Failure Analysis & Prevention
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Lecture - 14
Industrial Engineering Tools for Failure Analysis: FMEA

Hello, I welcome you all in this presentation related with the subject Failure Analysis and Prevention. And in this presentation I will be talking about the Failure Mode and Effect Analysis.

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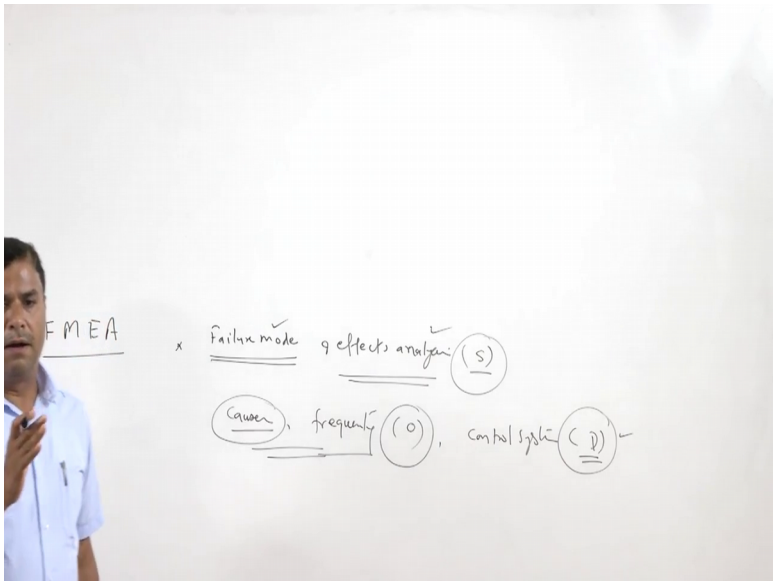

So, as the name appears the failure mode and effect analysis. According to the name we try to identify the failure modes and thereafter their effects are analysed. But actually the FMEA is much more beyond this means much more beyond the identification of the mods of failure and their effect on the functionality of the process or functionality of particular product or a software to see the ways by which it can fail or what will be the consequences and effects.

What it also analyses that causes which are leading to the particular failure mode and how frequently these will be occurring, so means the occurrence. So, the effect is analysed in terms of the severity and causes and the way by which these are occurring the different causes and the frequency of the causes is identified in terms of the occurrence. And ability of the system to detect the possibility of failure is based on the

control systems which are there with the product or with the process which is being considered.

So, we consider the detection levels for the possibility of the failures. So, apart from analysing the modes of failures and it its effects it also considers the causes which will be leading to the various failures through the different modes and ability of the system to detect the possibility of failure through different modes is also considered. And in combination of these three factors severity with regard to effect of a particular failure mode, the tendency of occurrence or the frequency of occurrence, and the ability to detect these three aspects are clubbed together actually in FMEA to see the things that should be given importance the kind of action which would be there in order to reduce the possibility of the failure of a particular process or the product or the software in which it is being applied.

So, this is the scope of the FMEA and if you go what is the failure mode failure mode is about the way by which or the ways by which a component assembly product process etcetera can fail to perform its function.

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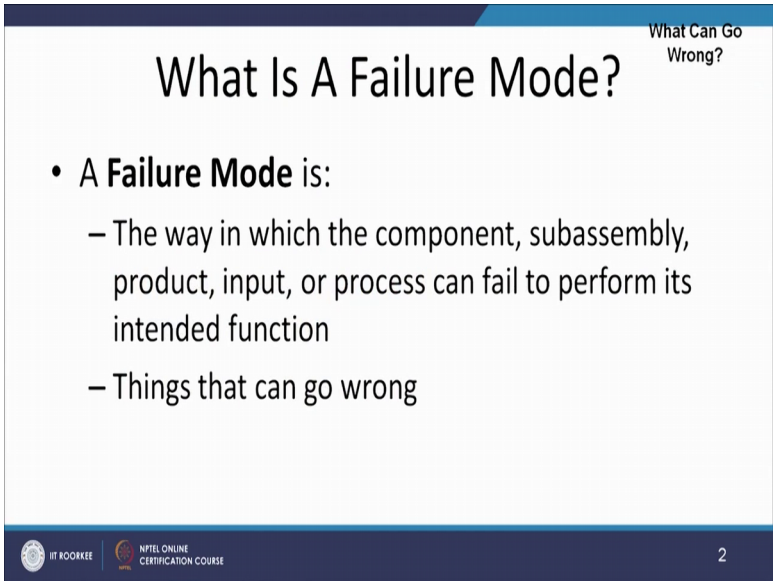

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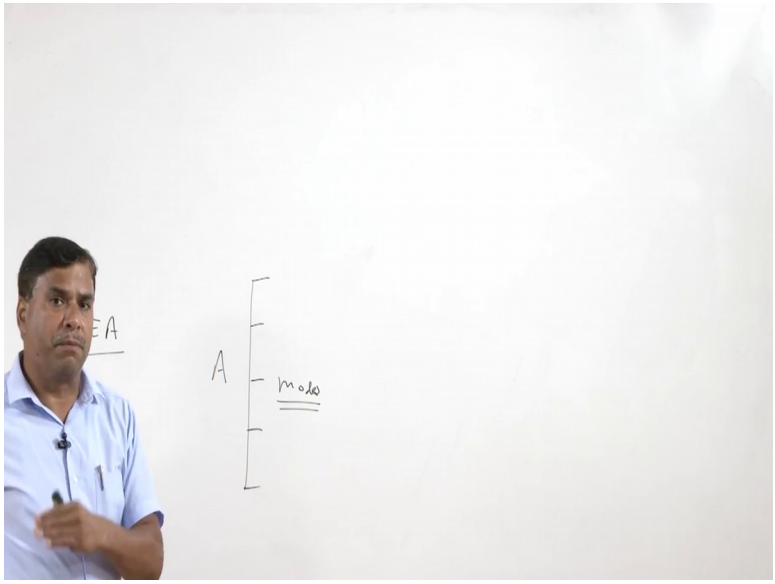

So, these are the different ways like there can be product A which will can have the tendency to failure through the different ways. So, all these will be termed as the failure modes.

So, we need to identify the various ways by which a product or process can fail or can do in different way than expected then it will be termed as failure.

