Health, Safety and Environmental Management in Petroleum and offshore Engineering

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Module No. # 01

Lecture No. # 08

Hazard Identification and management in oil and Gas industry using HAZOP

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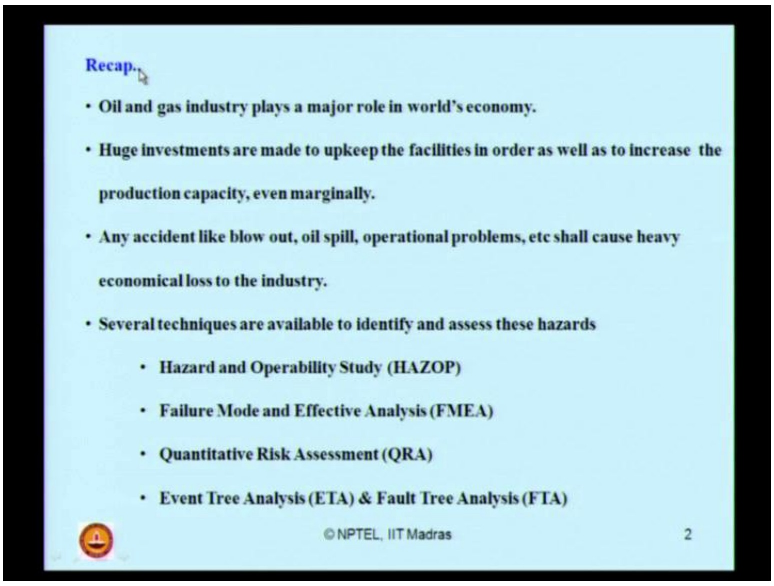

Ladies and gentlemen, now we will continue with module one lecture eight. In this lecture, we will explain you how to conduct in detail an HAZOP study for a specific example, which I will illustrate you step by step. So, this lecture is dedicated to hazard identification and management in oil and gas sector using HAZOP methodology. Let us quickly recapitulate why and what are all the important factors which lead us to do HAZOP study.

Oil and gas industry plays a major role in world's economy. Huge investments are made to upkeep the facilities in order to increase the production capacity, even marginally. Any accident like blowout, oil spill, operational problems, shall cause heavy economic loss to the industry. Several techniques are available to identify and assess these hazards.

For example, hazard and operability study which we call as HAZOP which are now focusing in the present lecture. Failure mode effect analysis which is called FMEA, which we will discuss in the subsequent lectures. Quantitative risk assessment (QRA), which we will discuss in the next module. Event tree analysis and fault tree analysis - ETA and FTA respectively which we will discuss in the subsequent modules.

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Let us quickly recapitulate that HAZOP is actually applicable at four stages of operation. You can apply HAZOP at the drawing board stage which we call as a design stage. You can also apply HAZOP at the construction stage or the process stage. You can also apply HAZOP when you want to make any process modifications or finally, you can also do an HAZOP study once the accident has occurred. We specifically call this kind of action as accident investigation report - AIR.

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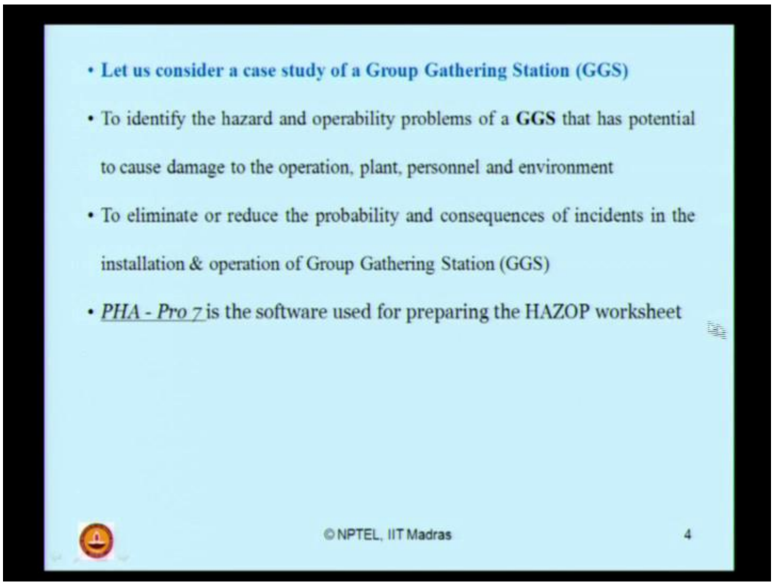

Now, I want you to take through a case study which we will discuss and prepare an HAZOP report for this case study. This is actually an application problem of a group gathering station. I hope you all understand what do I mean by a group gathering station. I will explain very briefly what is the segment of analysis of a GGS considered in the present study. I have identify group gathering station and tried to located the hazard and operability problems of that station because a group gathering station in general has potential to cause damage to the operation plant personnel and environment as well.

