Health, Safety and Environmental Practices in Offshore and Petroleum Engineering

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Module – 02
Operational Safety
Lecture – 18
Hazop (Case study)

Friends, welcome to the 18th Lecture on Module 2 on online course HSE Practices in Offshore and Petroleum Engineering and the (Refer Time: 00:21) of NPTEL, IIT Madras.

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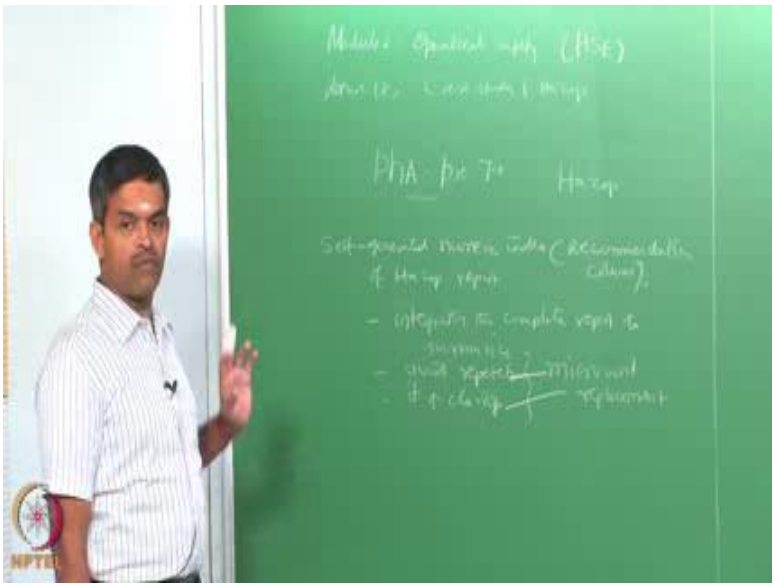

In Module 2 we all know that we are focusing on Operational Safety, the course is HSE Practices in Offshore and Petroleum Engineering. Today in Lecture 18 we are going to continue with the hazop study, but in detail on the case study of hazop. So, let us quickly rewind slightly back in the last lecture and see what we saw, please look at the screen.

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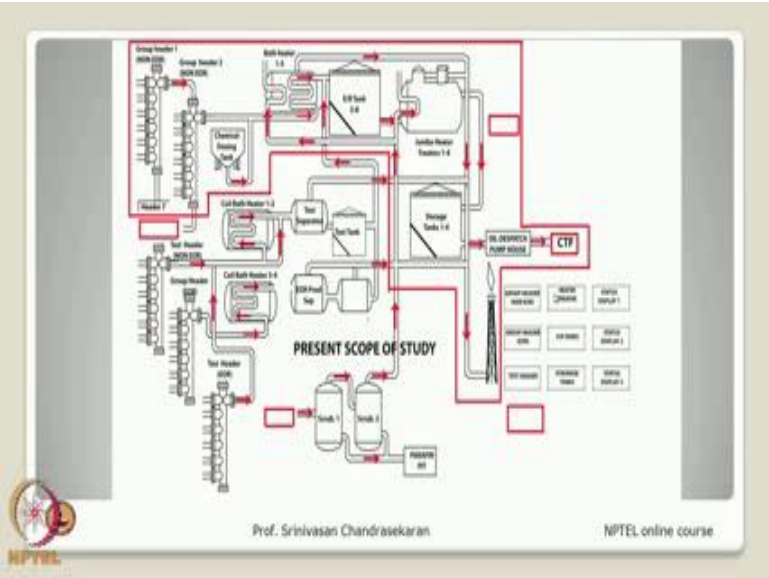

This was the process in instrumentation diagram and the flow diagram which has been discussed in the last lecture. So, the group headers 1 and 2 which is got production manifolds are connected which actually explores and produces crude oil is being delivered to the bath heater. Bath heater of course separates oil, water and gas. So, water may be gas available and separated here is been straight away taken to the flaring stack the oil and gas mixture partially enters through the emulsion recipient tank, where it is further processed and oil and water are separated and the separated water is taken out to the effluent treatment plant, where it is further treated before it is disposed to sea. Whereas, the oil which is being taken away from here is going to jumbo heater treater where again it is being chemically treated and the crude oil is going to the storage tanks 1 to 4 where the oil pumps dispatched composed will actually go take them to CTF from there it is dispatched for the commercial purposes.

So, this is a small segment which is marked in red line which is the present scope of the study for which today we are going to write the hazop report. Let me remind you hazop report primarily circumscribes with two things; one is the design intent, the design intent is the purpose for which a specific process flow diagram is created or a process instrumentation setup flow line is created. Deviations are the inappropriate functions which are not satisfactorily happening in the process flow line.

So, these two are expressed indirectly using two words what we call as primary key words and secondary key words. Primary keywords are related to the design intents of a given system and secondary key words are related to the deviations from the design intent of a given system. Each one of them when they are standing alone has no meaning they have got to be combined together we have also seen in last lectures all secondary keywords may not get combined with all primary keywords. So, one has got to declare what are the primary and secondary keywords which you are going to use.

On the other hand what are the design intents and deviations you are going to perceive in a given flow line that you got to declare in advance which is explained in the methodology of hazop report for this particular case study in the last lecture. So, let us without wasting time move on to the hazop report directly. So, look at the screen now.

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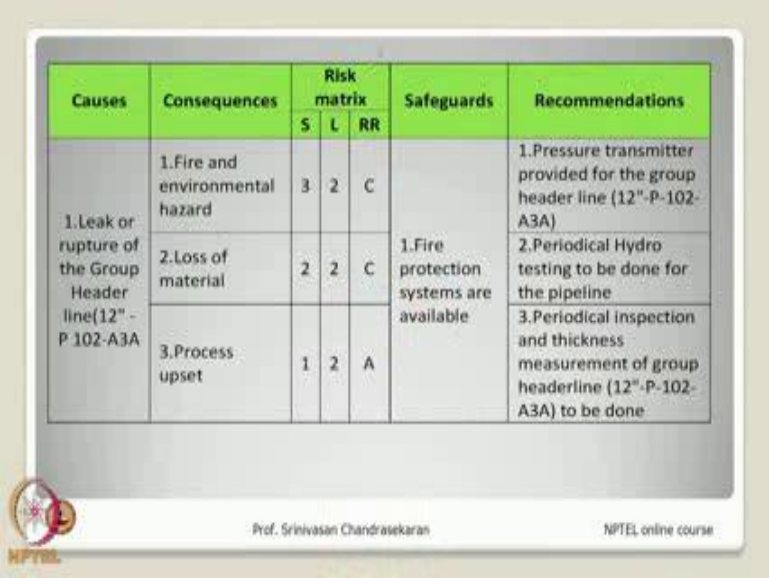

I am going to show you the computerized output of the hazop report which has been produced using software by name pha-pro. So, we have used pha-pro the release 7.0, the updated release is also available now for commercial purposes. So, it is got a separate module and hazop study, so one can use it for all chemical risk problems or any process industry. We have used the advanced version of this particular software. And you see on the screen now the first set of tables which are showing me the hazop report for the

segment which has been discussed in the previous line.