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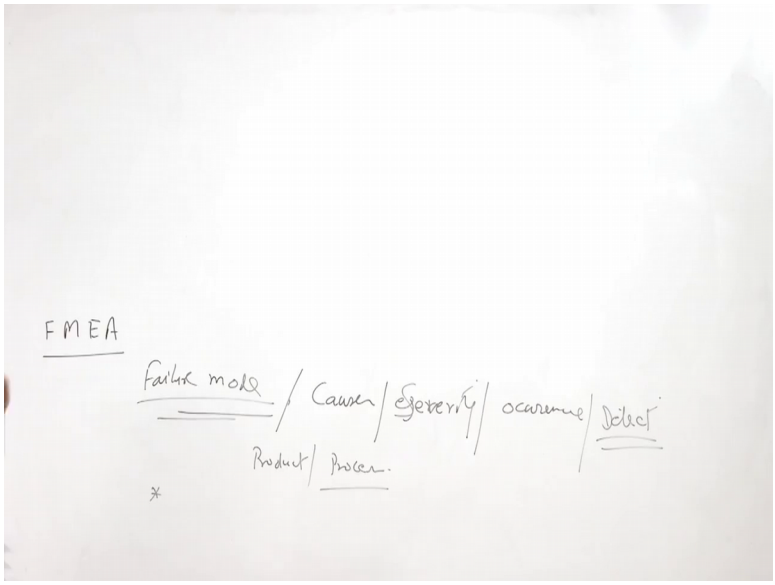

Mode; failure mode and thereafter what we have when the failure FMEA failure mode and effect analysis is applied either in a product or in a process it helps us in number of

ways through the identification of the failure modes and the related causes and their severity or the effect severity in terms of the effect and the frequency of occurrence and how easily or how difficult to detect their occurrence.

So, when these this approach is applied either any either for any process or for product then it will be leading to the certain benefits and these benefits may be in terms of the like the methodology of the means the FMEA facilitates the process improvement means if we are applying for in the FMEA is being applied for a process which means that it will be able to see what are the various ways process fail or what are the various modes of the failure for a given process. So, that we can identify what are the different aspects which must be taken care of in order to avoid it is the failure of the process.

So, when the FMEA is applied to a process.

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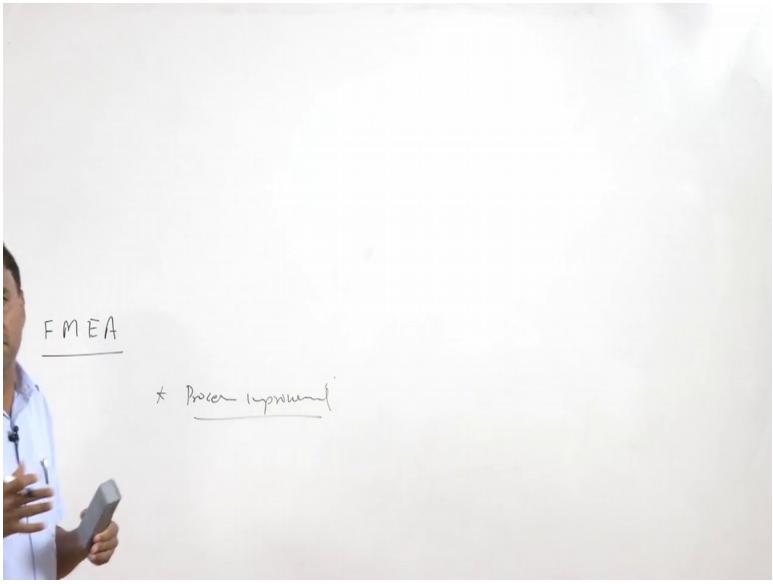

It helps in the process improvement means process improvement means it will be able to the process we will to deliver the things or the goods with much closer variation much lesser variation and more uniformity for the given kind of the product.

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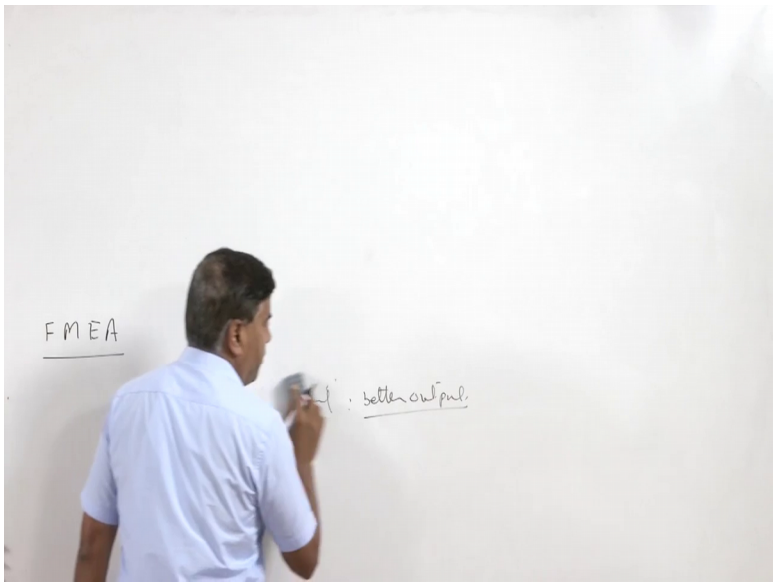

So, when the process is improved, it results in the better output and reduced rejection. So, yield actually with the process improvement increases the second thing which the benefits which is obtained say if it is applied for the product then the possibility for the failure of the product is reduced. So, it is always good that if FMEA is applied at the design stage. So, that it can take care of the various ways by which a product can fail and. So, the failure tendency for the product during the service is reduced and that in turn helps in improving the quality of the product and the customer satisfaction.

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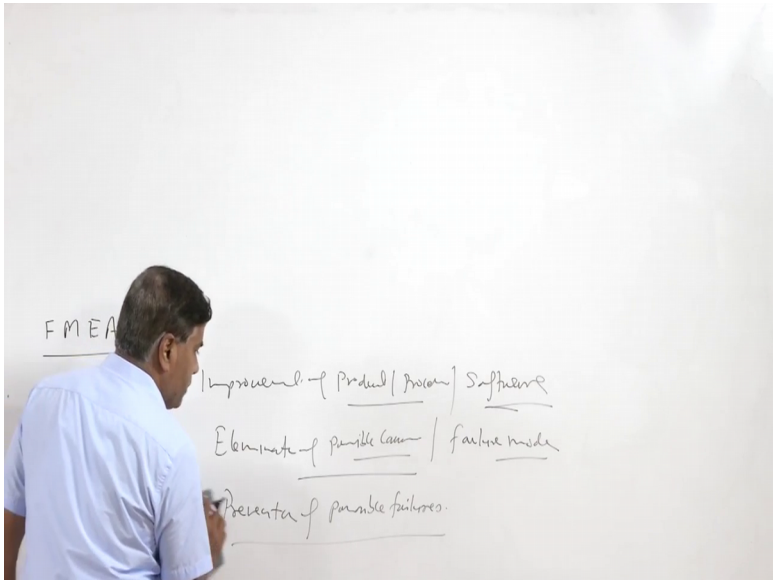

So, with regard to the failure, it helps in improvement of both products and processes when these are applied similarly if it is applied in the softwares. So, it will help in improving the quality or the way by which software can work during the service after the development.

