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NPTEL ONLINE CERTIFICATION COURSE

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

Module 1
Safety assurance and assessment
Lecture 11
Hazard Analysis techniques

Dear friends today we will talk about the 11th lecture on module 1 where our objective ways to focus on safety assurance and assessment in this lecture we will talk about hazard analysis techniques this is online course on HSE IIT Madras based of NPTEL IIT Madras.

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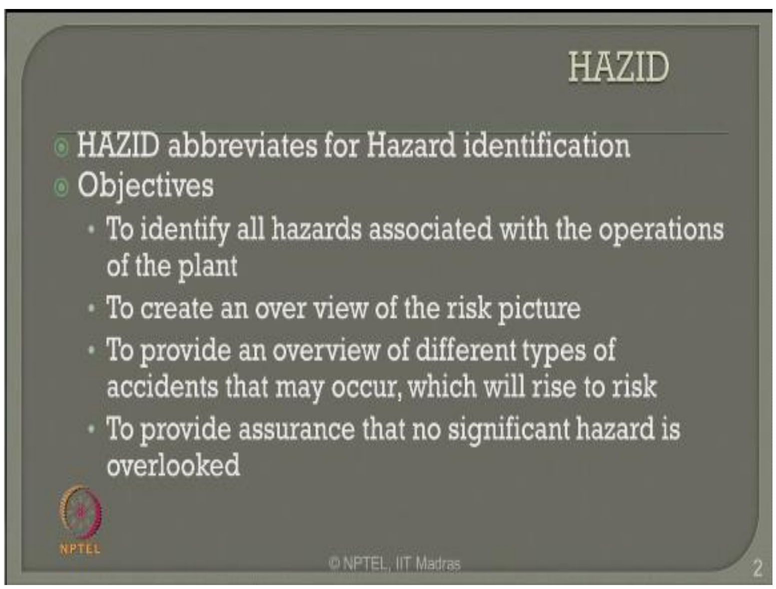

The movement we talk about hazard analysis procedures the fore most idea which comes in mind as an important analytical tool is HAZID. HAZID abbreviates for hazard identification the principle of that is of any HAZID study are the following to identify all hazards associated with the operations of the plant to create an over view of the risk picture.

To provide an overview of different types accidence that may occur which will rise to given risk to provide assurance that no significant hazard is over looked friends as it has got very primary focus in preparing such analysis it essentially ensures that no significant hazard is over looped so HAZID is nothing but identifying hazards there are many methods by which an HAZID report can be carried out you have to conduct service you must interact with people working on plant you should try to know what are the different factors that are associated with the hazards scenario in the given product unit and based on that you can prepare an HAZID report.

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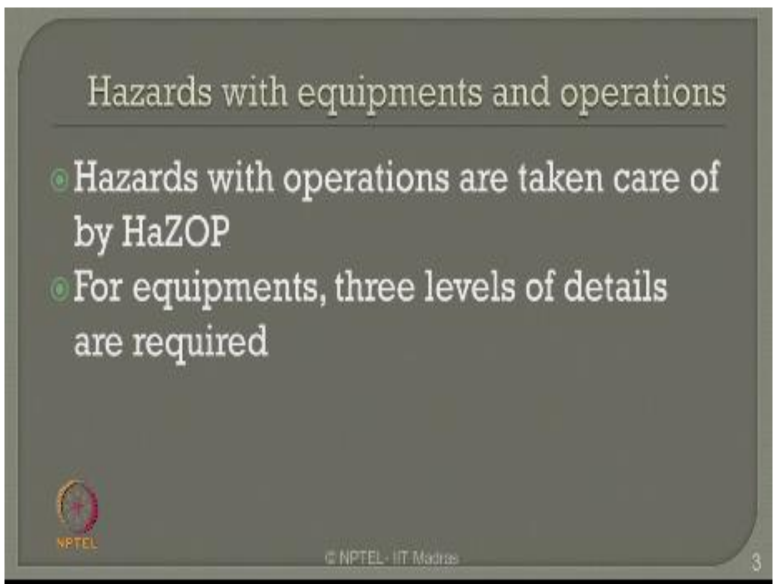

Now there are of course hazards associated with different plants and equipments and of course there are hazards during operations of any given process plant oil gas industry is no emission on this hazards with operation are generally taken care of by a detail study call HaZop we have already seen some details of HaZop study in the last lecture in this present lecture I will take an example case study and I will explain you how HaZOP report can be prepared for a case study applied to oil and gas industry. When we talk about equipments where we want to conduct hazard analysis for equipments.

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The three levels are the equipment level, the subsystem level and the system level in equipment level generally all equipments valves instruments are identified separately as possible hazards individually in a subsystem level all subsystems such as separation stage compression stage are identified separately as possible hazards please understand at equipment level and subsystem level they are independent and they are local in system level we globalize them interconnect them such as electrical mechanical and instrumentation hazards.

So electrical mechanical and instrumentation hazards can include subsystems related to operation compression separation stages etc… they of course also include equipments related to valves instruments electronic equipments etc…so system level is an integration of hazards in subsystem and equipment level together but there are scenarios there are different advantages metric and insides of different levels of hazard analysis let us quickly see what are they so let us ask a question what are conman problems with such divisions of doing hazard analysis.

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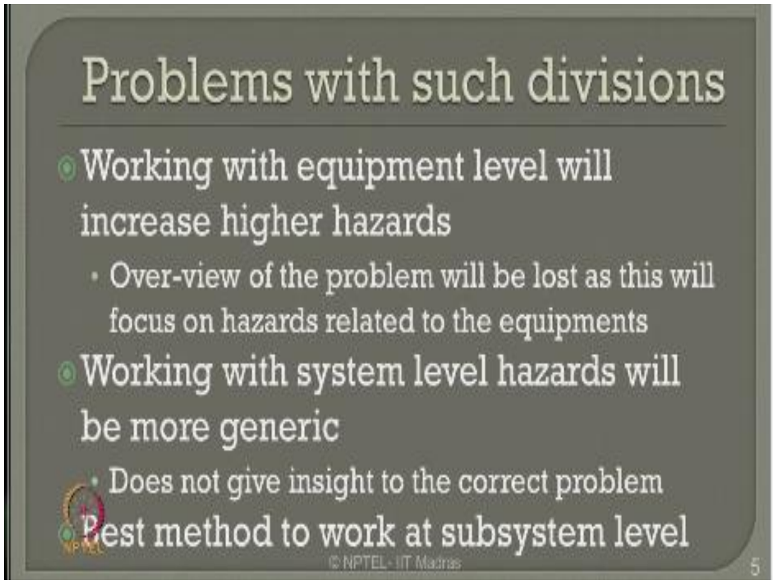

If you talk about hazard preparation or hazard analysis only with equipment level you will understand that this kind of hazard analysis generally increases hazards in higher rate essentially because the over view of the problem will be lost as this will essentially focus more on problems are hazards related to equipments so hazard analysis and equipment level is a micro level study where the focus is on the mechanical component the working components of an equipment alone where as interaction of a man machine interface is to detail sited in HaZOP analysis or hazard analysis done at equipment level.

When you talk about system level let us say the next level working with system as some problems regards the hazards in this particular level of study will become more generic therefore these kind of studies of hazard analysis done at system level as they are globally connecting both equipment and sub system level they will generally give detail inside to the correctness of the problem now there are three levels of hazards one can locate one is the equipment level which as got difficulties in micro focusing working of the equipment are components alone.

The other is system level which is more generic and more higher order therefore it does not give inside to the correctness of the problem the left over is the sub system level which is the best method to work in hazard analysis.

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One can ask a question in the given hazard analysis scenario what would be consider as the most difficult part the most difficult part in hazard analysis is essentially identical a significant hazards that arise from the process it is very difficult friends to more really that hazard scenario that arise from the process. There are many reasons for this fundamental reasons are there is a tremendous variation in the operational temperate pressure at which the process plant works therefore any variation in the pressure temperature etc…

During the process stage can result in significant hazards which is very difficult 4C unless otherwise you have an experience in such process plans so the most difficult task are the part in hazard analysis is to identify the significant hazards the arise from the process therefore the answer to this problem is to do a structured analysis which will help to achieve this mandate.

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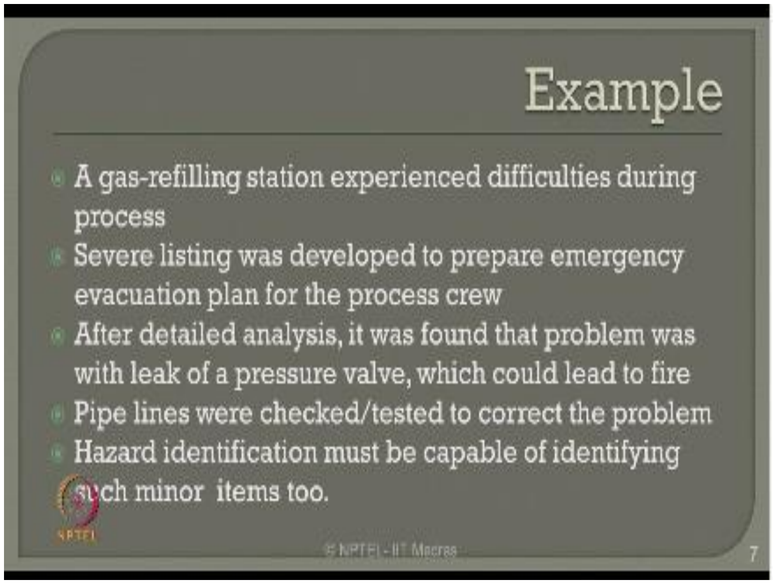

Let us ask quickly an example question let us say a gas refilling station experienced difficulties during a specific process severe listing Was developed to prepare emergency evacuation plan for the process crew this depends on the experience of the people working on both based on the near miss events in the recent past a severe listing was developed which result in an emergency evaluation plan in case of any hazard satiation arising in the rifling station now after detail analysis it is interesting for you to know it was found that the problem was with the leak of the pressure valve which could lead to fire

Now dear friends you please understand the emergency evacuation plan prepared for the process crew focused on experiences and difficulties that are faced by the personal in a refilling station but a micro level problem of leaking of a pressure valve was not focused which was not in attention at all in the whole study which could lead to fire.

Therefore a pipeline has subsequently checked and tested to correct this problem and if this simple illustration one can easily understand that hazard identification during a process like identifying a leak in front of a pressure valve because pressure valve will have a leak only when the pressure crosses is specific threshold value of the valve. So this is process related problem so hazards identifying during the process is very difficult and there is rather the most difficult task in an hazard analysis. So hazard identification therefore must be capable of identifying even such minor details also there is a success of any hazard analysis technique.