Let us say I have a specific deviation in the on the design intent which I am going to talk about let us say in the successive tables. So, for a given specific deviation on the design intent let us say flow line there is no flow, then one can say the flow line which is not having any flow or reduced flow may occur due to many reasons. We have to identify the causes. If you look at the causes column here, the number 1 is generated automatically from the software. The cause can be due to leak or rupture of the group header which is 12 inches line which is designated as P-102 A3A which is actually a specific classification given by the user to identify a specific line in a given flow line segment. So, 12 inches is the diameter of the line which is about 300 millimeters.

So, there can be possibly a leak or a rupture in the given line on the group header which you saw in the previous slide. What would be the consequences this can result in? It can cause fire and environmental hazard; it can also cause loss of material whatever has been explored as a crude oil can also obstruct the whole process

So, interestingly you also add something new in the hazop report which is latest invention which is being added to the hazard studies since about 6-7 years in the recent past. What we call as risk matrix? The risk matrix is going to tell me 3 columns; one is what we call S which is severity, other is likelihood; the third is the risk ranking. I will explain this particular risk matrix later once I complete the hazop report tables for all possible design intention deviations.

Let us say the severity likelihood for a specific consequence is 3 and 2 and it is having a risk ranking C we will talk about this slightly later. Now let us also look at or examine or inspect the safeguards present in the existing system. The safeguards present in the existing system refer to fire protection systems which are already available in place. So, the fire protection system can be an agency to mitigate or to control fire and environmental hazard it can also prevent loss of material to some extent of course it can prevent the process upset of the whole line by bypassing the line if the line is found to be leaking or ruptured from the group header.

So, the existing safeguards are indicated in the report. Now based on the understanding and expertise of set of people who prepared this report recommendations are given in the last column. The recommendations say introduce or provide a pressure transmitter for the group header line 12 inches P-102 A3A which refers to the same nomenclature as you see in the causes column here. So, introduce a pressure transmitter or provide a periodical hydro testing facility or provide a periodic inspection and measure the thickness of the measurement line which can always tell you the loss of material of the pipeline because of corrosion.

So, all these recommendations I want you to notice ladies and gentlemen there has been numeric number created by the software, let us say 1, 2 and 3. Please understand this is not type as 1, 2 and 3 by the user or the report creator this is self generated by the software. There is a very interesting interconnectivity of this particular number generation which I will explain you in the further slides. Similar number is also generated here it may appear to you that these numbers are appearing in serial number 1, 2 and 3 it is not so I will explain you and show you.

I want to insist only one thing here that these numbers are not typed with numerical number they are self generated from the database of the existing software. Moving on to the screen let us say the second deviation which is seen which also refers to a cause can be the isolation valves.

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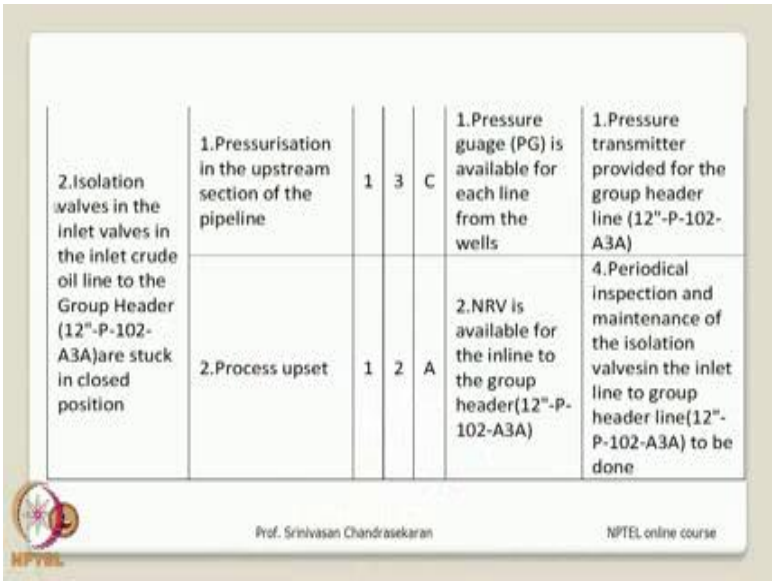

The isolation valves in the inlet crude oil line to the group header are struck in a closed position. When the isolation valves are stuck in the closed position there can be also no flow in the given line. So that is again indicated and generated as number 2. Obviously, if you look at this generation of 1 and 2 you will notice compared to the previous slide which already had consequences 1, 2 and 3. The consequence 1 refers to fire and environmental hazard, whereas in this case the consequence 1 for the cause 2 refers to pressurization, so this number is again generated.

However, if you look at the process upset consequence occurring form leakage referred to number 3. Whereas, if you refer to the process upset generated because of causes from isolation of valves getting closed it is given 2. But if you look at the recommendations, if you look the serial number 1 to introduce pressure transmitter this is exactly matching with the serial number 1 of the previous column. It means whenever you want to type say you want to introduce or recommendation introduction a pressure transmitter you will generate a number automatically, whenever this particular recommendation is foreseen in the hazop report it automatically gives you a number.

One may ask me a question what is the advantage of this kind of numbering. It is very interesting friends to know if I really want to consolidate the whole hazop report which is

running in volumes and pages as a hazop manager I want to know where are those recommendations where I want to introduce pressure transmitters. So you can always type pressure transmitter only those segments, only those causes resulting from the deviations will be highlighted in the whole process line. For example, in this particular case you want to highlight the locations where pressure transmitter need to be introduced as a recommendation of hazop report, then you need to introduce on the flow line near the isolation valve, you need to introduce on the flow line near the leakage of the rupture group header etcetera.

So, this will exactly tell you there is going to be a self generative interlinking of the report from one segment to the other, from one cause to the other cause, and from one plant to the other plant as a whole. So you can a summarized hazop report for the entire plant though your report is generated only on segment of the plant. This connectivity is automatically created by the software database by introducing this kind of numerical algorithm while you keep on recommending.

On the other to can make it very simple to understand for the first time when you type introduction of pressure transmitter the number generated is one, for the next time when you type the same recommendation the already number generated is verified and the number is introduced here. Obviously, you will see after one there is no 3 4 is coming because 2 and 3 are already available here. So, 2 refers to hydro dynamic testing, 3 is of course to inspection and 4 refer to inspection, you may say sir 4 is also referring to inspection, 4 is also referring to inspection. Now what is the difference, this is inspection regarding to thickness measurement. Whereas this is inspection regarding to maintenance of isolation valve so both are different.