The second thing it also helps to identify the various ways by which various causes which can lead to the failure of the product and processes. So, it helps in elimination of all possible causes which can occur which can be the reason for the failure. So, causes for failure modes are taken care of for a particular process or the product. So, once these are eliminated automatically over the product or the process or the software is improved.

And since in this case in this in FMEA we are eliminating the possible causes for the failure modes and which in turn leading to the improvement in product and processes and this in turn helps in preventing the prevention of possible failures prevention of the possible failure. So, this is; what is the dead benefit that possibility of the failure of the component is reduced because it helps in taking care of all possible failure modes through the preventive measures.

What kind of approach is used in failure mode and effect analysis there are certain very simple steps like whether it is a particular product or the process.

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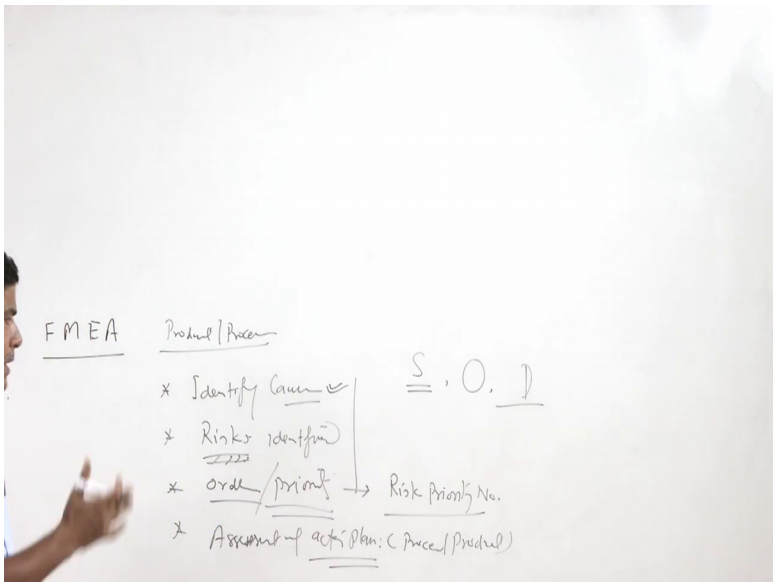

So, which is being considered for the FMEA then we need to identify the causes for various failure modes the various ways by which a product or process can fail.

And once if this failure once the failure occurs by one or other way then what are the risks associated with. So, risks are identified and established if failure of one aspect is not having very high risk then it may not be important to take care any big step to rectify that maybe there may be some other the modes which may require higher priority as compared to others where risk is less. So, high risk failure modes are preferred over the low risk. So, risk is analysed risk associated with the failures is identified.

And then when we have the causes means the different failure causes different leading to the different failure modes and the related risks have been identified this can help us in identification of the order of order in which action is to be taken order means the priority in which action needs to be taken.

So, this is basically achieved in terms of the risk priority number for each failure mode risk priority number is determined and the failure mode having the higher risk priority number that is given higher priority as compared to the others which will be having the lower priority with regard to the possibility of these things higher risk associated with the failure in terms of the severity the tendency of the occurrence more frequently occurring failure modes will be given higher priority. Similarly, the detection possibility if one failure mode which can easily be detected may not be given higher priority as compared to others which will be difficult to be detected before the occurrence of the failure.

So, it FMEA also helps to prioritise our actions and the locations where the effort should be placed in order to reduce the possibility of the failure and apart from this it also helps in assessment of the assessment of the action plan if something has been implemented in order to reduce the possibility of the failure reduce the risk associated with the failure.

So, this assessment for both process and product can be done to see up to what extent there is a change in the possibility of the risk priority number means what is the change in risk priority number after implementing the action plan in order to reduce the failure modes and reduce the possibility of failure through the preventive measures.

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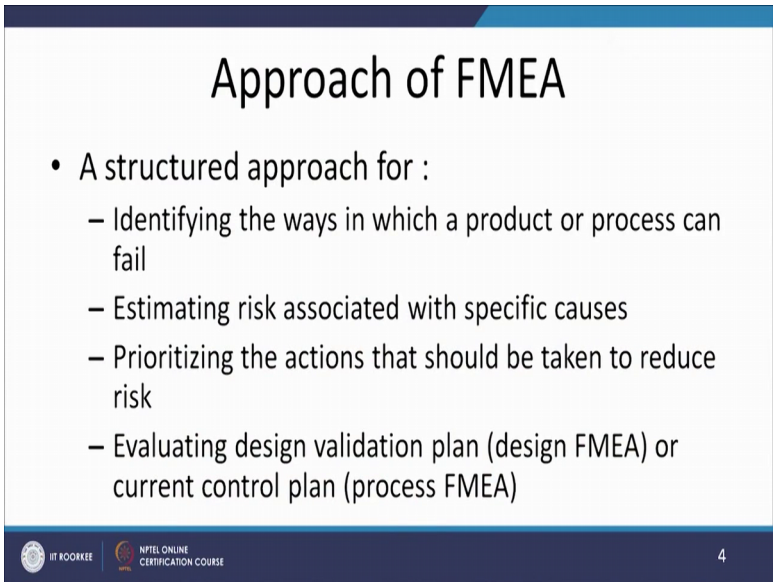

So, this is broadly approach it helps in identifying means in FMEA we try to identify the various ways by a product or process can fail what are the associated risk if the failure is occurring and what and how to prioritise the different actions that need to be taken in order to reduce the possibility of the failure. And if whatever actions have been implemented to see their validity and to see their effectiveness this helps in taking the further corrective actions to see the way by which we can reduce the possibility of the failure.

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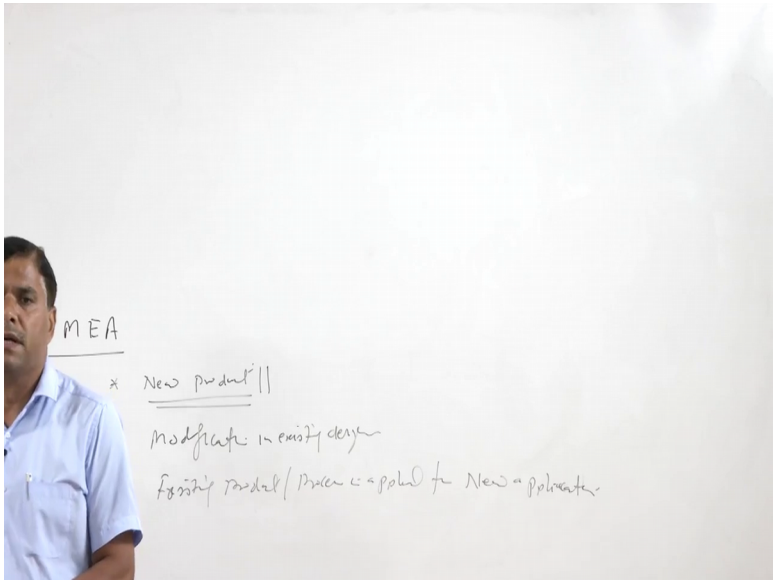

Then when to conduct this kind of FMEA; so the one possibility is that either or new product is to be developed. So, when a new product is being developed we need to see; what are the various ways by which a product can fail. So, if that is explode the different ways and the possibility of the severity possibility of occurrence and the possibility of the control systems is a checked closely to see whether will be able to detect the failure tendency or not what will be the possibility of the occurrence for a particular failure mode and what are the various causes which can lead to the different types of the failure modes. So, that then these features can be incorporated in such a way that new product will have the minimum possible failure tendency.