So, the objective of this study could be to eliminate or to reduce the probability and consequences of incidence. Remember the catch word here is not an accident. Incident is related to hazard, hazard is a scenario. As long as the hazard or the scenario is not realized into an accident, there is no risk. So, to eliminate or reduce the probability and consequence of incidents in the installation and an operation of a group gathering station. So, this HAZOP study is applied to a GGS at the installation and operation stage itself. I have used a software by name PHA-pro version 7 for preparing the HAZOP worksheet.

Ladies and gentlemen, you can recollect that HAZOP worksheet can be recorded in two formats. You can have a full recording format which includes all possible deviations from the design intent given therefore, the report is very comprehensive. So, here what I am describing to you is a full recording format of an HAZOP worksheet which is prepared or generated using a software by name PHA-pro version 7.0.

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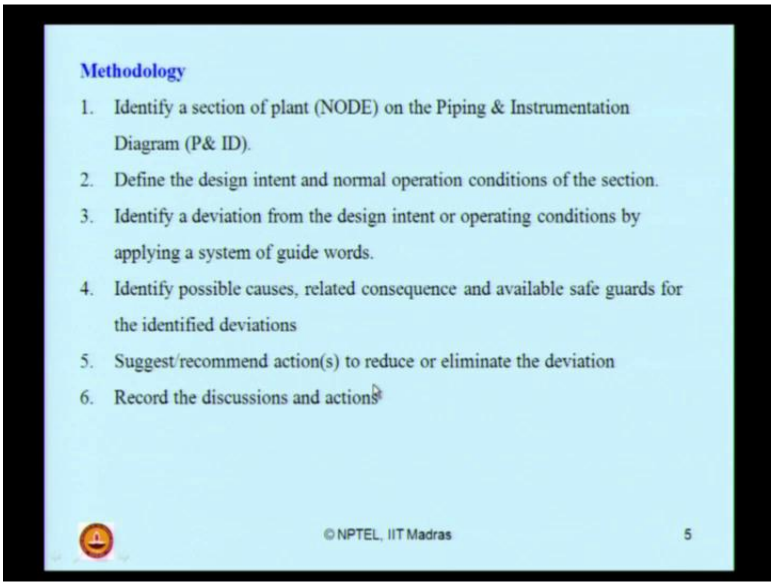

Let us quickly go through the methodology how this case study was done. In a given group gathering station from the piping and instrumentation diagram given to you in detail, study carefully the P and I diagram and identify at least one section of the plant. Now, we call this section identified as node in the study. Now, for that identified section of the plant of the group gathering station define the design intent and the normal operational conditions of this section. Once you have defined the design intent then identify subsequently at least one deviation of this design intent or operating conditions by now applying a system of guide words.

Ladies and gentlemen, recollect that the guide words are primary and secondary keywords which we discussed in the last lecture. Try to make a list of possible keywords which can be appropriately used for the selected problem like a group gathering station. Pick up those appropriate keywords and try to list them before you start doing an HAZOP study. Then identify the possible causes related consequences and existing safeguards for the identified deviations. Based on your detailed investigation carried out on this level, suggest or recommend actions to reduce or to eliminate these deviations. Finally record the complete discussions you have or you intend to have with the management and also what recommendations you propose in terms of reducing or eliminating or mitigating the envisaged risk on the plant.

These are as 8the following six steps of what we will do to carry out the HAZOP report for the case study of the group gathering station.