So, whenever you type a new recommendation on the same stack or the same line on the same segment if a recommendation is new it gets a new number and the recommendation is a existing it gets a old number. So, you can easily summarize. It avoids lot of repetition this will improve clarity, therefore a self generated numeric index in particular in the recommendation column of hazop report is useful in integrating the complete report to summarize that is first advantage. Secondly, it avoids repetition. Three, it improves clarity. This is sort of micro word replacement, because this improves clarity this

improves repetition. But it is actually done by the software automatically by referring it to the standard database.

Let us look back the screen again we will continue with the cause number 2, isolation valve getting stuck. The consequences can be pressurization in the upstream line and process upset. Of course the risk ranking is automatic by severity and likelihood generated on a five point scale, I will come to this slightly later. Then the safeguards available are the pressure gauge available for each line so that this pressure gauge can check whether the pressurization happening in the upstream line is beyond the threshold value of the pipeline or not. However, non return valve is also available which will always avoid the process upset, because whenever the line is stuck or closed it will not allow a back flow in the given line.

So, that is also considered as an advantage as a presence of non return valve. However, to improve on the facility to mitigate the consequences seriously we recommend to introduce pressure transmitter and provide periodic inspection of the maintenance of the valve, because choking of the valve because maybe due to a non maintenance of the valve in many reasons

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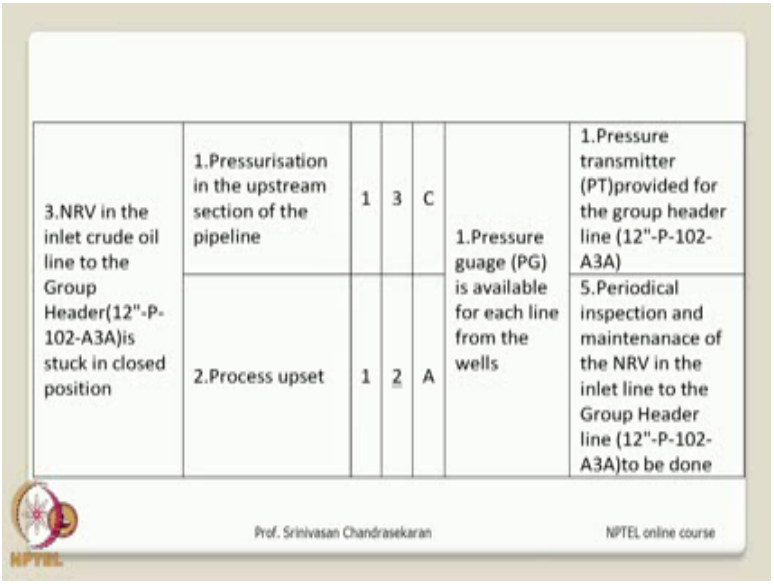

Similarly, the third cause could be the non return valve in the inlet crude oil which is again stuck closed position, so it may result in pressurization of the streamline. So obviously, when you say the pressurization is one of the consequences of the upstream line it gets a number automatically as 1 when you repeat it again. Similarly, when you say process upset it gets a number automatically 2, because it related to the same. However, it can always create this number different because the process upset caused because of leak and the process caused because of closing of the valve get the same number. This is close of the valve it gets number 2, this also close of the valve isolation valve gets number 3.

However, this process upset was due to leakage it gets number 3. So obviously, there is no ambiguity in the report. You need not have to remember all those events, you need not remember the sequences and the numbers allotted, the database available in the software self generates these numbers whenever you key in this recommendation or this consequence automatically from the drag and drop menu available in the software the number is automatically available parellely for you to refer.

So, we are talking about non return valve in the inlet crude oil which is stuck up in a closed position, it may result in pressurization of the upstream line, it may cause process upset. Pressure gauge is available in each line so again this recommendation or this safeguard availability is common; pressure gauge available from each line from the wells so it gets a number automatically from the database. Now see that though the hazop report looks like as it was spreadsheet or an excel sheet available in written in simple English, however we can see there is an intelligent link happening. So, please pay attention here.

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The hazop report generated using software has following advantages; one it creates cross reference automatically. Set of causes, consequences, safeguards, and recommendations are available in the database. They can be easily used with pull down or drag and drop facility. And most importantly, the database actually helps you to prepare a professional hazop report, because for example when you are preparing a report for the first time you may not know the technical knowledge of writing recommendation, identifying safeguards available in the given system, or identifying the consequences. There should be uniformity; there should be a professional touch in the report so this is automatically generated. So, the software will assist you from its database available.

Most interestingly one can also update this database with user interface. So, it is very interesting that we have got many advantages by using software for a hazop report. So one may disagree with me, the hazop report is not a simple English written or generated tabular form, it is having some mathematical connectivity, it is having improved clarity, it is having a very strong inbuilt implicitly existing database for references which are actually referred from international regulations of oil and safety industrial directorates.

So all these words, all these professional statements available in hazop reports as generated by any software in this case we have used pha-pro they will help you to

generate a professional report and they will definitely help you to avoid repetition in your entry and that improves clarity of the whole report when you actually summarize.

Now, let us pay attention back to the screen now. This is the third cause for a flow no that is flow is the primary keyword here.

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No is the secondary keyword, on the other hand flow is the design intent in the given line, no is the deviation in the given line. So, what are the reasons, what are the causes for no flow? The first cause was; we could say it is a leak in the crude oil line. The second cause could be the isolation valve is stuck in closed position. The third cause could be the non return valve; NRV is stuck in the closed position and so on so forth.

Please pay attention to the screen now the consequences arising from NRV getting stuck in the closed position results in pressurization of upstream line and process upset this gets the severity and likelihood automatically on a given number, I will show the matrix at the end. The pressure gauge to check the pressurization is available already as a safeguard. However, we recommend introducing a pressure transmitter in the given line, the number is still generated automatically cross refer to existing database available. We also say periodic inspections, so you may get a new number here because this inspection

is pertaining to NRV, whereas the previous periodic inspection pertaining to isolation valve it gets a number 4. Now this gets a new number 5. So, the number is automatically generated depending upon the recommendation foreseen by you as a hazop item.