Second is that when the new design or new product is to be made second is when the modification is made in the existing design modification in existing design third is the when the existing product or process is applied for new application means a product or process may have very good record of the performance in one set of the conditions, but when it is applied for the different set of conditions we need to again relook into the way by which the given product can fail under the new set of the service conditions or in new set of the applications.

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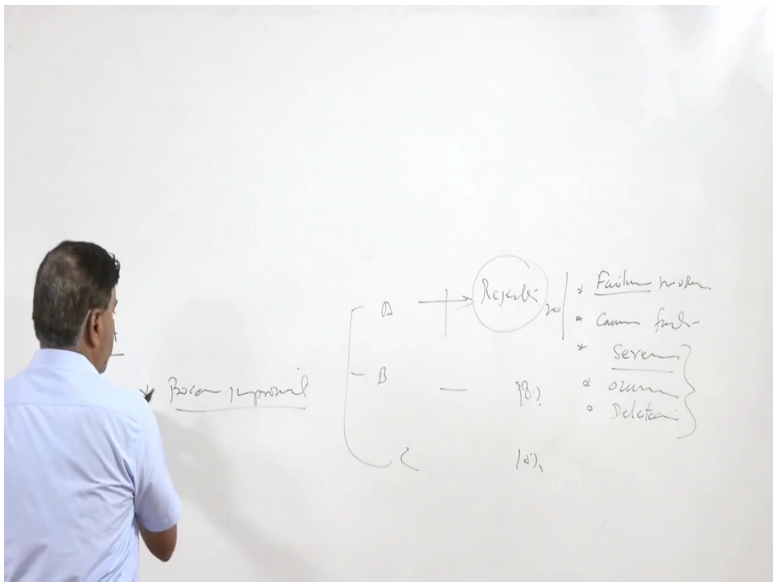

So, these are the three ways there is one additional way when the given process is to be improved like process improvement is also one of the possible areas where we know like there are if say a B and C processes and they are having the different rejection rates like

20 percent, 18 percent, 18 percent and 10 percent. So obviously, the process which is offering higher rejection rate will be the candidates one.

So, we need to investigate the various ways by which the failure of the process is taking place and leading to the higher rejection and this is one and then what are those causes what are the different means the different failure modes and these are being caused by the different factors. So, what is the possibility of related with the severity for the different failure modes possibility of the occurrence and possibility means the kind of detection level which is available for the different kind of the causes. So, these are clubbed to see what can be done actually to reduce the rejections so that the process as a whole can be improved.

So, the process improvement product improvement or application of the existing product to the new process or the improvement of the existing product or the process or the 3 or 4 possible areas where FMEA can be effectively applied for reducing the failure tendency and increasing the service reliability and the way by which product will perform during the actual service.

So, for FMEA one particular what you can say the form is used for the purpose of analysis basically this form involves.

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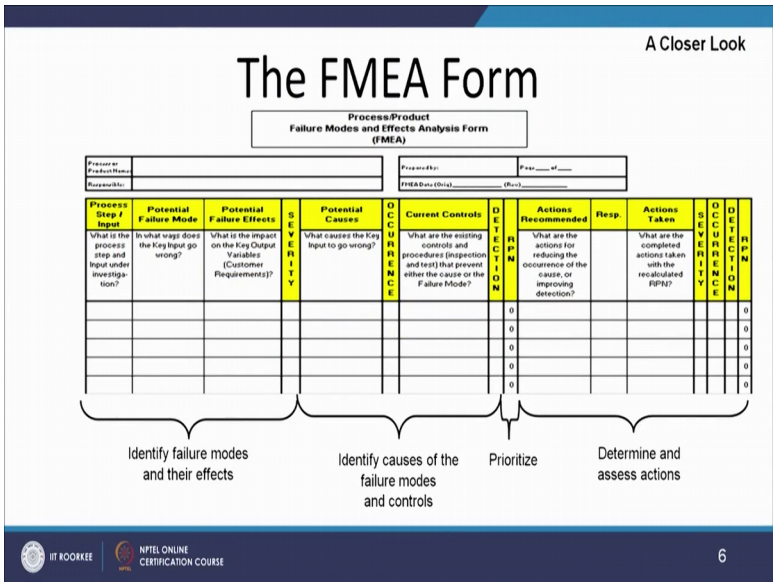

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The detailing of the which product or the process function is being considered there can be different parts of a product or then there can be different steps of the process like A B C and then we need to see in which what are the various failure modes for each of the part or each of the step of the given process.

So, failure modes are identified for process a for process B for process C or 4 part a part B part C of a particular product and after this failure modes we try to identify the effect what if the failure occurs. So, effect is identified due to the if the failure of a occurs due to due to the mod x or mod y, what will be the effect and what will be effect if the, a fails due to the mod y what will be the effect.

Similarly, if the B fails due to the different causes what we will be their effects. So, the different failure modes and the effects are identified and after this. So, of course, this is not the job of one person we need a team. So, basically this is the team based approach where we will be having the representative of all those people who will be concerned with a product or who will be concerned with the process like if it is a product there may be design engineer there may be manufacturing engineer material engineer dealer customer supplier all these people who are all those people who are concerned with the product or with the process will you brought into the team. So, can they so that they can give their inputs for the different aspects related to the failure modes and their effect when their failure occurs and thereafter we have to identify the severity level.

What will be the level of severity when A fails, when B fails and when failure of the C occurs. So, this severity level is identified and after identifying the severity level we try to determine the causes for what are the causes due to which fail the A will be failing what will be the causes due to which the B will be failing and what will be the causes due to which C will be failing. So, all these causes for each either step of the manufacturing process or parts of a product are identified.

And then after identifying the causes we try to see the occurrence is about the frequency of occurrence or frequency of higher is the frequency greater will be the occurrence. So, occurrence of a particular cause what is the possibility of a frequency for occurrence of a particular cause that is identified. So, E for each cause the occurrence is identified which will be leading to the failure of A or B or C.