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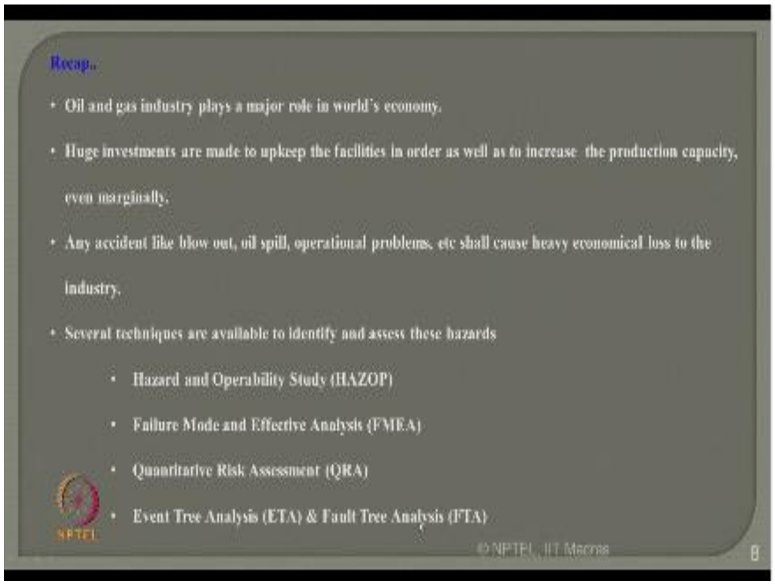

Now let us quickly ask a recap, how hazard analysis becomes important for oil and gas industries? Oil and gas industries play a major role in worlds economy, huge investments are made up keep the facilities in order as well as increase the production capacity even marginally any accident like blow out, oil spill, operational problems shall and has resulted in any economic loss to the industry and to the economy of the country.

Now there are several techniques available in the literature to identify and assess theses hazards, remember these are all techniques which enable you to first identify and then assess mathematically the hazards present in a plan, remember hazard and risk are different, hazard is a scenario risk is a materialization of the scenario, so what are the studies available in the literature for identifying hazard and assessing them.

In the list the top is hazard and operability study which we call as HAZOP followed by which focusing on mechanical equipments people also do failure mode and effect analysis which is abbreviated as FMA of course there are quantitative risk assessment methods QRA tools available to also do as an analysis, Even tree and fault tree methods are also one of the methods for hazard analysis, we will see all of them in detail in subsequently in different lectures on this module.

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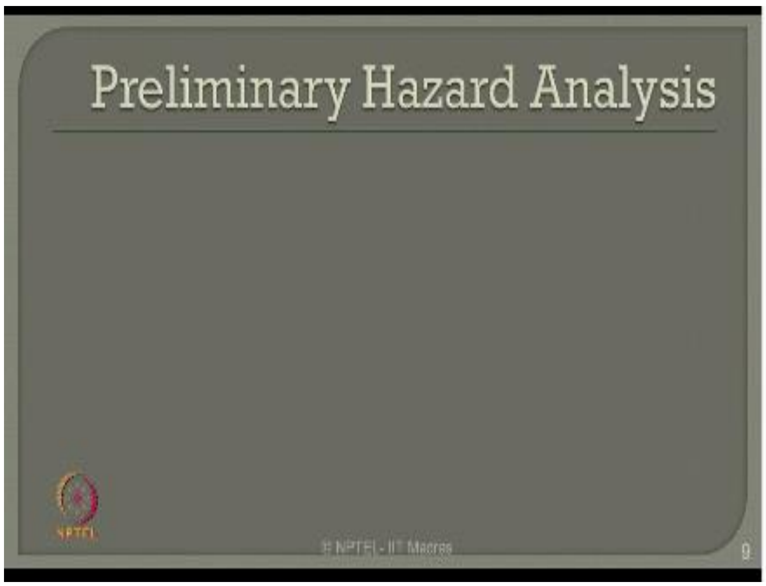

When we talk about preliminary hazard analysis because any analysis has got a preliminary and little stages of analysis let us talk about preliminary hazard analysis.

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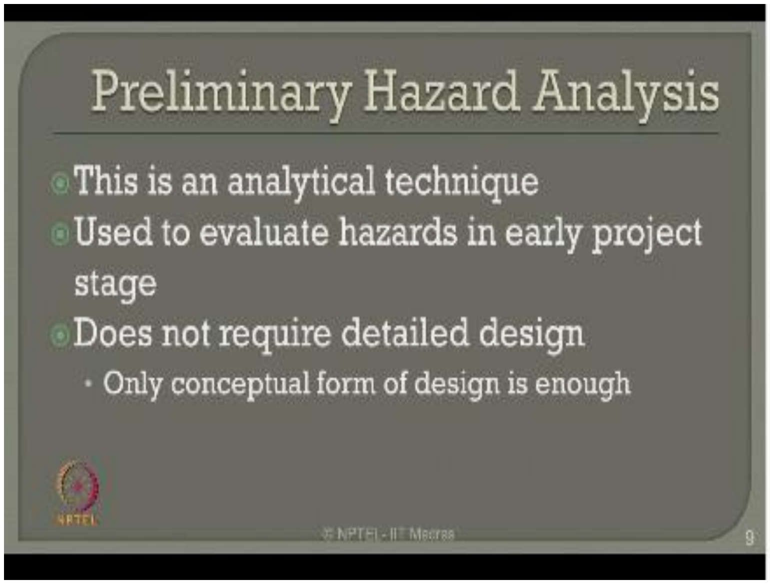

This is an analytical technique which is used to evaluate hazards in early project stage so preliminary does not add to the hazard is preliminary it is only the stage of a project which is early therefore it is preliminary, it does not require of course a little detailed design only conceptual form of design is enough to carry out preliminary hazard analysis.

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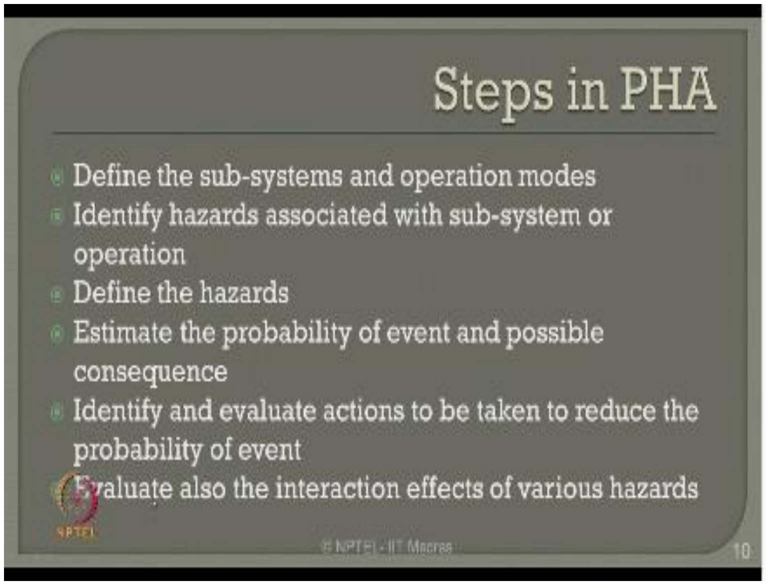

Now what are the steps involved in canning about preliminary hazard analysis? You have to define the sub system and the operational modes of the plant, one should identify hazards associated with a sub system or operations, define the hazards very clearly that arise during the process, estimate the probability of events and possible consequences that arise from these events, and therefore finally identify and evaluate actions.

That are to be taken to reduce or mitigate or eliminate the probability of occurrence of such events, finally evaluate also the interaction effects of various hazards. This in any important stage in a process plan like oil and gas industries because we know the hazard scenario of one is highly dependent and interconnected with the other therefore interaction effects must to also evaluated because there is always a cascade in effect of one hazard on the subsequent.

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Followed by which the next kind of study what people generally do in hazard analysis is SAFOP.

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SAFOP stands for safety operation study it is used essentially for analyzing work processes and procedures, it will only thoroughly review the safety procedures involved in operation in terms of work process and procedures the essential objective of the study is to only evaluate risk factors of the events, it can be applied to new and old plans as well, it is mainly used for process interventions, material handling, crane operations and maintenance.

So this is a micro level study conducted in every process plan only for process interventions if you are got any major changes in the process, if you are having a material inventory handling and when you want to really work out safety regulations are procedures review the safety procedures for carne operation and maintenance of the entire plan SAFOP study are generally carried out.

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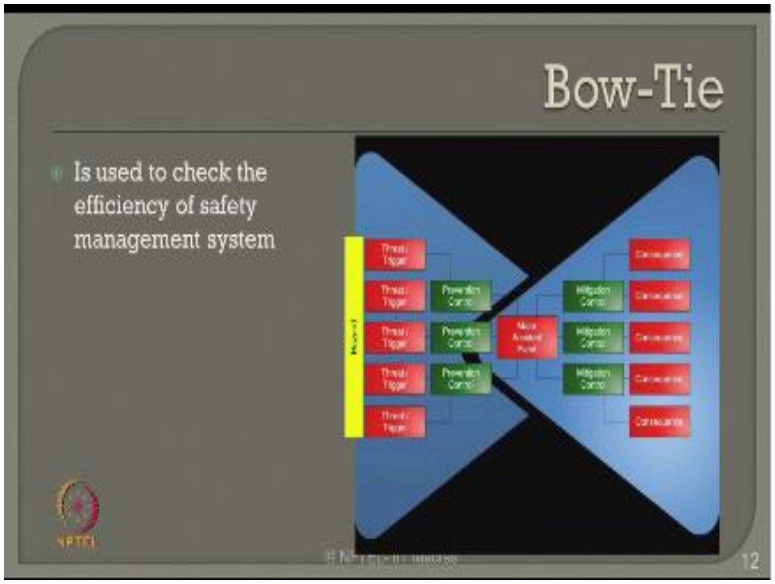

The next method available in the literature is Bow and Tie, Bow and Tie method is essentially used to check the efficiency of the safety management system so as I said in the beginning every plant including oil and gas industry do have safety in norms very well maintained in other level and strictly follow in every plant now it is essentially duty of a plant manager to review the safety procedure and adaption of the procedure as per the rules periodically, so Bow and Tie concept is one of the method which is used to check this efficiency of the existing safety management systems.