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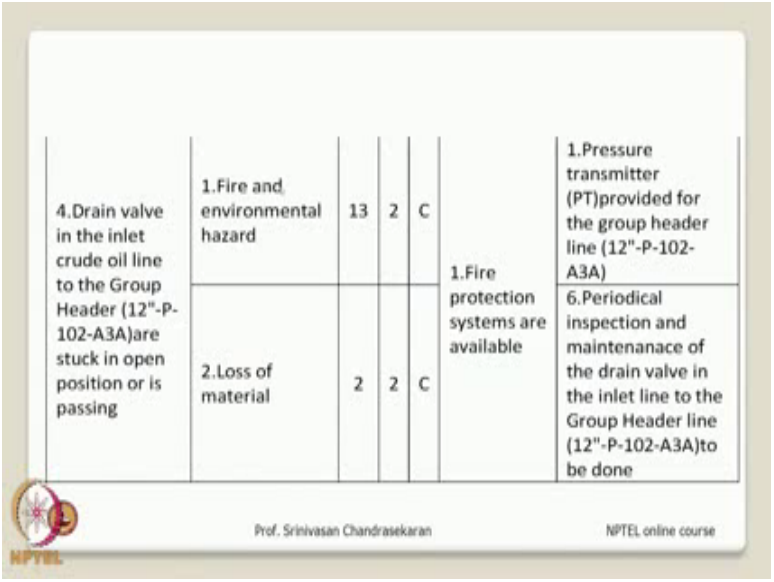

Similarly, the 4th cause could be the drain valve in the inlet crude oil pipe struck in open position or it is passed. The 4th could be the drain valve is kept open. Moment the drain valve is kept open there will no flow in the line because whatever crude oil you pump from the header will all go through the drain valve there is no flow in the line at all. Now, this can result in fire and environmental hazard. The moment you see here fire and environmental hazard it gets a same number as you see from here. So, there is a very interesting self generated facility available in software and that is one of the main advantage if use the software for hazop writing.

So, loss on material this gets a risk ranking and the likelihood; the severity, the likelihood and risk ranking. Fire protection systems are anyway available to control the fire and environmental hazards, but however we are always recommend a pressure transmitter provided it gets the same number because it is referring to database. We say periodic inspection on the drain valve. The periodic inspection refers to drain valve therefore gets a new number 6.

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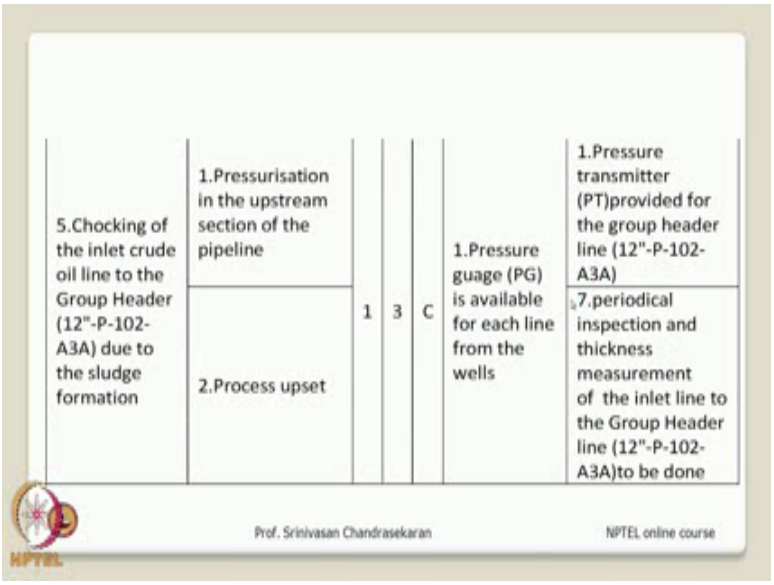

Let us move ahead, 5th cause could be choking of the inlet crude oil line. Pay attention to the screen. Now it will result in pressurization, it can cause process upset, it has severity and likelihood on a scale of 1 and 3 like this, the risk ranking refers to C, pressure gauge is available in the safeguard already which can tell me whether the pressure is extent is dangerous beyond limit or not.

However, we recommend introducing a pressure transmitter in addition towards existing available plus we also recommend periodic inspection since this inspection is related to inlet line thickness measurement we say number 7 automatically generated from the software.

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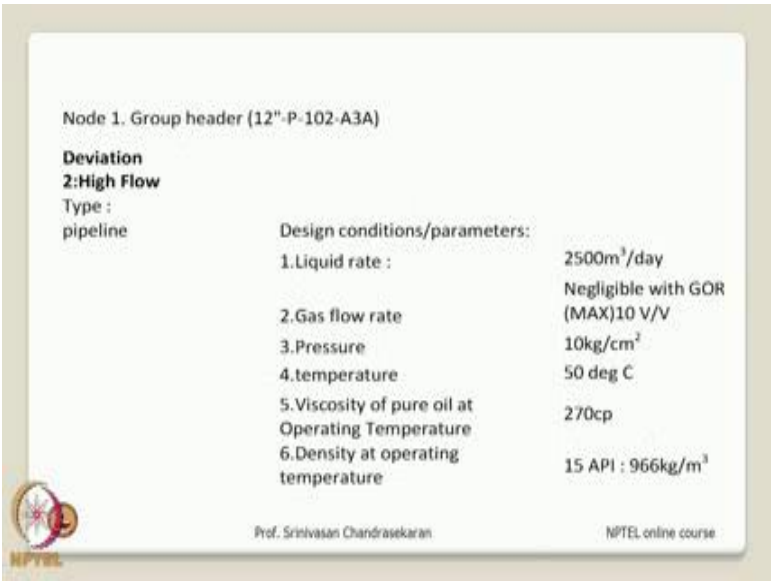

So, now let us go to the second deviation. The first deviation on the design intent was flow no that is the first one. The second one what we are going to see now for the same segment is the deviation is high flow; flow high one can say like this. That is the case what we are now discussing. Now, we are looking at the node 1 the group header this 12 inches P-102 A3A there is a designation on the pipeline available and given by the user. We are looking for high flow or flow high. The design conditions which we are now estimating the liquid rate, the gas flow rate, the pressure, temperature, viscosity and density, these are available and measured on site which is in the given flow line.

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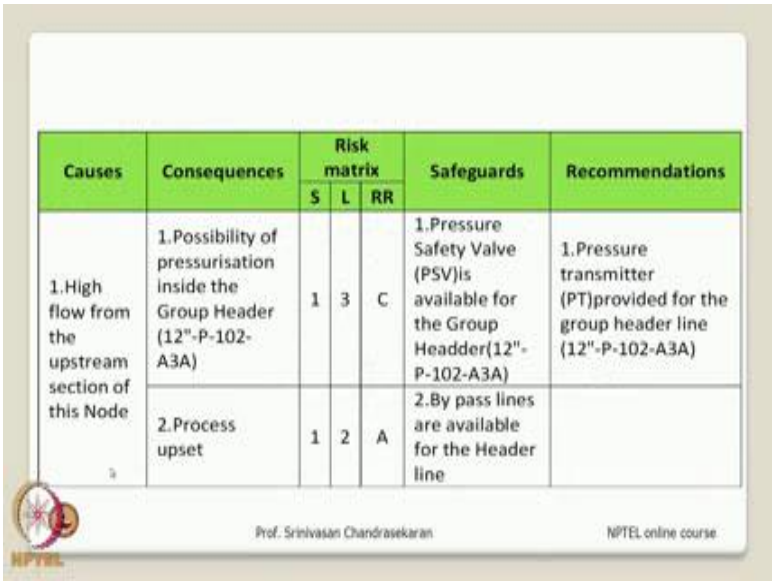

Based on which we identify the consequences and causes. The causes could be one of the cause resulting from high flow could arise from the upstream section of this node. This can cause a consequence of pressurizing the group header. It can also result in process upset the safeguard available we already have a PSV what abbreviates for pressure safety valve. So, whenever there is a high flow indicated in the line the pressure safety valve will be released and the flow can be controlled, because the pressure has got to be anyway controlled otherwise it will result in catastrophic blast.