Thereafter, now we have the control systems identifying the controls system or the detection control or we write the control what kind of the mechanisms methods we have in place. So, that the different causes leading to the failure of A are prevented what kind of control and control systems and the mechanisms we have. So, that it can detect the possibility of occurrence of the causes leading to the failure of the B. And similarly the possibility of occurrence of the causes how effectively it can be detected so the controls systems and the mechanisms which are there in place which will see the possibility of occurrence or particular kind of causes leading to the failure of C.

So, those are control systems basically are identified like in the in the pressure cooker if the pressure cooker can burst. So, before that we put in like safety wall. So, safety wall is one kind of the control system before the bursting of the pressure cooker takes place we the safety wall fails. So, this is one kind of control system.

Similarly, we have like in automobiles also we have different indicators if the speed goes beyond the limit we reach the red region. So, likewise there are different kind of control systems as per the product and the processes after this control system. So, we try to mention the ease of detection try to assess the ease of detection how easily the possibility of failure for a can be detected how easily the possibility of the failure mode for the B component or B step can be detected and how easily C can be detected. So, that is what is identified through at the detection level.

What we have to see here severity S occurrence O and detection D is to be qualitatively identified by the team. So, all these 3 severity occurrence and the detection level are identified either in scale of the 1 to 10 or in the scale of one to 5 it is always good to choose the wider scale. So, that we can have much of better flexibility to rate the different factors. So, severity is rated say in this particular example if the severity is high will rate 8 and if the occurrence possibility is moderated then we will rate 4 and if the detection possibility is difficult its easy difficult to detect then will be the rating high. So, high rating when the detection is difficult and low rating when detection is easy high occurrence possibility then will be rated high and if it is moderate or low then will be rated less like one.

So, similarly for say for an example severity for the B is 4 occurrence is 6 and the detection level is 2 if it can be easily detected then the failure can be easily be taken care of then C say for 5 4 and 3. So, once we get all these data about the ease of detection less easy to detect means it will be rated high and very easy to detect will be rated less a high possibility of occurrence it will be rated high and low possibility of occurrence then it will be rated 4 similarly high severity high number.

So, now product of all these 3 is achieved. So, here severity multiplied by the occurrence multiplied by the detection and product of this 3 will be leading to the 8 into 4 into 8 and here, it will be like for into 6 into 2 and similarly 5 into 4 into 3. So, it will it will be 60 and here 48 and here it will be much larger like 32 multiplied by 8, so 6 and 2 1 4, so here 256. So, this is too high value.

So, if we consider the different the parts a part or a step of manufacturing process will have the higher risk priority number. So, means this should be given the top priority in order to in order to avoid the possibility of the failure and thereafter once this is taken care of it will be this one which should be taken care of. So, likewise we are able to prioritise the particular part we are able to prioritise the particular step of manufacturing process in terms of the kind of severity which will be there if the failures occur.

And in times of the in terms of the occurrence and in terms of the ease of detection this risk priority number this is basically called risk priority number RPN this is what is identified. And once if it is there with us it will be will help us to see which one is to be taken care of first and what are those causes we should be taken care of because if we

know these are the causes because of a was failing. So, we need to take the corrective action to take care of these causes so that the possibility of the failure can be reduced.

So, this is what I have already talked the kind of team that we need for the failure analysis its team based approach.

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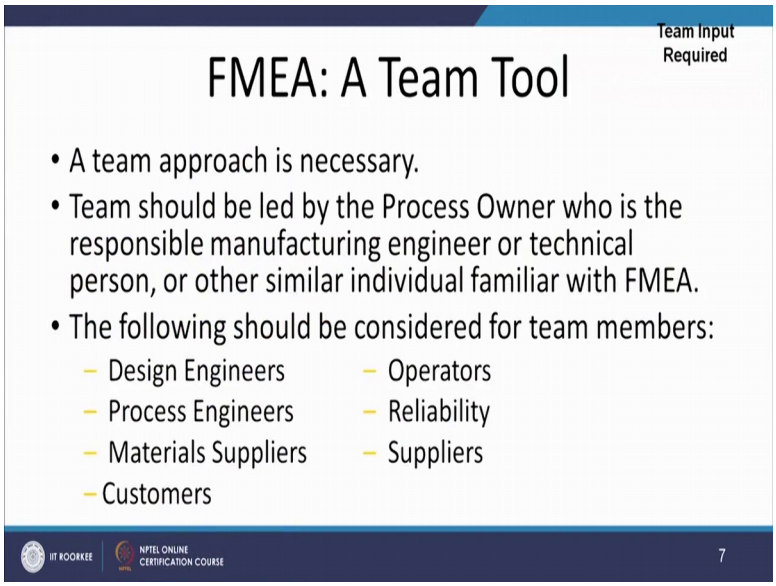

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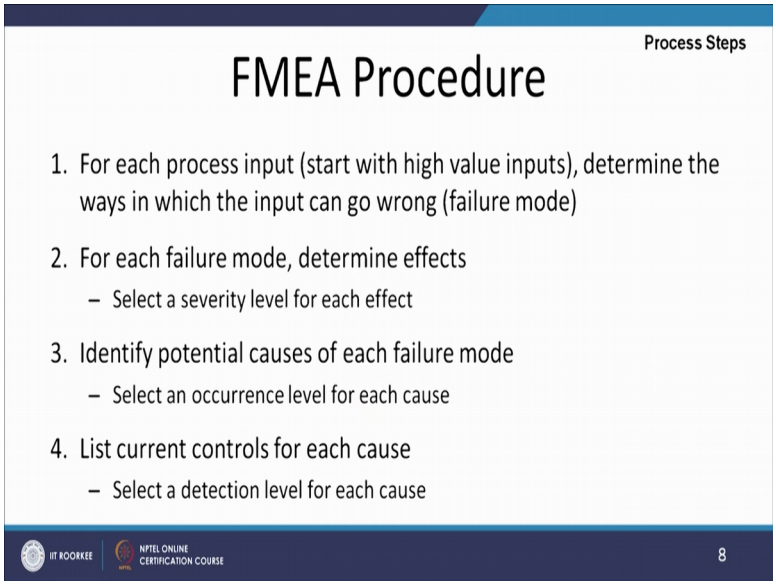

And those who matter for the product or the process must be brought into the team in order to carry out the FMEA procedure of the failure analysis is simple one wherein for each input function, we need to identify the ways by which things can go wrong and then

we try to determine and the different failure modes and the severity for each severity level for the each effect which will be there due to the failure and then potential causes for the failures are identified and there occurrence level is determined. And thereafter, we also try to see what kind of control systems we have to detect the possibility of the failure. So, the detection level is also identified.