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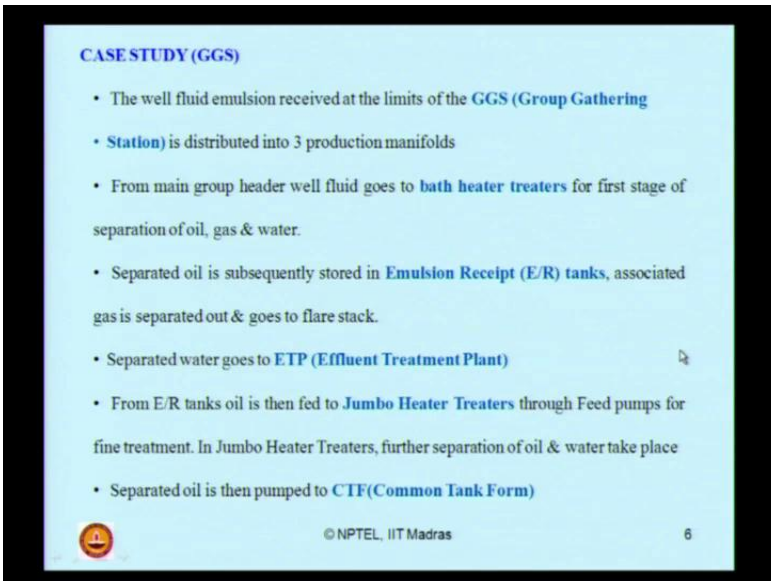

Now, the case study considered is a group gathering station I have a figure of the station in the next slide.

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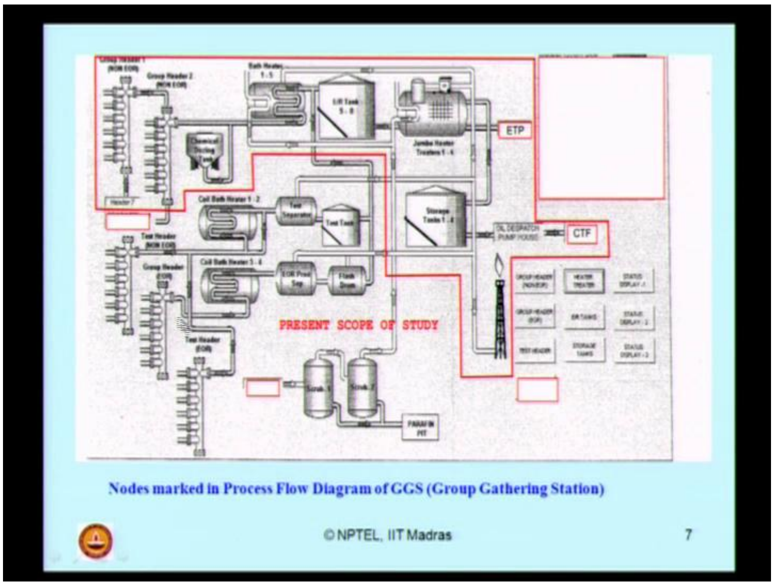

So, this is the group gathering station. I will explain this process very quickly using this figure then I will explain what is actually happening in each of them slightly in detail.

This is a process and flow diagram of a GGS. There are many manifolds which supply oil from the wells which are a type of non enhanced oil recovery feed. I call them as group header, because the name group header qualifies that this is a header which collects from different groups of wells in one. So, I can have many number of group headers. Here in this P and ID, I have got two set of group headers - group header one and group header two. The group header one and two receive the oil supply from the drilling well to this collection point. From the group header one and two, the substance or the content starts flowing to what we call as bath heater. There are many bath heaters located in this scenario, there are about five in numbers. I simply say one to five.

The purpose of a bath heater is, it will separate oil, water, and gas from the accumulated substance from group header one and two. To do this, I need a chemical dosing tank for enhancing this process. So, I supply a dosing chemical from this tank to this bath heater. This diagram do not show any of the instrumentation and the valves located because this is simply a process flow diagram.

If you want to look at the location of valves and other pressure gauges and instrumentations in the system you should look at what we call as process and instrumentation diagram. So, from the PFD diagram once the substance is collected in the bath heaters which is separating oil, water, and gas from the inlet substance the gas collected is transferred to what we call as flare stack. The oil collected and the water together will be sent to what we call as enhanced recovery tank. The recovery tanks ER, there are about five to eight in numbers in this process. Then the substance is forwarded further to what we call as jumbo heater. The jumbo heater again further purifies oil and water, and whatever content of water has been separated, it has been taken to what we call as ETP.