So we have a safeguard present in the system PSV's are available, bypass lines are also available. Whenever there is a high flow in a given line you can always bypass the production line from section A, A to section B. So, bypass lines are also available in the design in the original group header, so we take that as an advantage. However, the unit recommended provision of pressure transmitter is a common recommendation therefore the number 1 is again continuing from the database.

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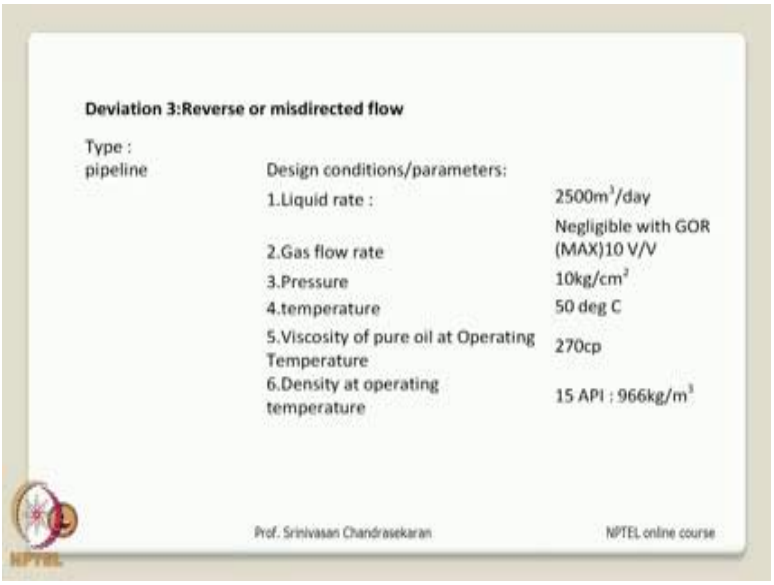

Similarly, the 3rd deviation could be reverse or a misdirected flow. So, the third could be flow reverse. The first case was a no flow, the second case was there is a high flow, and the third was a reverse flow. So one easily see here what are those secondary words getting combined with the primary words or what are those deviations expected from the design intent in a given hazop report. You get an experience of learning this by studying more and more on this hazop report. I prefer and I recommend strongly you should have an access to any one software there is one freeware available on the net you can try this.

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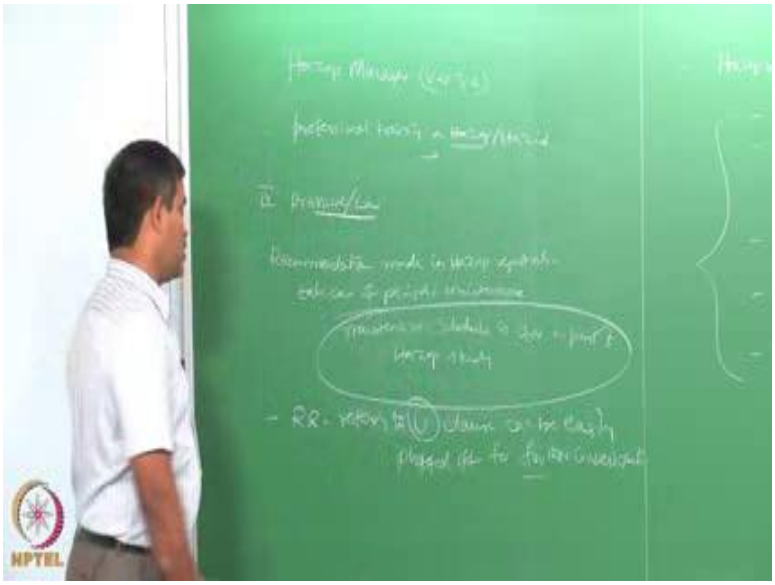

Hazop manager version 3.0, is a freeware this will give you a glimpse of writing an hazop report. And most of the software's which are commercially available for hazop report production are also available on a free trial basis for 15 days 1 week etcetera, you can also have an experience of this. And many of the companies in India of course and in Abroad which you can see from online do conduct professional training on hazop and hazid. They do organize certificate courses for a very short duration of 1 week 3 days like that. Please look around for that they will give an access to the software as well you can join them and try to learn.

So, it is very interesting. Once you learn how to write a hazop report you will be finding it very fascinating and interesting and it is very simple. Now let us pay attention to the screen. The 3rd deviation what are aiming at is reverse flow or miss directed flow. The design conditions are available on the screen now.

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For the same design condition we say that the causes could be the isolation valve in the first group header or the testing line is stuck in open position. The consequences can be it can upset the process line it can result in loss of containment. There are no of course specific safeguards available. Interestingly you see the safeguard column against this cause and consequence remains blank. So therefore, it is very essential that we introduce recommendations of pressure transmitter provision on the line and periodic inspection of the isolation valve.

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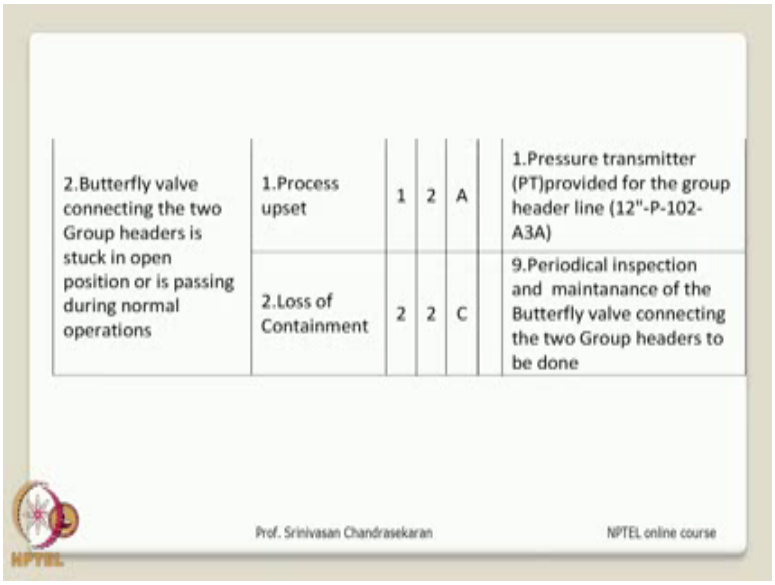

So, one can extend the second reason for reverse flow the butterfly valve connecting the two group headers is stuck in open position. So one can say that will cause process upset can result in loss of containment, so periodic inspection of butterfly valve can be introduced. For example, you can also add one more here introducing sensors or alarms to indicate that the butterfly valve is left in open position that can also be one of the recommendations. We can always introduce a sensor in a given line and connect the sensor to the control panel. So, the control panel personnel will know that the butterfly valve is left open or stuck up in open position.