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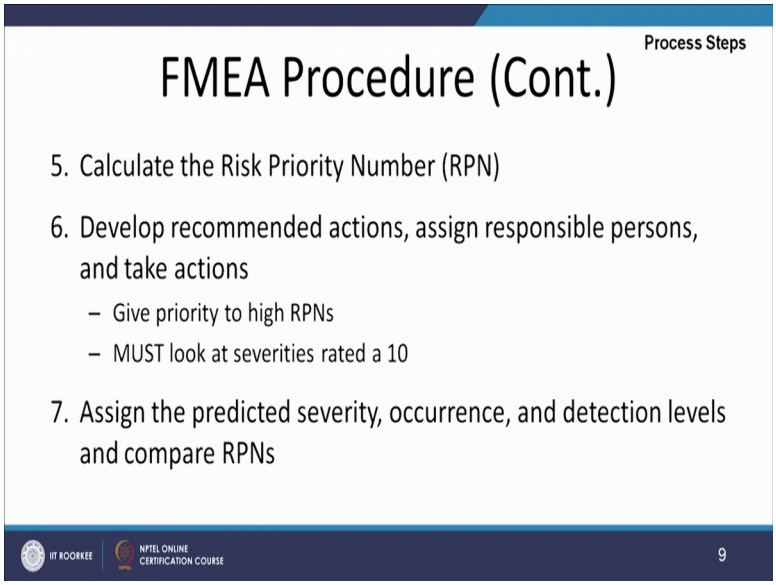

And based on these 3 the severity occurrence and detection level we determine the risk priority number and based on that we try to develop the recommendation for the actions on the different aspects that should be taken care of in order to reduce the risk priority number for the different parts and different steps and once the action is taken we again try to repeat the same thing in order to find the kind of change in RPN is taking place, so that the further corrective action can be taken in order to avoid the possibility of the failure.

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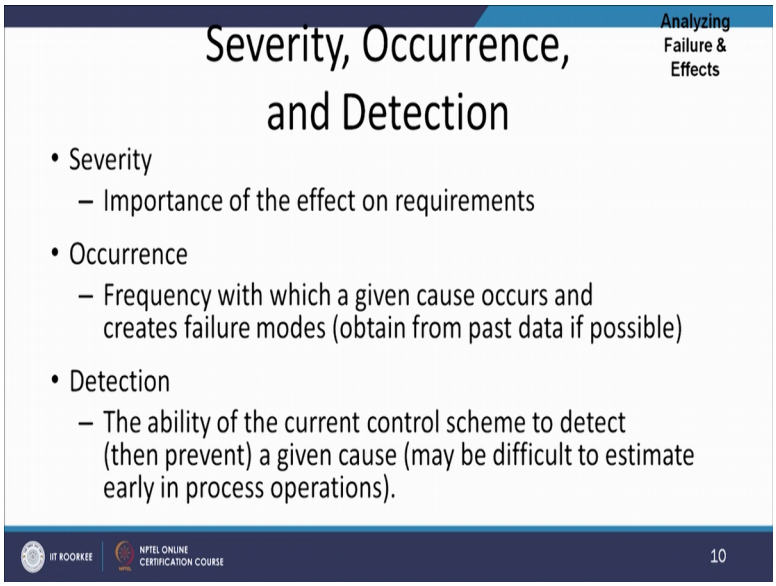

So, this is what is there in like severity is about the importance of the effect on the requirements if the requirement is very adversely effected by a particular product or the process then it will be rated high and occurrence if it is high like frequency with which given cause can occur if it is high, then it will be rated high rating will be given and this will be based on this can be based on the possibility of the means the data from the history of the product.

And detection level is about the ability of the current control is scheme to detect and then prevent the given cause and it may be difficult for especially when the new process is being developed or new product is being developed because we may not be sure really.

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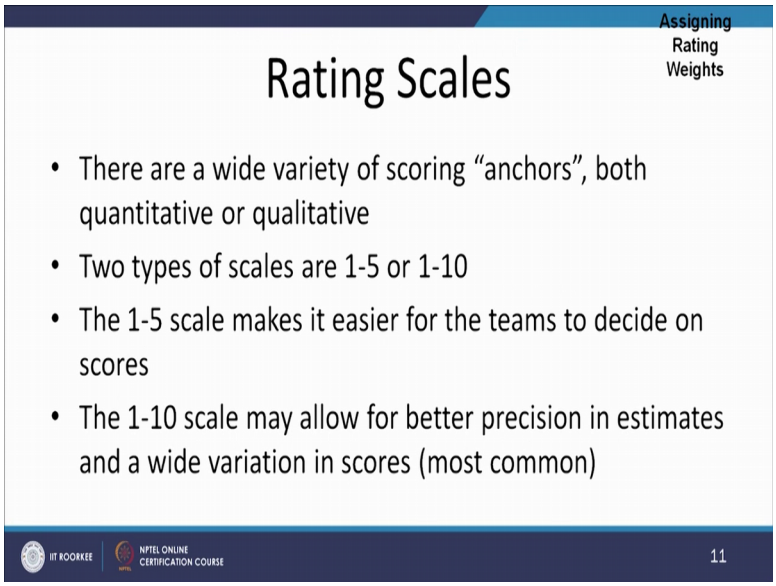

What are the ways by which it can go wrong?

And then the rating is scales as I have said the 2 types of the rating scales are used one to 5 or 1 to 10; 1 to 5 scale is easier for the team to work when, but it of the larger scale offers the much better precision in terms of the flexibilities and the kind of ratings which can be given.

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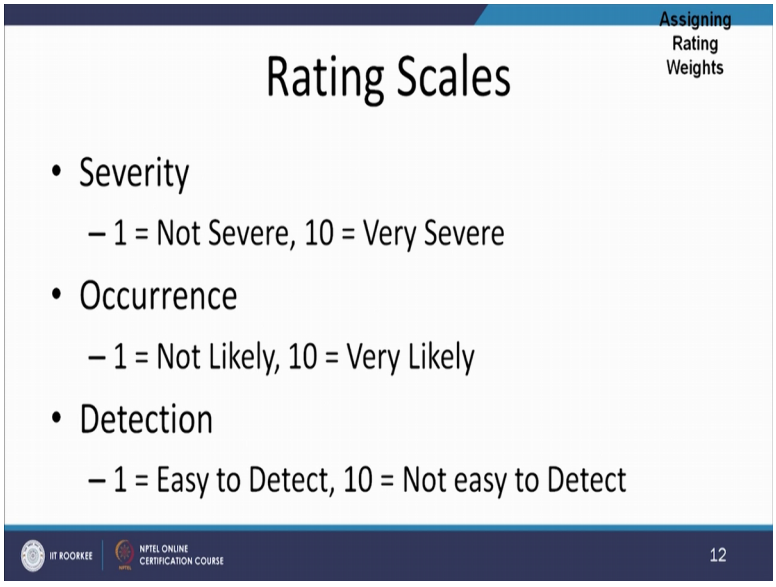

And then just to reiterate severity rated is as 1, if it is not severe and rated as 10 it if it is very severe similarly occurrence 1 not likely and 10 for very likely. And similarly, the detection level very easy to detect one and not easy to detect like then ten rating is given.