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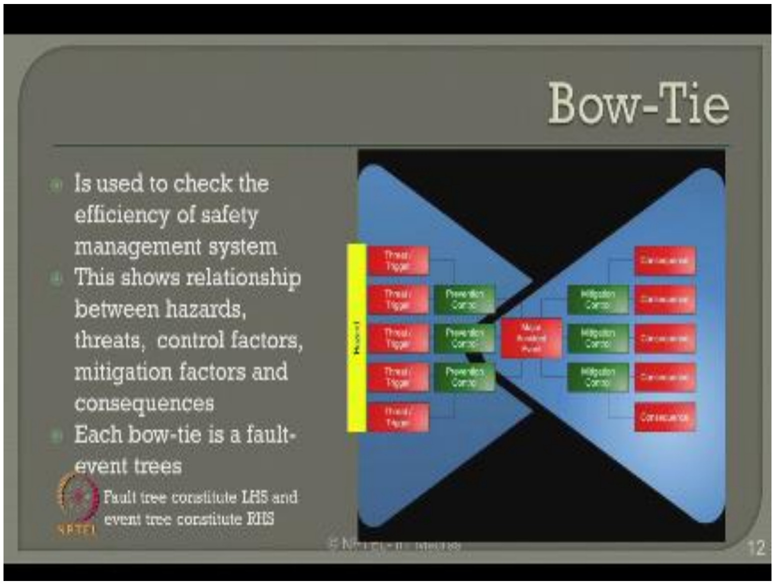

Now look at this figure, there is an HAZOP scenario present in the plant this hazard scenario can give threats to different kinds of problems these threats can trigger of different scenario that can decide or cause an accident, now of course as we all understand in the original design there will be lot of prevention control mechanisms also available in the plant. So taking care of these prevention and control mechanism.

In order one can easily find out an evaluate what is the possibility or probability of the hazard triggering of to become an accident, now the question is when you talk about accident it can be an incident it can even it can be a major accident so one can easily find out what is the probability of these triggering events which arise from an hazard scenario though available prevention control measures.

Are existing can result in a major accident. Once this probability of occurrence of accidence is evaluated from the procedures then one can also look at the mitigation control methods what you already have in place which can be used to control the accident if it has occurred and if you are not able to control or mitigate 100% what only be this consequences which are arising from demanding this control mechanisms.

So it is very interesting the right hand side of this Bow and Tie are tie problem, talks about the consequences and the control measures. The left hand side which is the bow which talks about the scenario and the prevention mechanisms, so integrate together this is call a bow and tie analysis system which is generally used only to review or to check. The efficiency of the existing safety management systems in place.

So this shows a relationship between the hazards, the threads, the control factors, the mitigation factors and subsequently the consequences that arise from the hazards. Each bow and tie is a set of fault tree and event trees. Fault tree constitute the left hand side of the diagram and event tree constitute right hand side of the diagram that is a very simple example how a bow and tie diagram can be constituted or analysis can be done for reviewing the existing safety management system in place in the plant.

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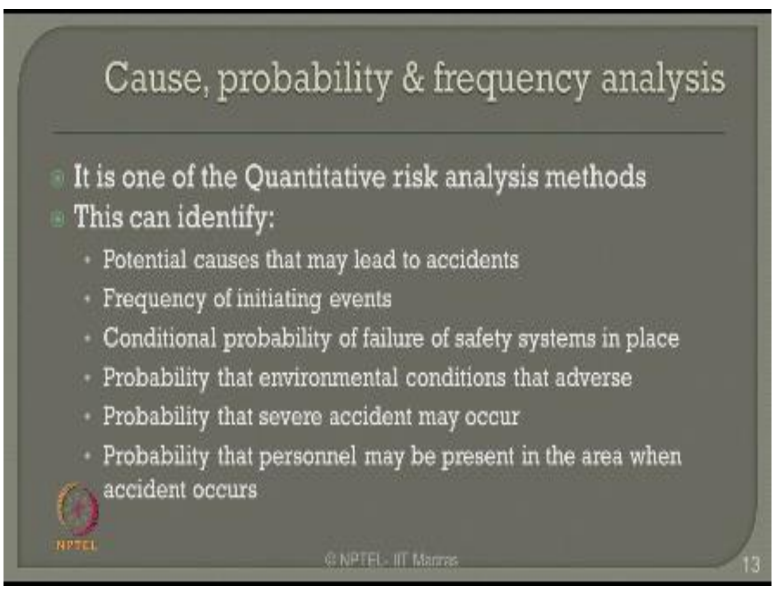

Next to this in the list is cause, probability and frequency analysis. It is one of the quantitative risk analysis methods abbreviated as QRA. This can identify the potential causes that may lead to the accidents. It can also identify the frequency of initiating events, the conditional probability of failure of safety systems in place. Probability that environmental conditions that can adverse and cause problems to the plant. Probability that server accidents may occur.

Probability that personnel may be present in the area when accident occurs all these are looked into in this kind of analysis where the causes, the probability of occurrences and frequency of such occurrences are all considered in analysis which we digger that call as CPF cause Probability and Frequency Analysis which is also one of the hazards analysis methods adopted in oil and gas plants.

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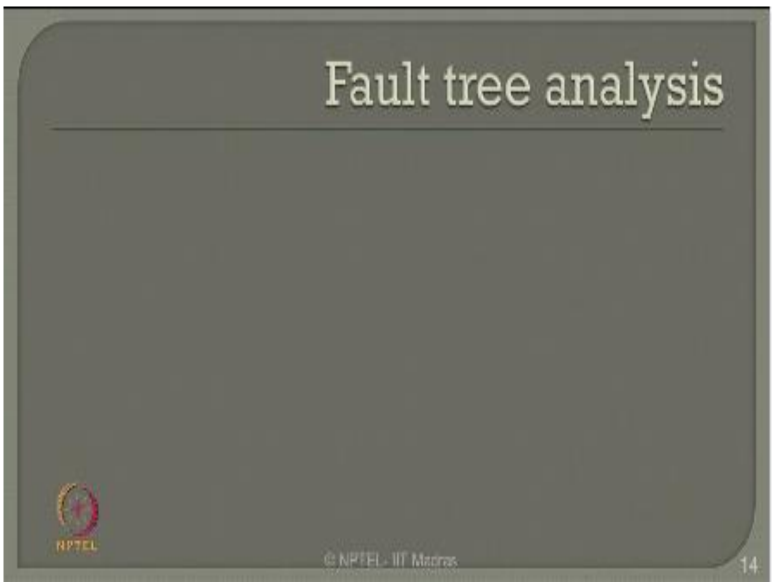

Most interestingly and commonly use technique is a fault tree analysis we will have a separate lecture to explain FTA with an example of problem. Let us quickly see FTA is a logical.

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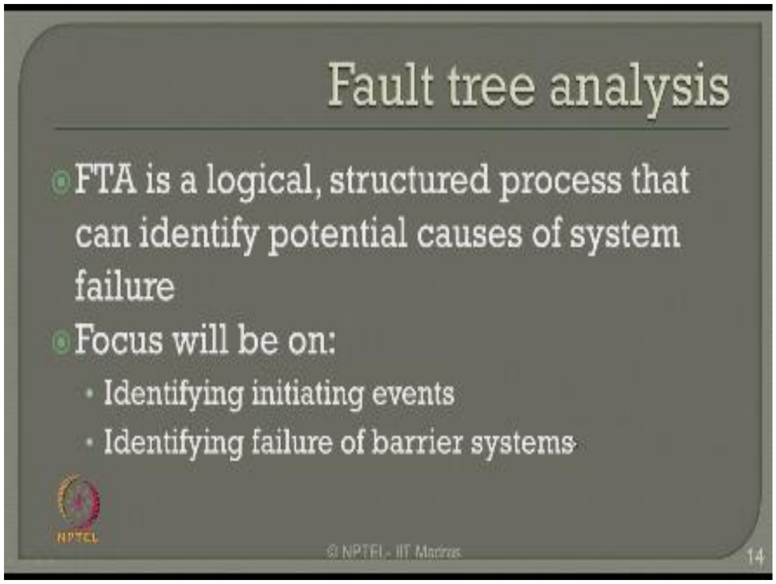

Structured process that can identify the potential causes of the system failure. So it talks about the system in total it can also focus on sub system depending up on the requirement or intricacy of the FTA. FTA will essentially focus on identifying initially once an identifying the failure of barrier systems so we will be talking about initially interestingly to identify the initiating events and then subsequently identifying also the failure of any barrier systems available in place in a plant.

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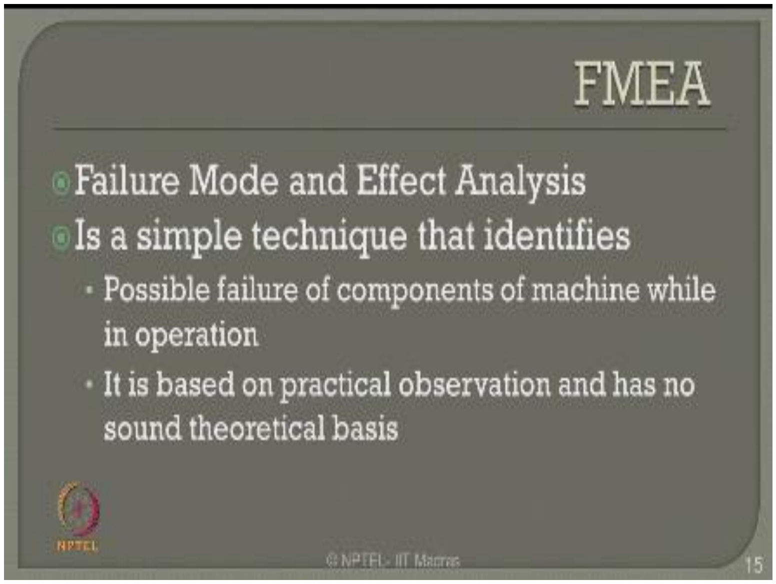

Forward by which the other list existing in hazards analysis is FMEA. Failure mode and effect analysis, it is one of the simplest technique which identifies the possible failure of components of a machine while in operation. So this is a machine level study or mechanical equipment level study where the failure modes of mechanical equipments are identify and then they are postulated failure and try to understand what with the consequences for base mechanical components if they failed the perform the indent that function.

It is based on the practical observation and of course has no sound theoretical basis.

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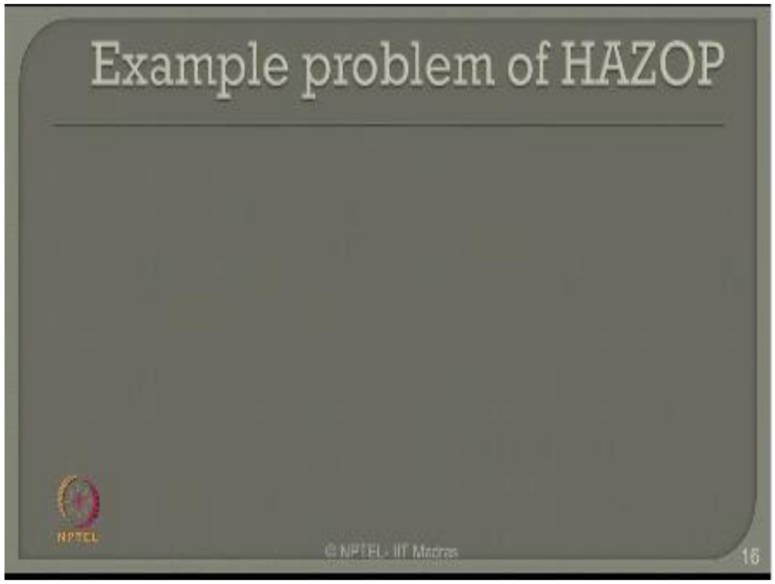

Let us talk about an example problem of HaZOP analysis, HaZOP is an important method of hazard analysis used for oil gas industries.