So, no safeguards are available against this particular cause and consequences in the system therefore this is left blank. And recommendations are there and the number is automatically borrowed from the existing database as the previous recommendation referred first. Whenever you refer this for the first time it gets a number, when you refer it for the second time it borrows the same number back again.

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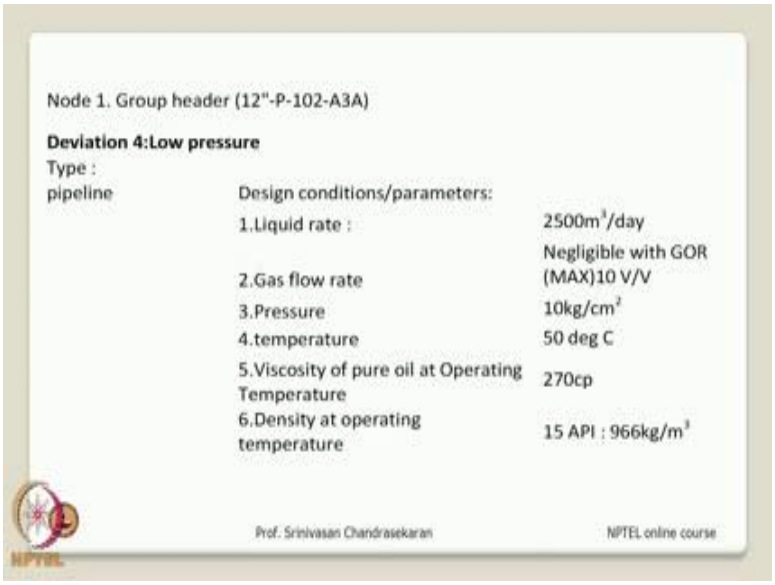

The 4th deviation could be pressure low. There can be a low pressure in the given system, so the data which we are looking at is the liquid rate, gas flow rate which is common. Of course the viscosity is about - 270 centipoise here and the density at operating temperature is about 15 API. The pressure operation is about 10 kg per centimeter square. We are talking about low pressure in a given line.

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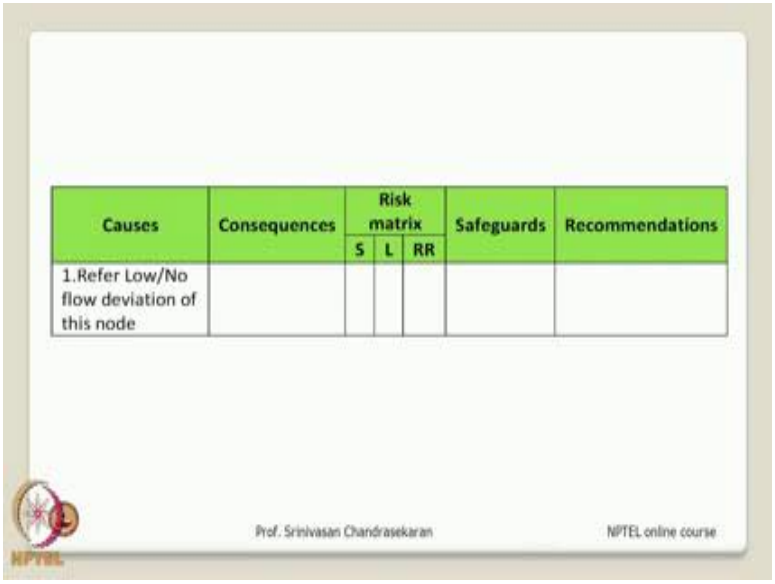

The causes could be there can be no flow deviation in the given node. This will of course, have no consequences because the pressure relief valve will be able to control or the bypass lines will be able to accelerate the pressure availability and therefore the line will not be disturbed it will not cause any process upset at all. Therefore, thought this cause is identified it will have no serious consequences and therefore no recommendations to this effect are made in this specific study.

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Similarly, the second could be a high pressure. It can again have a more deviation in the flow line. Even there is a high pressure, pressure relief valve already been attempted in the second flow high so we can see here the pressure can be also higher here. Therefore, those recommendations will take care of this consequences and causes as well. So, no specific recommendations are required for this specific flow line etcetera.

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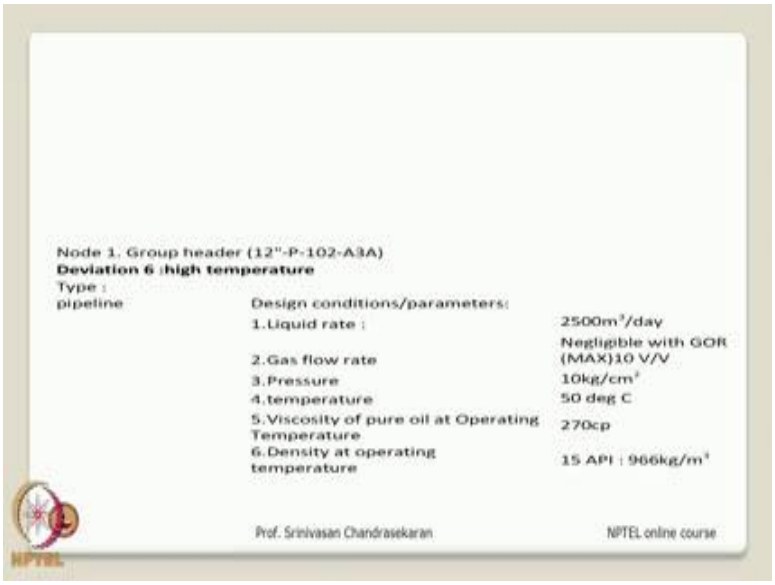

The second the next can be a deviation 6 which is high temperature - high temperature will result in external fire.

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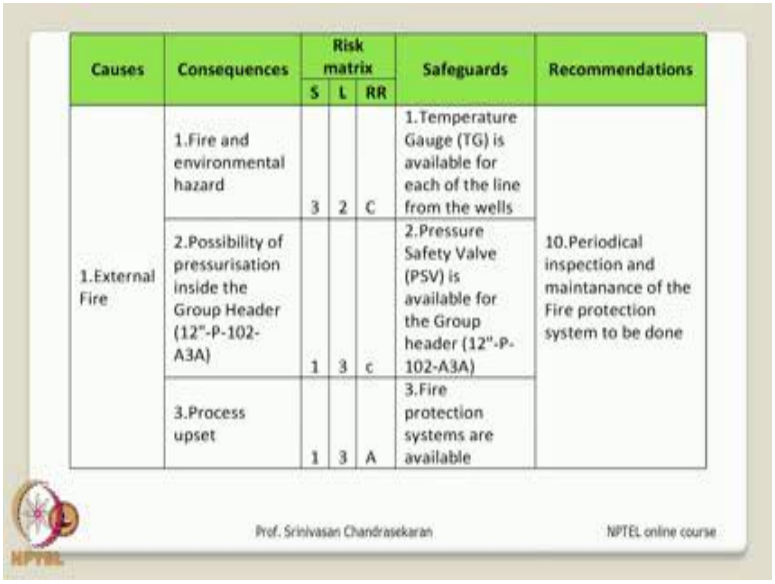

Because you know temperature is one of the important sources which can cause fire. So, high temperature will result in external fire. You have a fire environmental hazard,

borrows a number from consequence one which I already have indicated. There is a possibility of high pressurization in the group header line, the process upset can happen. Safeguards existing in the system are the temperature gauge is available for each line, pressure safety valve is available for each line, fire protection systems are available for each line; however we recommend periodic inspection of the specific system against fire protection. Because all these temperature gauge pressure, safety valve, fire protection systems need to be periodically inspected and tested and maintained properly so that these safeguards can really control the consequences or the effect of consequences which arise from these causes.

So, please understand this is a very interesting part I want to discuss here. Even though you say these consequences can be easily taken care of by already existing safeguards say temperature gauge, pressure safety valve, fire protection systems like sprinklers etcetera, you must ensure in the report that they all should be maintained properly in order. So, always put a safety recommendation here that they should be periodically inspected and maintained, and there should be record available in the system that when there was lastly service, when there was lastly maintained, at what pressure and temperature and operating condition they were tested. So, that should be available for inspection and based on that you will recommend that periodic inspection still is necessary so that such serious hazards can be easily controlled if these are available in place and they are also working.

So, you have to ensure that hazop reports also take care of interesting periodic maintenance that is very important. The recommendations made in hazop report also take care of periodic maintenance. That is why I said maintenance program or maintenance schedule is also a part of hazop study that is very important. Pay attention to the screen now, we are looking for the cause and consequences arising from high temperature we said it can cause external fire.

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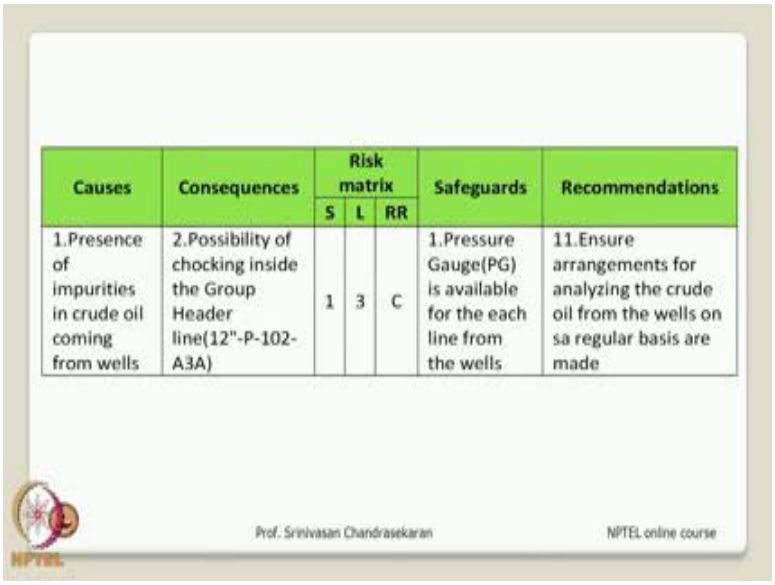

It can cause the presence of impurities in crude oil coming from the wells; it can result in choking of the line, because that can result in high temperature. The safeguard is pressure gauge is available to release this pressure. However, ensure arrangements that crude oil is free from this kind of impurities on regular basis.

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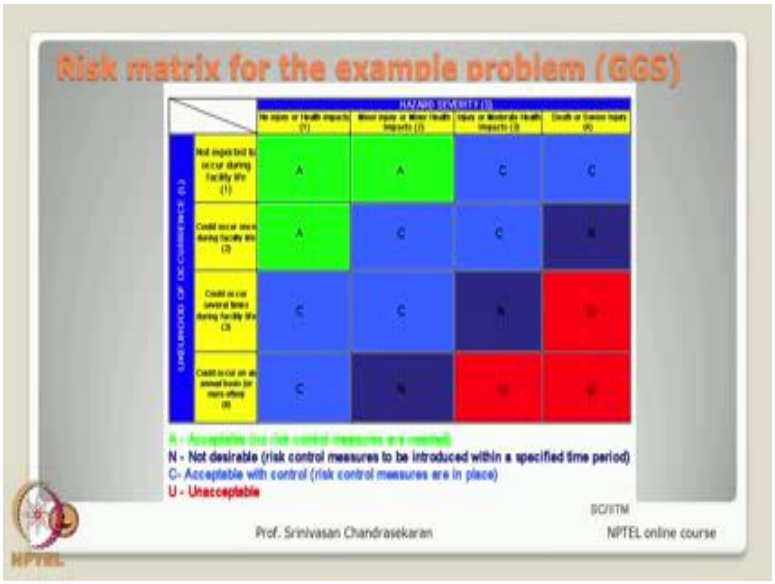

Now, kindly pay attention ladies and gentleman to the screen, we are talking about a new idea which is risk matrix for the example problem. So, for a hazop reports we have not been connecting risk. As we all agree at this stage we clearly know hazard and risk are two parallel facets of any analysis; hazard is much generic, risk is very specific and particular, risk should include or generally includes economic perceptive, hazard is more basic. If you are able to control and mitigate hazard risk will automatically be controlled. Therefore risk reduction, risk elimination are all a part of hazop study.

So, we already saw this in detail in the previous lectures, but now I am trying to integrate the risk analysis with hazop report. Hazop report is a qualitative study, risk analysis is quantitative study. So one can integrate this interestingly in hazop report by creating what we call the Risk Matrix. What is a risk matrix? Risk matrix will have a matrix of columns as you see here which will indicate the likelihood of occurrence on the rows; these are all rows these are all columns, the columns will indicate hazard severity as S and likelihood of occurrence as L. So, all these columns will refer to hazard severity, all these rows will refer to different likelihood of occurrence.

Now one can say not accepted to occur during facility life, if you do not expect a specific likelihood of occurrence at all to occur within the life time of the structure at all give the number as one. If you feel that it could occur once during the lifetime of the facility then it is 2, it could occur several times it is 3, if the likelihood is very very large it is 4 very often it will occur. If it occurs and it does not cause any injury which is hazard level then you call them as A. So, A indicates it is acceptable because there is no risk control measures needed for such kind of hazards.

So, the green ones indicates acceptable, the dark blue ones indicate may not be able to see the number here because of the color, this indicates non desirable. The C 1 indicates acceptable provided you have a control. It means the risk is under control, whereas the red ones indicate they are unacceptable at all by any means. So, this is the matrix which indicates me what is the likelihood of my specific event what I am discussing; this is referring to be cause, this going to be consequence. If I feel my consequence is falling in any one of this matrix the specific alpha numeric character can be attached to the hazop report directly.