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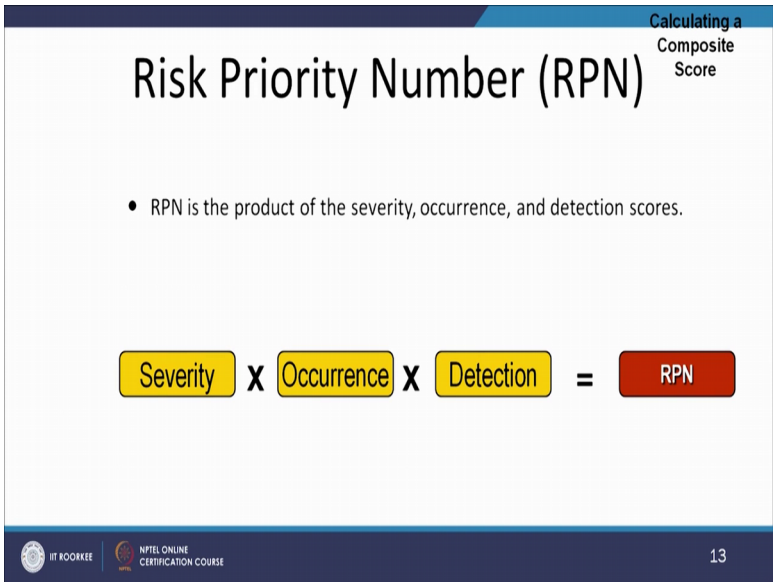

So, this is how risk priority number is obtained wherein severity multiplied by occurrence multiplied by detection this gives us the risk priority number.

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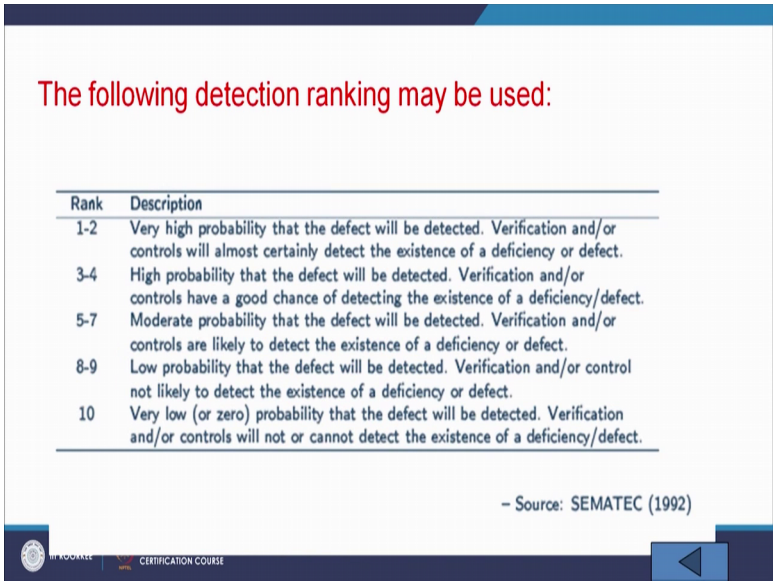

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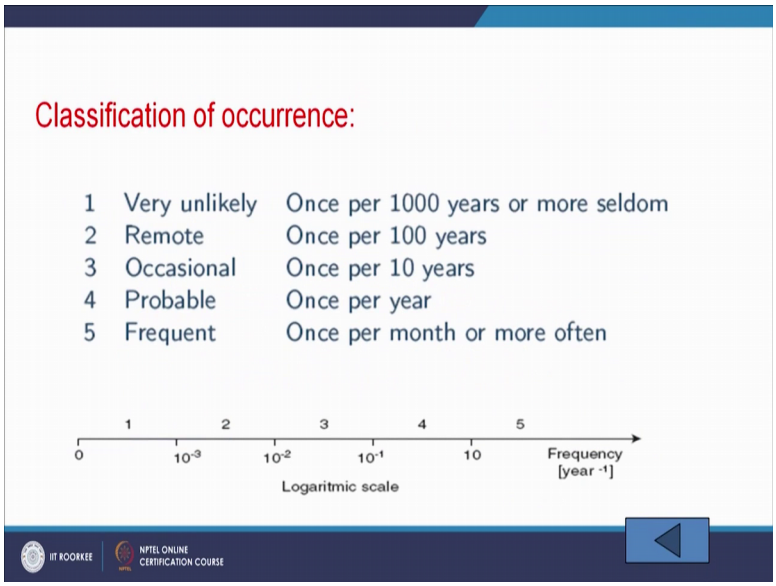

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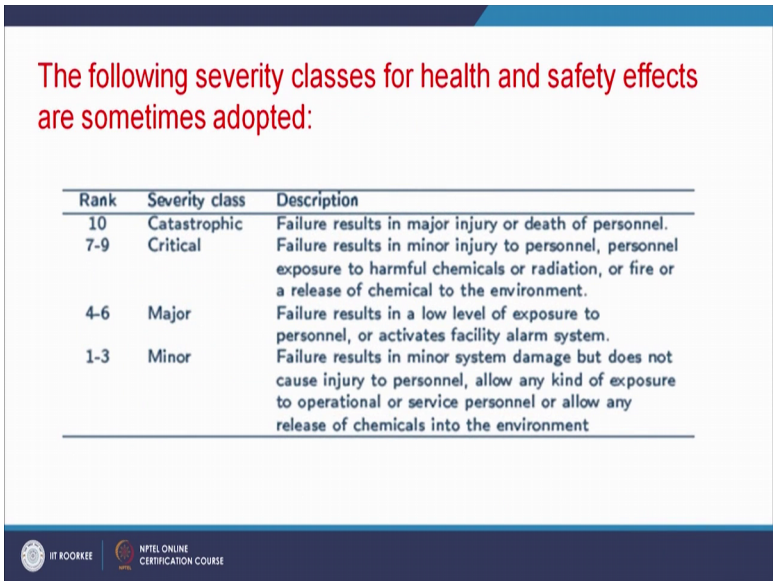