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HAZOP is applicable at four stages of operation it can be at the drawing board stage which is called as a design stage. It can be also done at the construction stage, it can be during process modifications, it can also be done after accident occurs, which we call as AIR that is accident investigation report. HAZOP studies can be done even as early at the design stage even as much you as post accident scenarios. So HAZOP is one of the very powerful tool which generally used in oil and gas industries to revisit the accident scenarios and to prevent or mitigate such possibility of accidents occurrences in the plant.

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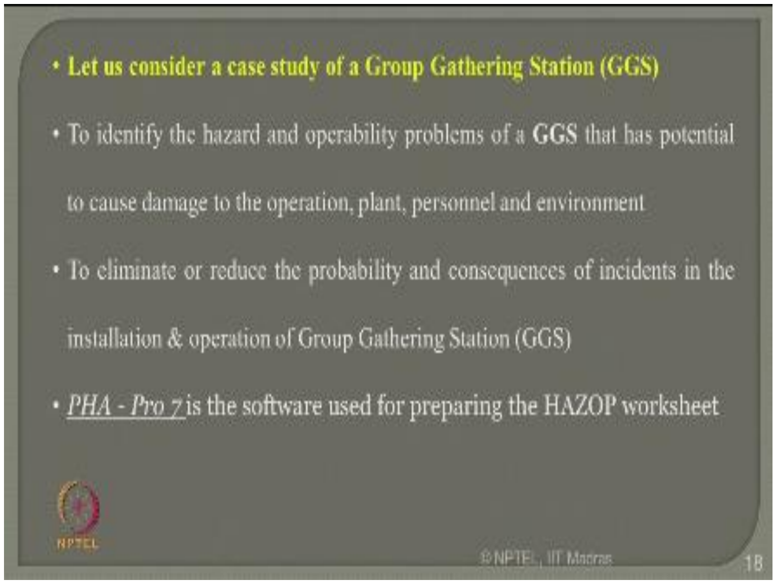

Now let us consider a case study in this example we will talk about group gathering station. Now before we do a HAZOP study for a group gathering station let us try to understand the vital components present in the process of a group gathering industry or group gathering station. Now the focus of the study is to identify the hazard and operability problems.

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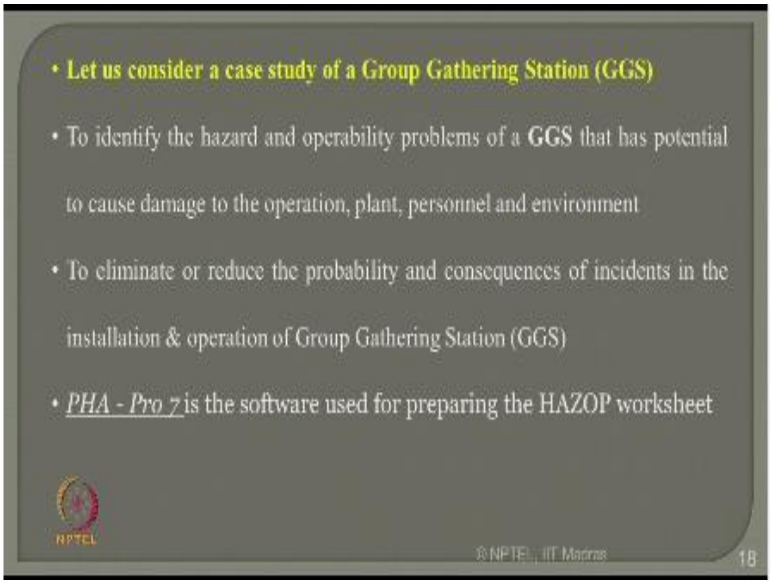

Of a group gathering station which has a potential to cause damage to the operation of the plant personnel and also the environment the societal risk and the individual risk both are encounter and therefore, the study gives an overview of both personnel safety and hazard safety management as well. Now objective is also to eliminate or reduce the probability and consequences of the instance in the installation and operation of the group gathering station. In this specific example, we have used PHA-Pro 7 which is one of the popular software which is used for writing HAZOP worksheets.

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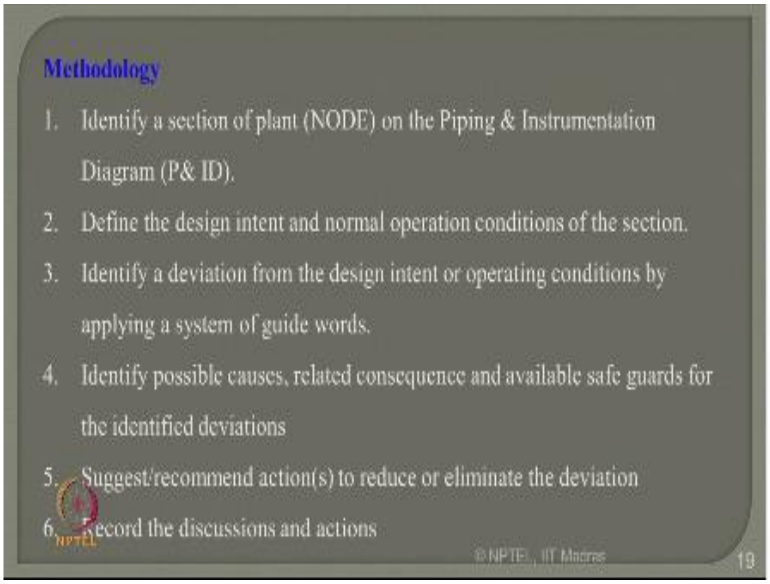

Let us quickly explain very briefly the methodology used for process in a group gathering station. Now the methodology of HAZOP report follow step by step in a given process piping and instrumentation diagram first let us identify the section of the plant which we call as node of the plant. Friends please understand HAZOP report is never done for the entire plant it is then only for segment ways of the plant.

One can integrate the entire plant in order one segment analysis is complete therefore, it is interesting for you to know the HAZOP reports interestingly look into mine a details of the process itself. As I said in the beginning it is always difficult to identify hazards in a given process therefore, HAZOP reports form a vital background in any process industry never the risk in oil gas industries also. Once we identify a given section in a plant.

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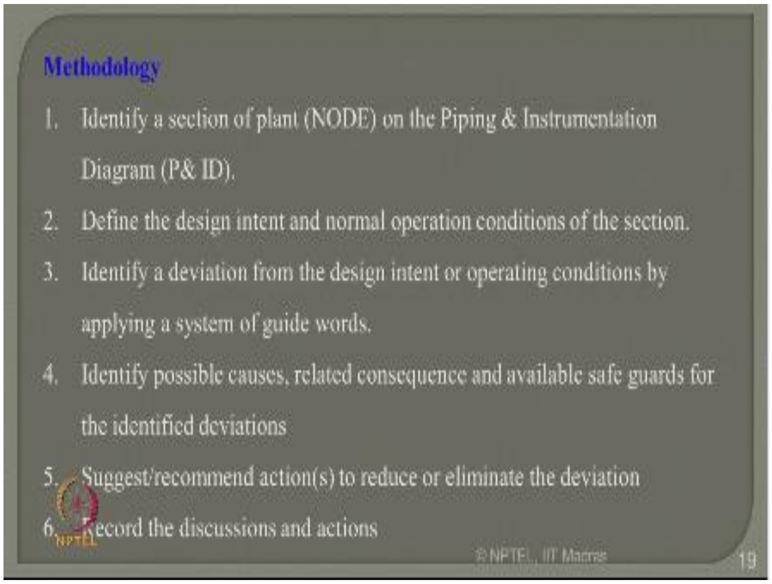

Which is taken from a process or piping instrumentation diagram define the design intend. We all know what is a design intend and what is the deviation when the design intend we have already explain in the last lecture. So for every node of the plant try to fix the design intend and normal operating conditions of that node. Once you do this identify subsequently.

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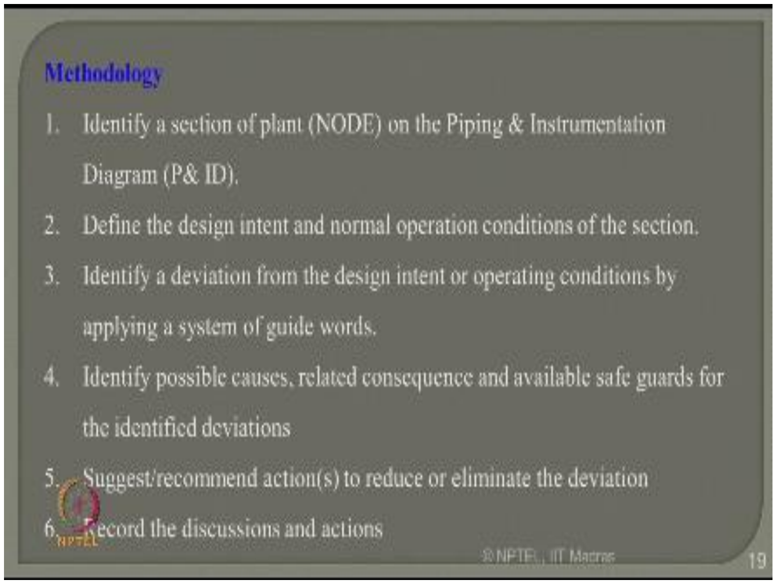

The deviation from the design intend, are operating conditions by applying a system of guide words we already know there are primary key words secondary key words pseudo key words which are available in the literature we must list them before we start rating an HAZOP report. So let us identify the deviation using secondary key words, let us identify a design intend which is in the primary key words combine them in a proper format so that we can start writing the HAZOP report. Subsequently identify the possible causes.