ETP is effluent treatment plant. The oil purified here or separated here is collected in a storage tanks one to four, from the storage tanks one to four the oil is further dispatched through the pump house to a common tank facility from where it will be distributed. So, this is one segment of the process and flow diagram, which is under the present scope of study. These are the nodes which I keep on marking in my P and FD.

So, the well fluid emulsion received at the limits of GGS is distributed to three production manifolds. From the main group header well fluid goes to the bath heaters for the first stage of purification where they separate oil, gas and water. The separated oil is subsequently stored in the emulsion recipient tanks, which are called as E R tank associated gas is then separated out and sends to what is called flare stack. The separated water goes to effluent treatment plant what we call as ETP.

From the emulsion recipient tank, oil is then subsequently fed to jumbo heater through the feed pump, for further refined treatment. In jumbo heater, further separation of oil and water takes place. The separated oil is then subsequently pumped to what we call as a common tank forum. So, this is my process and flow diagram which I am going to concentrate, and based on this diagram and understanding the process I am going to now do an HAZOP study.

Ladies and gentlemen, before we start doing an HAZOP study, we should first understand what is exactly the process happening in the case, and how the flow takes place. Based on this understanding, we should be in a position to select the design intents of different nodes or segments in this case. Subsequently appropriate deviations can be identified, because to prepare a HAZOP report primary and secondary keywords are important. Primary keywords associate to design intent and secondary keywords are associated with deviations. And only this segment of the group gathering station is now currently considered for the HAZOP study. If you have any questions please play back the couple of slides earlier, and try to understand the component level functioning of each one of them for a better understanding of HAZOP report.

Remember, if you do not understand the process and the flow sequence of a given PFD, I am sure you will not be able to successfully prepare an HAZOP report. HAZOP report is a perseverance of possible deviations from the design intents of a given process plant. So, mandatory is to understand the process first. I presume you have understood the functioning of a group gathering station. You have understood the importance of the selected nodes in the group gathering station discussed in the previous slide. Now, taking forward or the HAZOP worksheets, which we are going to prepare using a software PHA-pro.

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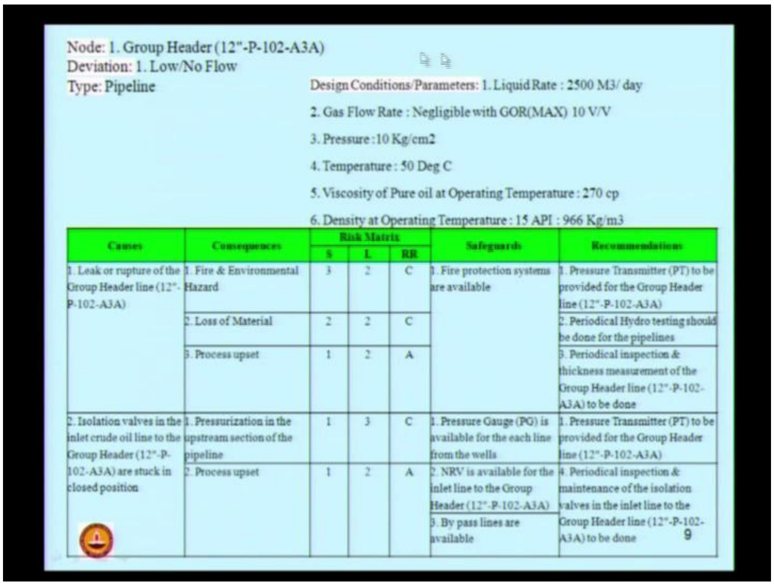

Node: 1. Group Header (12"-P-102-A3A)
Deviation: 1. Low/No Flow
Type: Pipeline

Design Conditions/Parameters: 1. Liquid Rate : 2500 M3/ day
2. Gas Flow Rate : Negligible with GOR(MAX) 10 V/V
3. Pressure :10 Kg/cm2
4. Temperature : 50 Deg C
5. Viscosity of Pure oil at Operating Temperature : 270 cp
6. Density at Operating Temperature : 15 API : 966 Kg/m3

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. Leak or rupture of the Group Header line (12"-P-102-A3A)	1. Fire & Environmental Hazard	3	2	C	1. Fire protection systems are available	1. Pressure Transmitter (PT) to be provided for the Group Header line (12"-P-102-A3A)
	2. Loss of Material	2	2	C		2. