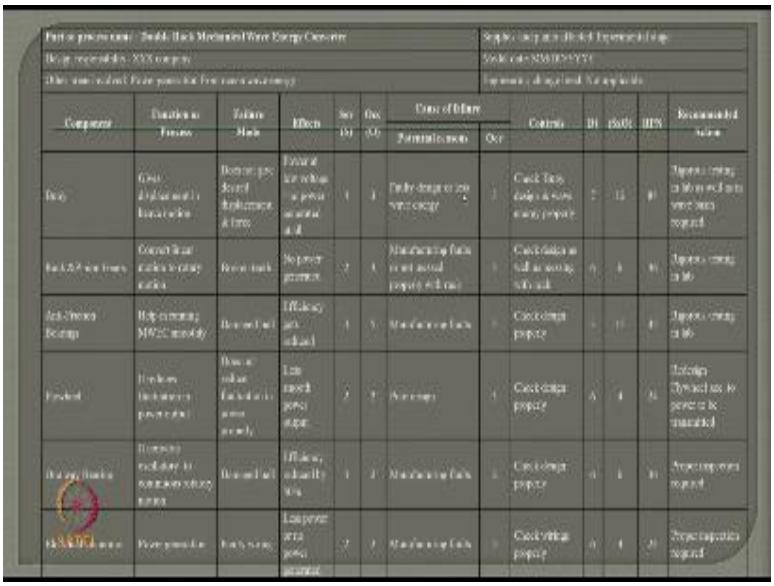

So when you identify the failure modes you can easily put them in a table of form like the component, what are the failure modes, what are the failure concept says in an overall function in the converter what would be the comment you suggest to improve the design. Now the design is improved and now you see it is a double wrap mechanical wave energy converter, developed at IIT Madras and take them to IIT Madras as an engineering design done by rosining department IIT Madras date and company or default, engineer level changed are not applicable.

Now the different components like buoy, back pinion, anti friction bodies, fly wheel, one way body, electrical generator. The functions are identified, the failure modes are detected, effects are shown on a scale of 1 of 10 severity and occurrence are given and subsequently risk quality number is created which gives me the most vulnerable component in a given system which becomes the buoy.

So if you do the FMEA analysis for a given component sets of a mechanical system, it is easy for all of us to understand how the failure will be sequentially initiated in a given system. Therefore, can always place the recommended actions, for example, in this case reverse testing is recommended in the lab in the scale model before the product is released for production.

Friends FMEA is one of the powerful interesting simple and basic tool to do risk analysis on working products before the product release for commercial production. I hope you have understood the lecture and enjoy the working models shown in the lecture which will initiate you to do such analysis for every product development at orient, thank you very much.

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