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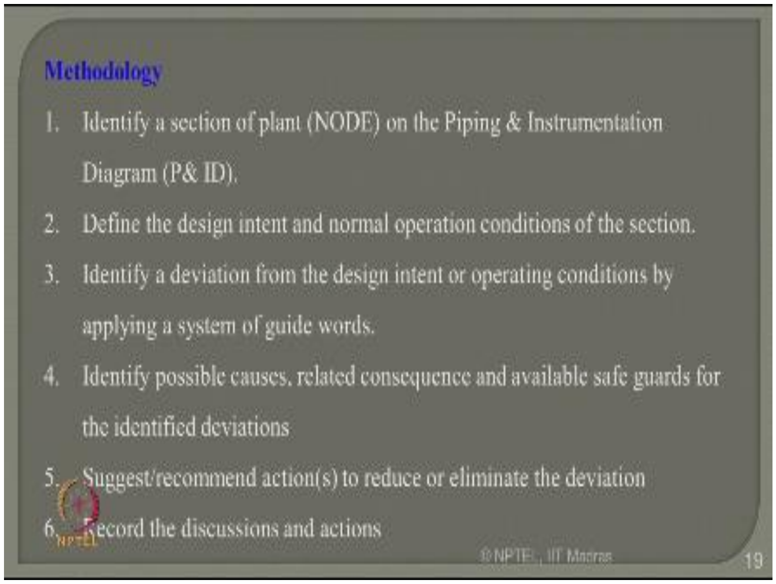

Related consequences and also check for the available safe guards for the identified deviations, because all will now form the part of hazard report finally in the last column of the hazard report you must suggest our recommend.

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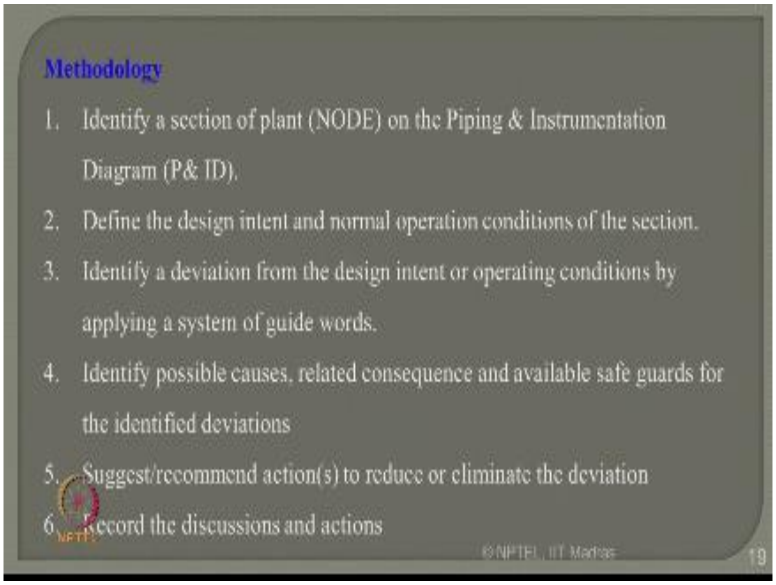

Actions reduce mitigate or eliminate the deviations now record the entire discussion and action in a proper format but we call Hazop report.

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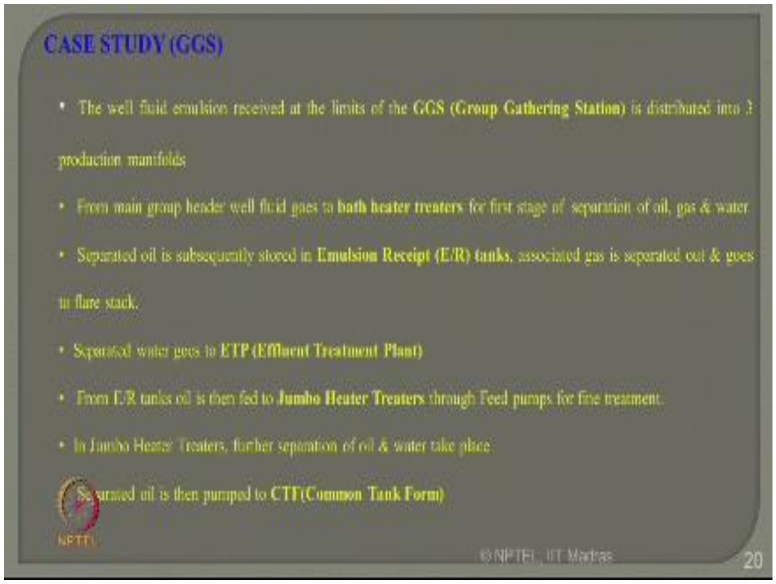

Before we start experience new writer hazop the report for a group gathering station let us state to understand what is the process happening in a group gathering station because if do not understand the details of the process it is very difficult to follow no twice in Tricay in the given note or in a given plant now the well flow emulsion.

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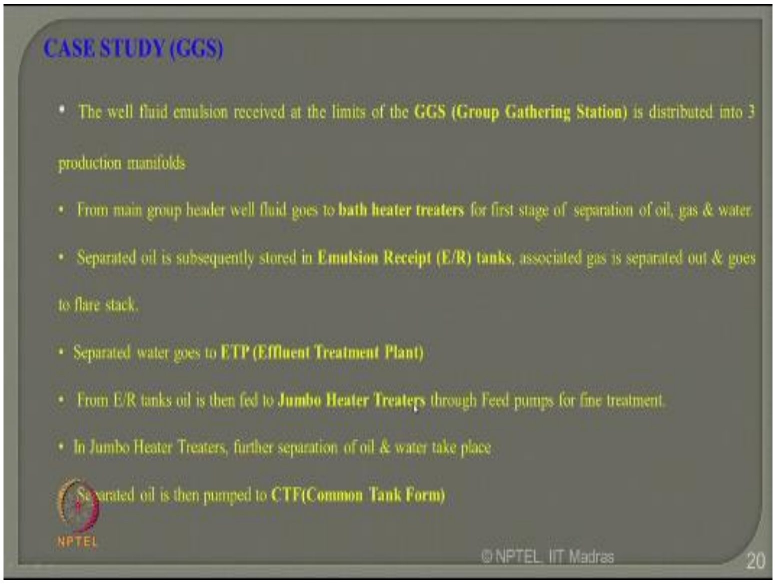

Receive at the limits of a group gathering station is distributed into three production manifolds three production manifolds which are used for producing crude oil is collected and connected to a group gathering station now they are all know connected so group main header where the fluid will now flow to yeah space called bath heater treator bath heater treator is basically their container are an equipment or a space there the first level of separation of oil gas and water takes place.

Now the separated oil from the bath heater treator is subsequently stored in emulsion receipt tanks is indicated as ER tanks the associated gas is separated how and those to the flash stack because this gas need to be flat off otherwise will increase the pressure which in cost Catastrophic disaster so this gas has to be flat of therefore once the oil gas and water are separated the gas which is separated will be now allow to flare of where as oil in subsequently store in emulsion receipt tank.

Which is called as ER tank or ERT's now oil is stored in the tank gas is flared of so the water which is present in the explosion states at bath heater Treater will now go to a fluent treatment plant separately where this treated and then spilled off from the emulsion receipt tank which is now containing only oil now the oil is then fed to Jumbo heater Treater and you require feed pumps for final treatment because this Jumbo heater Treater will maintain the temperature in a pressure which will now treat the oil.

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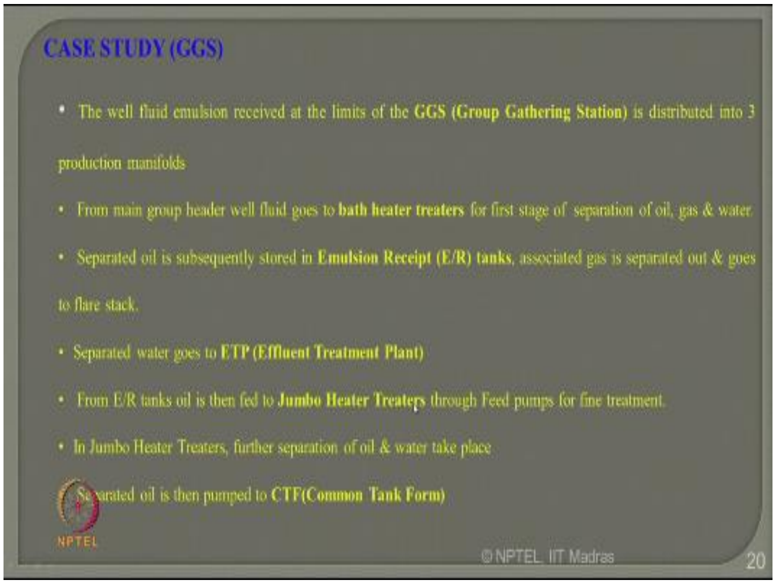

Or which will process the oil which can use for commercial applications in Jumbo heater Treater further separation of oil and water takes place because there are some Pharaphins present in the oil we should be separate or further so in Jumbo heater Treater further separation takes place of between oil and water now the separated oil allow if then pumped to common tank form which we aggregated as CTF now dear friends they given process instrument diagram has got many stages of process the first one is bath heater Treater.

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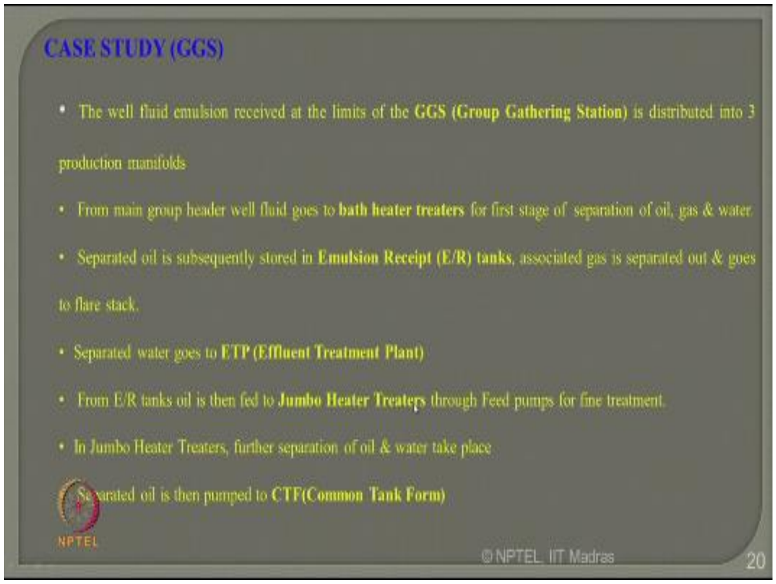

Where oil gas and water together are connected from here the y oil goes to emulsion receipt tank where as gas is flared of and water is going to a fluent it in plant subsequently oil from emulsion receipt tank goes to Jumbo heater Treater where this further treatment and the water goes has a steam of there is oil is in taken separately and fed and stored into CTF this is called common tank form now let us see the process instrumentation diagram of this.