Let us now go back and see presence of impurities in crude oil coming from the well it says the severity is of one. So, it means the severity of one it means there is no injury or health impact cost by process of crude oil in the given line. And the likelihood is on scale of 3 though the presence could be very frequent though it is on a scale of 3, but still it is not going to cause any injury or health impacts at all.

So, based on these two you get the risk ranking as C from the risk matrix because 3 and 1 would refer to C and C indicates it is acceptable with a control. So, what is the control we are recommending? We are recommending that ensure all arrangements were free from this kind of impurities periodically. So, 1 and 2 severity 1 which is coming in the vertical column, likelihood 3 which is coming from the horizontal row crosses at C and C indicates acceptable provided your risk control and we are recommending that this should be controlled with this recommendation.

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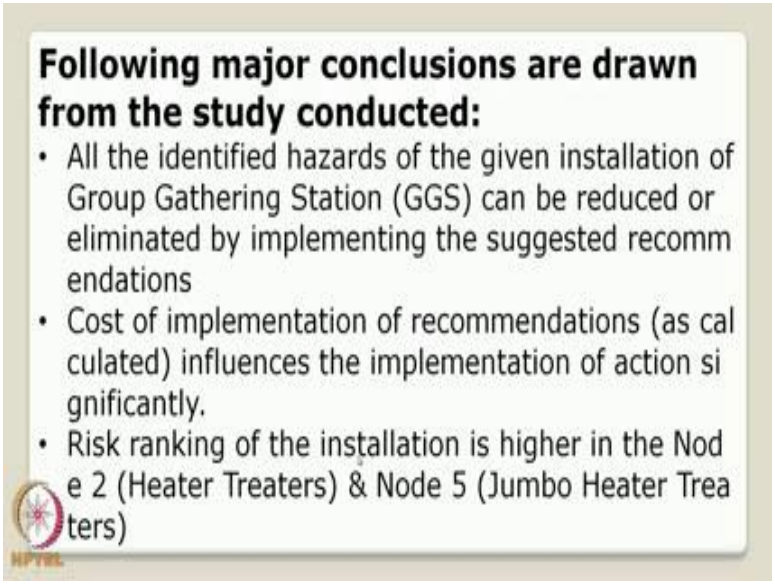

So, one can easily link the risk ranking from the risk matrix which is qualitative, which is connected to hazop report and hazop report itself will indicate risk also. So, a risk manager or a hazop manager can easily will able to know depending upon whether this ranking is in the basis of C A or N or U, U will becoming alarming. So, you will notice that if the recommendation is very strong and the risk ranking shows U for example, let

us see is there any U here. So, you have A here is one need not have to bother about this at all because A is an acceptable risk even if there are no measures. So, if there is anything U one can really look at that particular recommendation and then immediately act on that so that risk mitigation or hazard control becomes more effective.

So, risk matrix is a very interesting and logical technique which is interlinked to the hazop report in the recent past which helps the hazop manager to summarize and easily find out. On the other hand if you really wanted to know what are those recommendations related to the causes which is referring to risk ranking of U one can again plug it out from the hazop report easily. So, this will give me a specific node that is group header 12 inches P-102 A3A there is a node number in the group header a specific node has got a specific consequence and cause which is recommended which has got a risk ranking of let us say U. So, one can plug it out easily from 100, 300, 500 pages report in a very easy form that is very interesting advantage you have in hazop report generated by a software.

The risk ranking referring to U class can be easily plugged off for further investigation. That is what main advantage you have when you write a hazop report using software. So, that is very interesting and therefore one can easily try to do risk, so that is the risk ranking available. So, one can draw the following conclusions from the specific study let us quickly see this.

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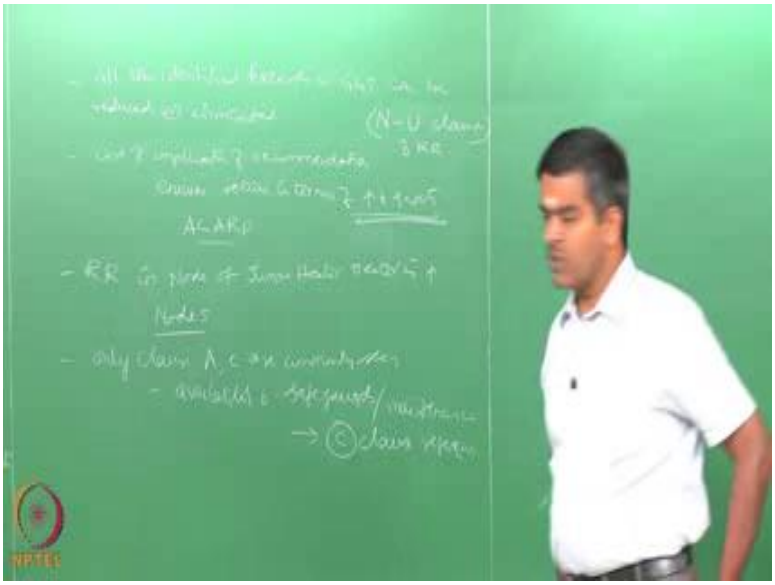

It is seen that all the identified hazards in the group gathering station can be reduced or eliminated. How can we say this? Because none of them follow N and C class sorry N and U class of risk matrix, so they can be either eliminated or reduced. Two more interestingly the cost of implication of recommendation, what do you mean by cost of implication of recommendation? Suppose if you have introduced or you want to deliberate introduce a pressure transmitter in a given line it requires some additional financial investment.

Of course, the cost of implication of recommendation ensures the term in terms of improvement of safety, that is what we call as low as reasonably practical. So, the investment towards this mitigation is giving you a benefit. If it gives you a benefit then it is good that you can invest on them. Next the risk ranking in the node of jumbo heated treatment is highest in the specific study at node number 5, though I have not presented the whole report I have given only the sample of the report. At node number 5 this showed the highest risk ranking. It is also seen only class A C are commonly seen in the report. So, while implementation recommendations related to C 1 has got to be very careful about the availability of safeguards and periodic maintenance of it, because this is very important for C class reference. You must ensure that they work.

So, friends in this study you have understood how to write an hazop report, how hazop report can be interestingly interlinked with the existing database, how a process and flow diagram can be studied segment wise to understand what all the possible deviation in the design intent which could happen in a given line, how software can be easily used what freeware are available in the open domain, how one can create a existing database for a better interference of a hazop report, and how hazop report can be modulated using risk ranking matrix available, and how you can summarize an important documents or set of recommendations from a volumetric hazop report as an hazop manager.

I hope you have understood and enjoyed the lecture. I want to and I really wish that you should have an excess to one of the software of this try to write a hazop report for a small segment in a plant. I hope you will able to enjoy this and you will be able to comfortably do this with the help of this set of lectures available. Should you have any difficulty please post it to NPTEL website to us we will try to answer you.

Thank you very much bye.