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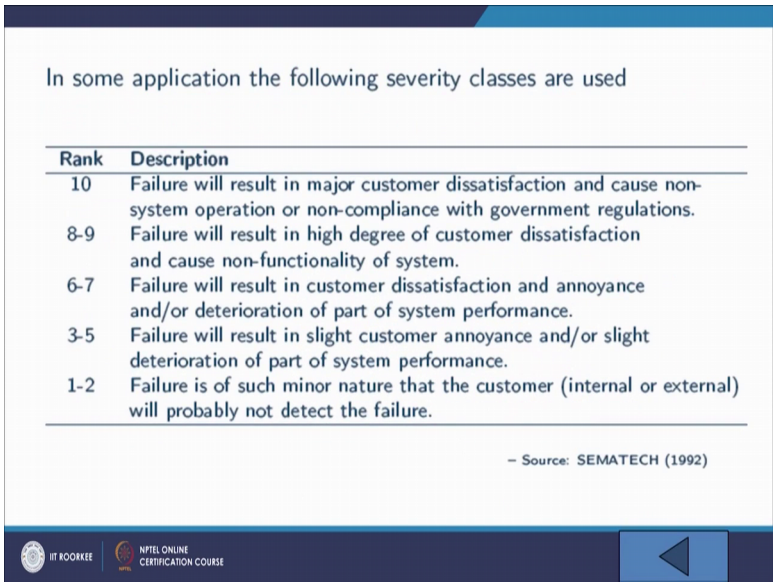

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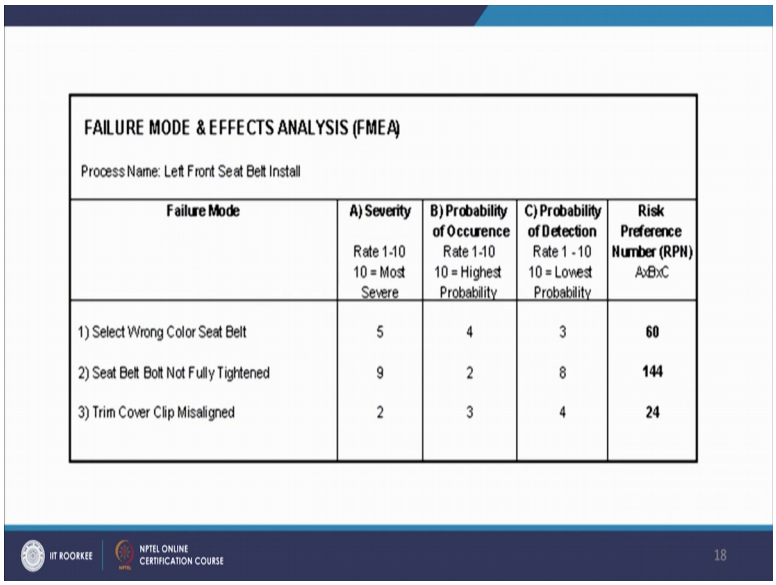

Now, I will be talking about one particular like example here this example is basically related with the front seat belt installation. So, the one function is like select the wrong colour seatbelt severity because of this is a moderate. So, it is 5 and the possibility of the occurrence is also low. So, it is 4 and the probability for the detection is also I means the possibility to go wrong means to select wrong colour is also less. So, 3 rating is given and the RPN is coming 60 seatbelt bolt not fully tightened if it is not fully tightened then risk is high because the possibility of the injury in case of the seatbelt. So, severity is

high and the possibility of occurrence is less. So, it is rated two, but the kind of the tightness which is there is difficult to detect. So, it has been rated high like 8.

Similarly, trim cover clip misalignment the kind of misalignment possibility the severity related with this is less occurrence possibilities less and similarly the detection possibility it is easy to detect if it is misaligned. So, again the risk priority number for the third factor is 24. So, if we see these among these the second needs more careful attention about especially about the tightening of the nut bolt, because its detection is difficult and the severity is high.

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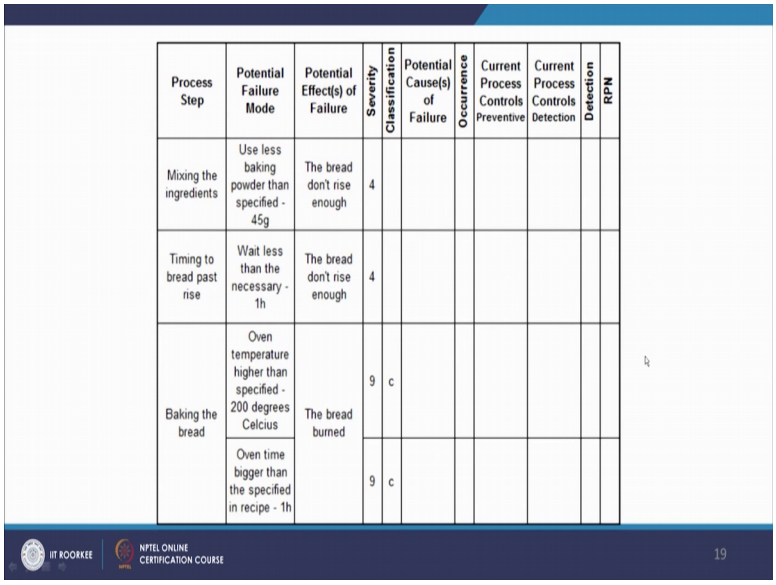

So, this one is to be taken care of first say likewise there can be many other examples for applying the FMEA approach.

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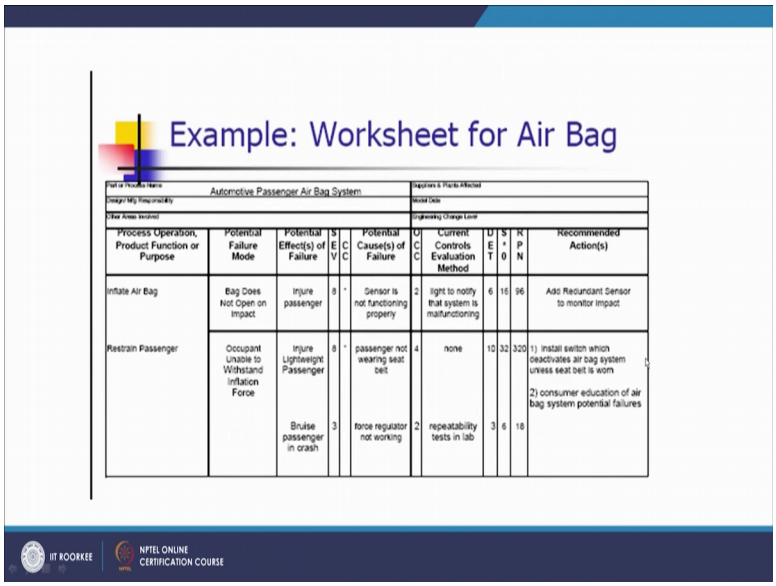

Now, here I will summarise. In this presentation in this presentation I have talked about the basics of the failure mode effect analysis, when it is to be applied, what are the benefits of the FMEA, and the what are the procedural steps for carrying out the FMEA for a product or the for a process.

Thank you for your attention.