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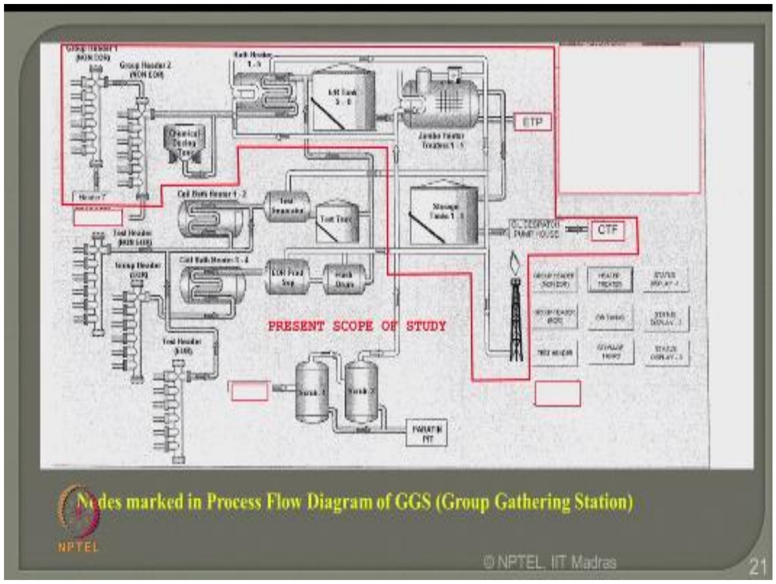

Plant now the figure of the screen shows you the process instrumentation diagram where the process is explained slightly in a graphically manner these are all the non enhanced oil recovery head as which we call s sub headers and which is got a group header one and grouper header two both these now collect the crude oil which is mixture of oil gas and water which is now fed to bath heaters from the bath heaters oil alone goes to emulsion receipt tank the water is taken to a fluent treatment plant.

The gas is flared of to the flat of separately so from the emulsion receipt tank the oil further goes to the Jumbo heater Treater in this particular plant taken for the study there are four Jumbo heater Treaters there are five to eight emulsion receipt tanks there are one to five bath heaters so from the Jumbo heater the oil which is now separated further from water is stored in the storage tanks from the storage tank is this burst of through the pump house to common tank form.

So briefly understand this is a segment which I am going to analyze which a marked in red now interestingly there are many group headers there are many bath heaters there are many enhanced oil recovery production separators and flash them available in the process plant but my hazop study is limited to only presence scope of the study focus only on the red marked portion which is now the designated note forming hazard analysis so mu hazop is no focusing on is specific segment of the plant.

Which is call has designated note in the given plant so from the given diagram it is man detail for us to designate a specific area for defining the scope of the study from the scope of the study is stop writing hazop report for a specific in this hazards given in the segment of the plant alone one can ask me an interesting question if I do hazard analysis through hazop report for different segments of the plant separately how do you integrate them because the whole plant has got to be integrated for the final hazard analysis report.

How do you integrate in per simply this is where the soft or helps us to know how they are integrated while I do the example I will explain you how they integrated also so the notes mark in the process for diagram have a group gathering station is shown to you on the screen now.

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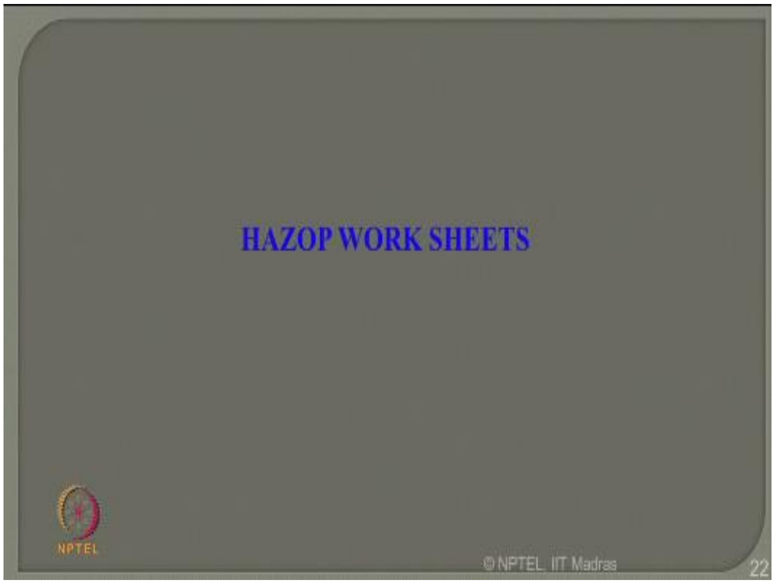

Let us start working at the hazop work sheets we are using PHA pro seven for working of this specific example for you on a academic interest.

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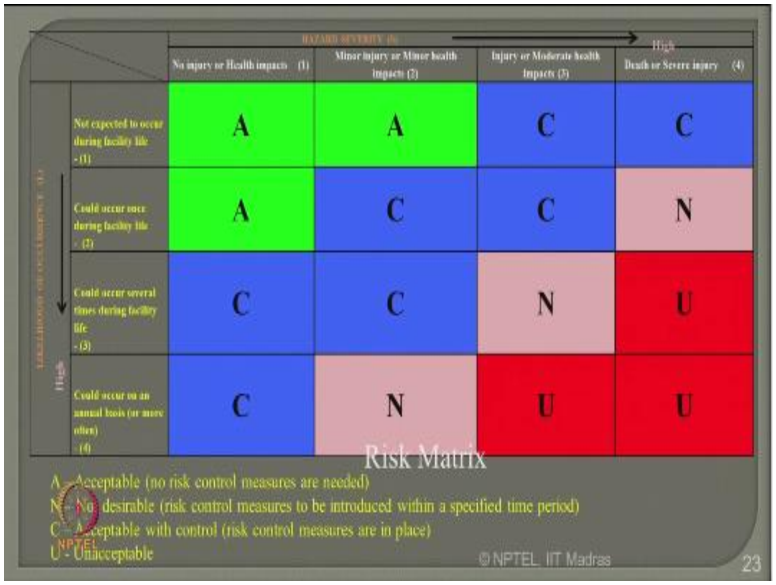

Before we understand writing hazop report let us try to clarify set of the issues how the normal plates is given in a hazop report we have already seen in the last lecture hazop report intensifies the design intents and deviations from the design intent if it is so then primary and secondary keywords are recognized and listed in the beginning of the report we should also k now how normal pressure can easily attached to this kind of report let us see this risk matrix.

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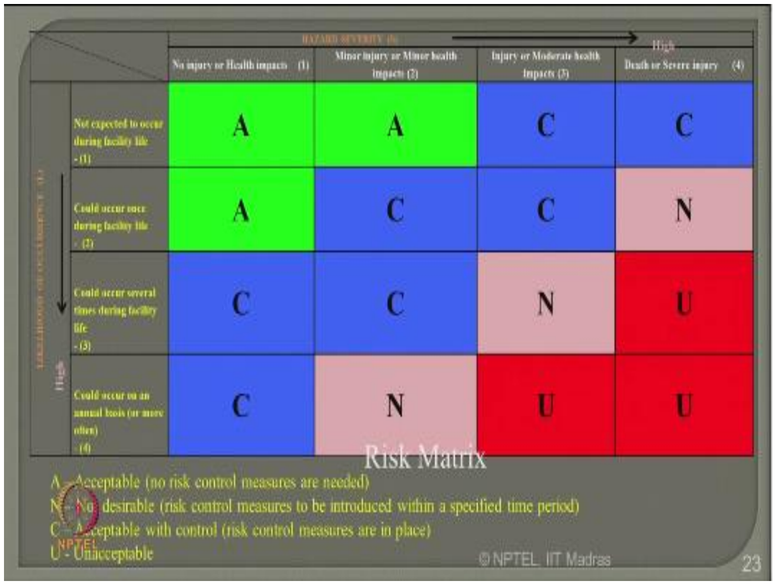

Which is generally adopted in oil gas industry the risk matrix has two segments the hazards severity indicated as yes the like to occurrences indicated as L sometime it is also called as HS or LS matrix hazard severity versus like lute of occurrences the hazard severity goes higher and higher towards a right hand side there has the like lute of occurrences goes higher and higher towards the bottom of the screen so this is the higher indication similarly this is higher indication for severity.

On the other hand this segment are all low severe and were as these segment this particular segment is higher like lute etc. now the entire matrix is divide in to different areas and zones were the Norman clutches patch is establish in the literature are given as A C N and U so A stands for regions were acceptable risk. That is no risk control measures or required, if you are identifying is specific risk zone or risk region has acceptable you do not require any additional risk control measures what is available in the plant is efficient.

The regions were N indicates or not desirable therefore 1 must activate risk control measures must be introduce within specific time period in a given plant. The regions were C is indicated they are acceptable with control provided the risk control measures are available in place and recommended strongly. There has reasons which are marked red in colour here they are unacceptable therefore one should not try to have any such regions in given plant.

So the risk matrix dividing the entire hazard severity and likely hope or appearing here now let us look that the cases of the classification of hazard severity starting from no injury minor injury, injury or motet health impact and death or severe injury, so in hazard severity is increasing towards this way on a scale of 1 to 4 whereas the like lute occurrence that not accepted to occur, could occur only during facility of the life could occur several times during facilities that life.

Could occur and unveil basis so if a specific hazard which causes no injury which not accepted to occur falls in a category A which is acceptable, if an hazard results and fatal end or death injury which also occurring an annual basis or could occur during the facility is categories as unacceptable. So this risk matrix friend will give you an idea how one can classify risk in a given plant in Norman clutches wearing from A N C U this how literature classifies hazards Norman clutches stile. So this will be used in hazop report.

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Now let us look at the sheet available to you in the screen this sheet already focuses and a specific note selected from the given process flow diagram now I have selected the group header the Norman clutch are given to this is number 1 which is generated automatically from the software, the group header consist of 12 inches pipeline not designated as 102 a 3A classification so this can be taken from the standard data base available in the software.

Now interestingly I am identifying the failure as a pile line failure and please see here I am writing explicitly the deviation, now the deviation indicates two words one is a first word followed by second word now that can be low flow that can be no flow so both are deviations for the design intent. But the design a condition for given specific location is indicated here which will be the liquid rate of 2500 cubing meters a day.

The glass flow it is negligible the operation pressure in this specific header is above 10 Kg per centimeter square the operation temperature is 50ºC viscosity of the pure oil have to operate in temperature is 270 centre pies density at the operating temperature is above 15apa which is closely 966 Kg for cubic meter. For once I identify the design conditions and the deviations what you want to focus on the pipeline.

Let us now look at only the causes the consequences the safeguards and recommendations which are of course the classical form in hazop report, the one word to see here in the middle is an advantage column which is added to hazop report which classifies the risk ranking depending upon the hazards severity and the likely would. Now let me just explain one of them in detail let us take leak or rapture of a group header line which designated us 12 inches pipeline 102 a3A so once you enter it here automatically the software takes the data base from here and enters it here automatically with the node number one.

Once a node number 1 is indicated it is automatically mentioned to the group header as shown here. Now the consequences of this cause of rupture of the header line can result in fire it can cause in normed hazop it can cause loss of material can also result in process upset. Now look at one specific example of a fire hazard the fire hazard if occurred you have a safeguard system you will have fire protection of fire fat in devises in place which are available in the plant.

Therefore indicate that in the safeguard column here however you recommend a special transmitter which is to be provided in the header liner so that exes a pressure generation which indicates a leak in a lecture of the line can be also mentioned. Now let us look at this particular matrix of risk matrix the severity if this kind occurrence happened is on the scale of three where is the like lute of this in the scale of 2, dear friends these numbers on a scale of 4 on a scale of 4 is clearly depend on how were experience in this kind of process plants. Now based on this refer to this matrix for example.

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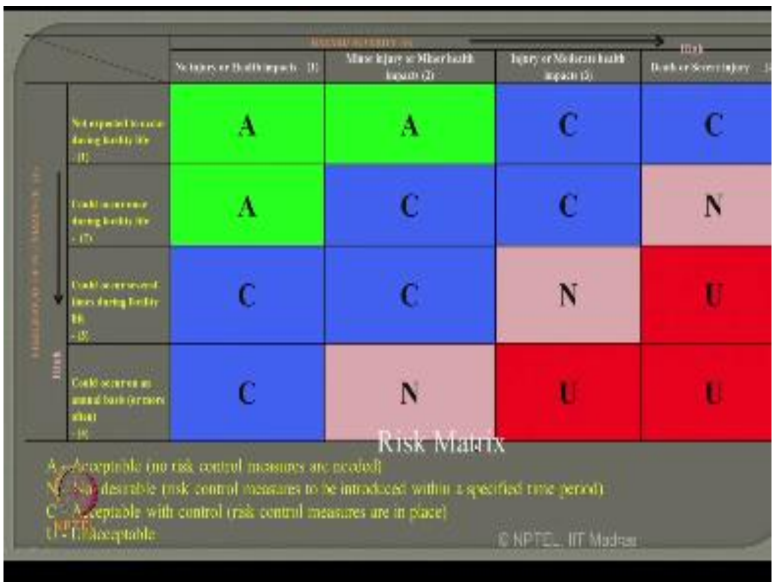

Get back here base on number give up a severity as a number given for likely lute you will know in which category of Norman clutches you are falling.

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So based on this you know the risk and harking is falls on Norman clutched C so Norman clutched C means.

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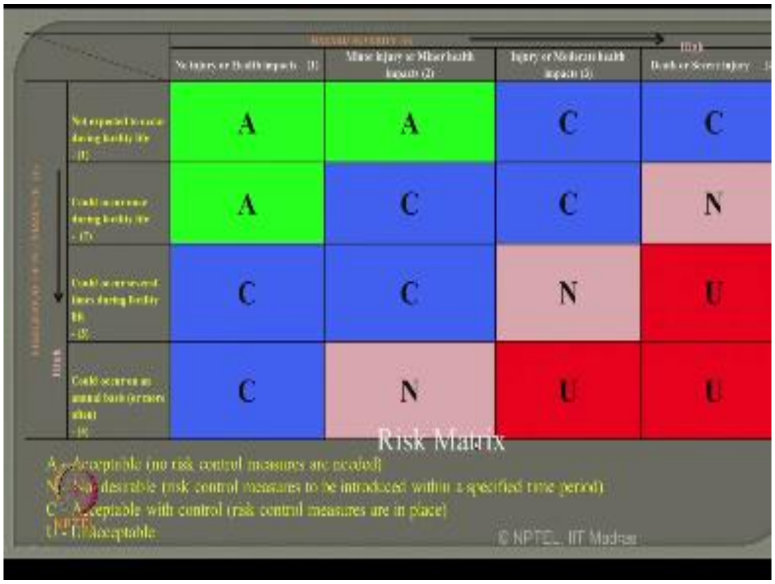

Acceptable with the control mechanism in the place.

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Now the control mechanism available in place is fire protection system so it is very interesting for us to know at least for one specific case once we enter the group header now with the specification the software borrows and Norman clutched enter the data here you enter the causes yourself and it is given a number once identify the cause look at the consequences check what would be the relevant severity and likely hope of this cause and con sequence depending upon experience once you have this the risk ranking is automatically done by the software depending upon the matrix already available in the data base you also give a recommendation similarly the loss of material severity can be two likely would can be two it also falls in the snacking C, on the other hand if our process upset.

The severity of this can be 1 the likelihood can be 2 whereas this product forms in an acceptable level of A, therefore there is no additional safeguard recommended for this based on the severity level and the risk ranking you can also try to give recommendations like periodic inspection can be done for the plan the thickness measurement of the header line can be also done periodical hydro testing should be done to check whether there is a leak available in the plant or the pipe line etc..

Similarly the next cause could be isolation involves in the inlet crude oil, again the same designated note is studied and the number is 2, for this the consequences could be if isolate the valve it can pressurize up stream side can cause severity risk ranking C where as a process upside can cause a risk ranking of A.

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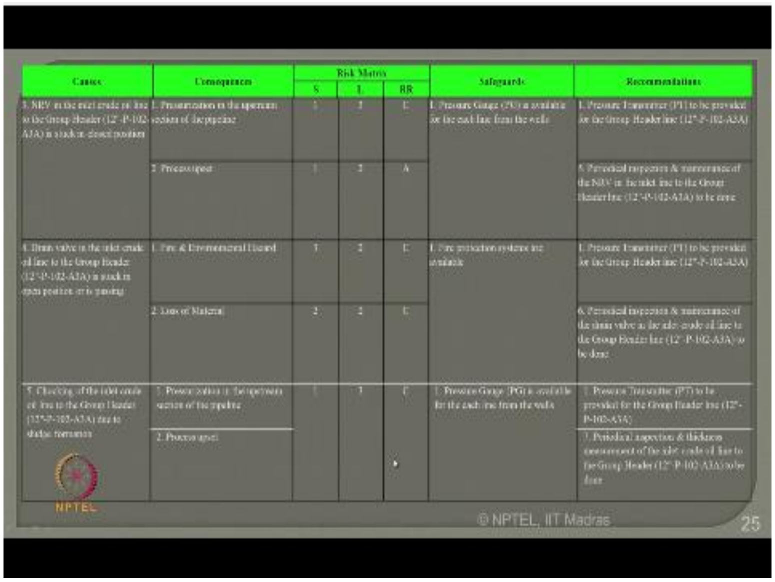

The non return valve in the inlet crude oil can also fail if there is a case the pressurization will happen which will cause risk ranking as C of course the pressure gauge is available to check the functionality of the non return valve. However, we also recommend pressure transmitter to be provided in the line to check any failure of non return valve. Similarly one can look at all these numbers automatically done please understand interestingly.

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The recommendation columns are getting generated a number, number 1 shows pressure transmitter provisions, number 2 shows periodic hydro testing number 3 shows periodic inspection. Now when you look at the second cause when a recommendation goes as pressure transmitter the number is automatically borrowed from the database and it is repeated so this need not to be typed again,

Once is your number 1 they automatically see pressure transmitter will be involved. Similarly when you recommend a new thing it gets a new number. So periodic inspection and maintenance of isolation involve so new recommendation in the report therefore gets a new number.

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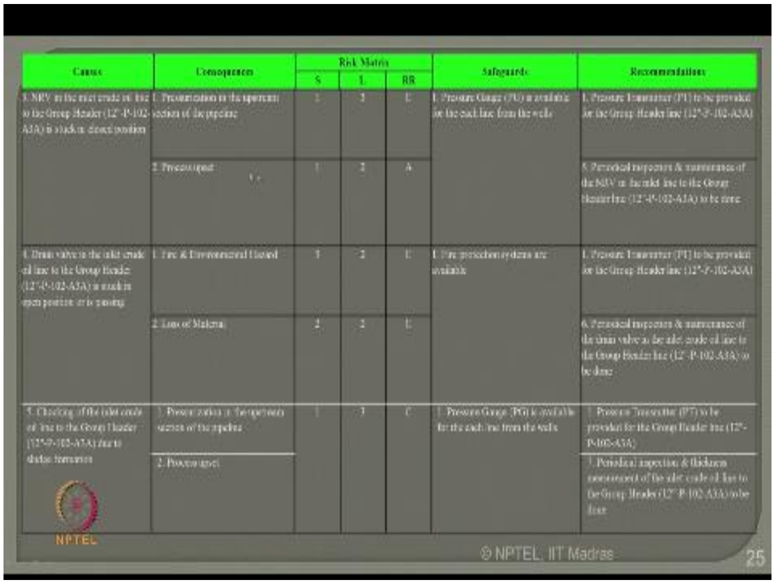

Subsequently the non return valve which is third cause you are recommending a pressure transmitter it borrows a number from the data base automatically, whereas if you give new recommendation for the non return valve it gets a new number 5. Subsequently whatever you give old recommendations they borrow the same number whatever new recommendations you type they get a new number.

So this is how the recommendations for different notes done in a HAZOP report are integrated for the entire plant. So you need not have to do HAZOP report for the entire plant yourself, you do note by note and every report in such order electronically can be integrated by simply preparing the recommendation column looking at this and you can easily find.

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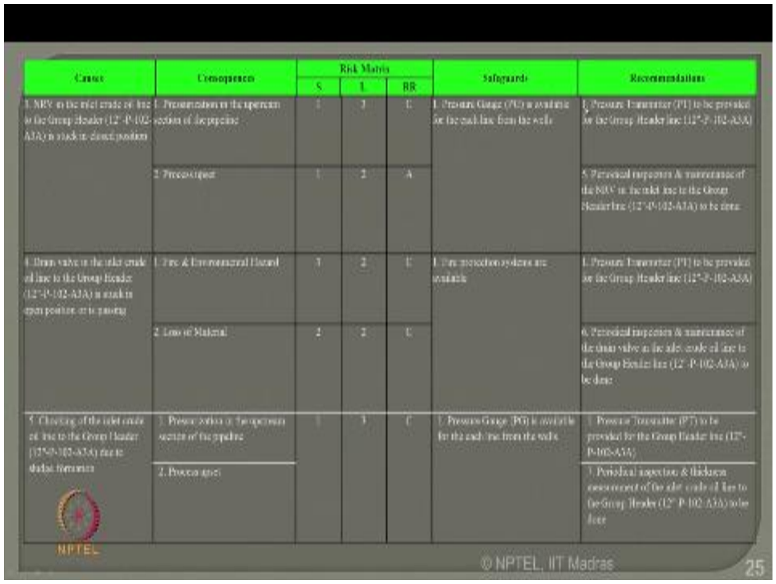

Subsequently the software also has an advantage whatever disc ranking which is on alarming stage like for example C, U etc, which are un acceptable that they are separately listed and they can be also called for immediate attention. So writing an Hazop report definitely requires identification of keywords primary and secondary, identification the causes and consequences and subsequently converting them into a quantitative statement which is called risk ranking. Dear friends please understand hazop report is qualitative, but it is also converted into quantitative number by which risk ranking is given based on which I can easily take actions for the given plant.

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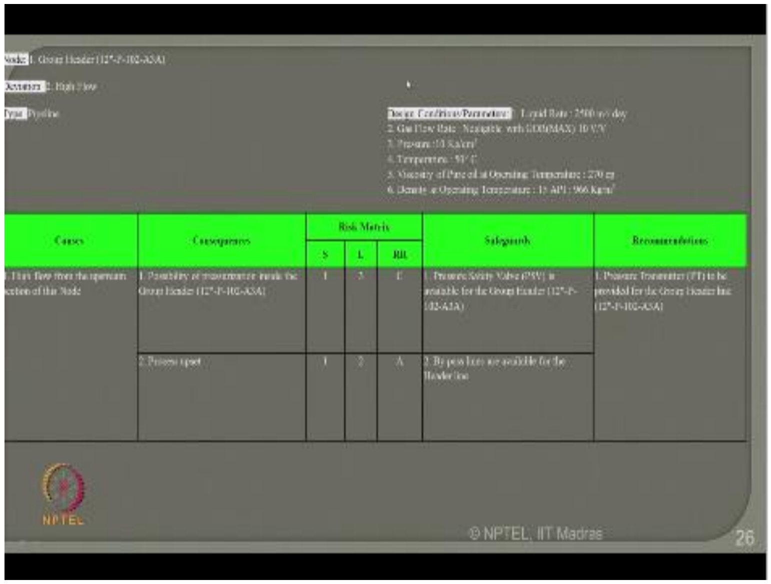

So there are different notes available and consequences are identified and in the same manner we keep on identifying the risk matrix and we also look at the existing safeguard measurements available and subsequently we give the recommendations. However, how many number of time give the same recommendation the number is borrowed from the standard database is available and created by you.

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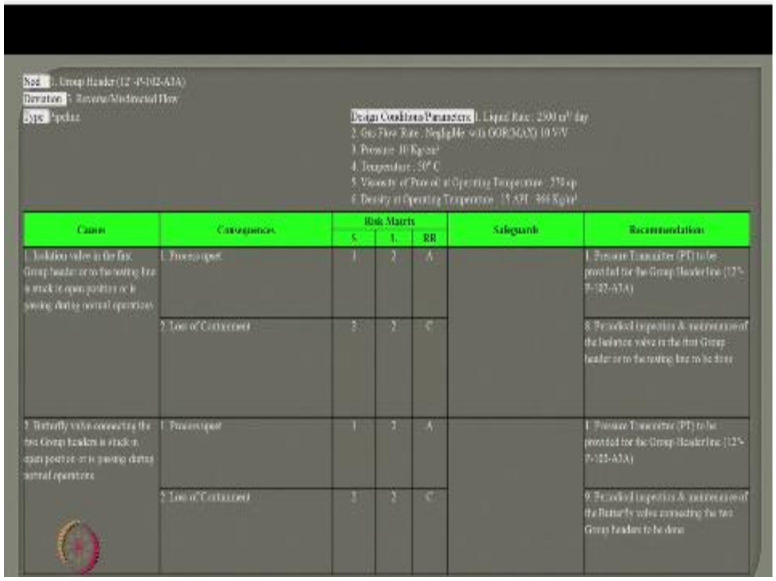

So this is the other note which is group header, now the deviation here is number 3 it is a new number reverse flow or misdirected flow. The earlier case was no flow or low flow, so whatever deviation you as knew it occurs a new number and for this new number again you can identify the causes, a consequences and if there is any safe guard and the recommendations. If you give any new recommendation it takes a new number, if you give a new recommendation it gives a new number because it is periodic inspection of the butterfly valve. Whereas the periodic inspection gets a different number if it is adopted to a group gathering header.

So whatever recommendation you state they all will be converted into a specific number and this can be recreated so that you can know what are the recommendations given for the plant.

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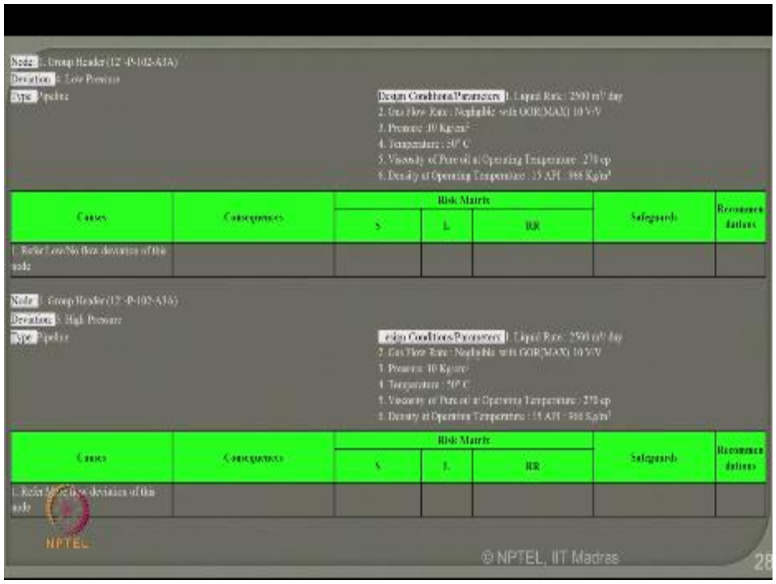

Similarly the report can be done for different headers for different segments, for different deviations as shown in the subsequence slides.

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So external fire, high temperature in the pipe line recommendations a new number, number 10 etc.

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Now we know that what is the meaning of these risk ranking matrix in categories of A, C, N and U we already also have these nomenclature present for different causes in a different plant note as C, A etc, based on this one can easily know what all the acceptable risk involved in the plant, what all unacceptable areas risk involved in the plant.

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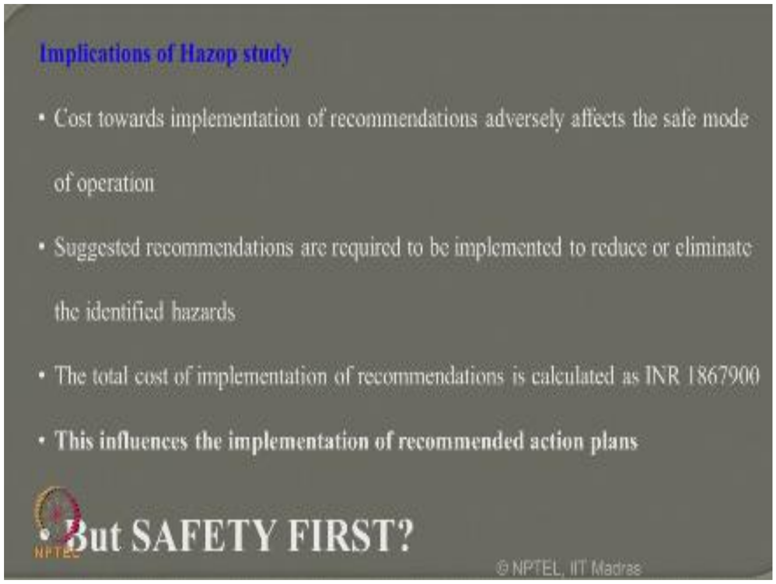

So hazop study has very serious implications the cost towards implications your implementation of recommended adversely affects the safe mode of operation suggested recommendation are required to be implemented that is mandatory, the total cost of implementation in this specific example resulted in about 18.67 lakhs, this influences implementation of recommendation action plan if you want really implement them. However, becoming safety first hazop reports recommendations are strictly implemented in the given plant and they are re visited subsequently by the next team of the hazop management.

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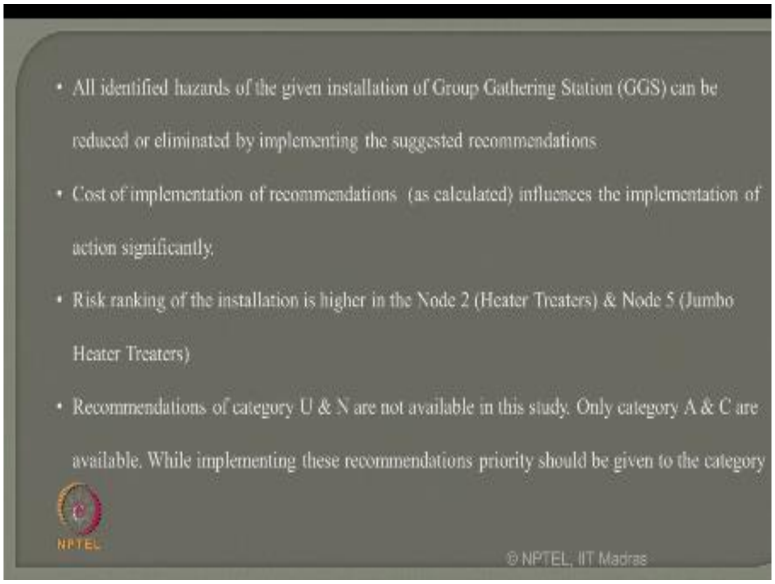

In this specific example we have understood that all identified hazards of the given installations in a group gathering station can be reduced or eliminated because there is no U category of risk involved. Cost of implementation influences the implementations plant accordingly, risk ranking gives very interesting idea and the highest orders in this case note 2 and note 5 which is jumbo heater treater and heater treator because these are the areas where the focus of risk reduction should be done by the plant. Recommendations of U and N category in this case are not available in the study only A and C are denoted therefore the plant is safe.

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So this example made you to understand how to write an hazop reports for a given process station hazop is a qualitative method of a writing a report this example illustrated how to prepare an hazop report and this lecture gave you different hazard analysis method briefly. Thank you very much.

<u>Online Video Editing /Post Production</u>

K.R. Mahendra Babu

Soju Francis

S. Pradeepa

S. Subash

<u>Camera</u>

Selvam

Robert Joseph

Karthikeyan

Ramkumar

Ramganesh

Sathiarai

Studio Assistants

Krishnakumar

Linuselvan

Saranraj

Animations

Anushree Santhosh

Pradeep Valan .S. L

NPTEL Web & Faculty Assistance Team

Allen Jacob Dinesh

Bharathi Balaji

Deepa Venkatraman

Dianis Bertin

Gayathri

Gurumoorthi

Jason Prasad

Jayanthi

Kamala Ramakrishanan

Lakshmi Priya

Malarvizhi

Manikandasivam

Mohana Sundari

Muthu Kumaran

Naveen Kumar

Palani

Salomi

Senthil

Sridharan

Suriyakumari

<u>Administrative Assistant</u>

Janakiraman .K.S

<u>Video Producers</u>

K.R. Ravindranath

Kannan Krishnamurty

IIT Madras Production

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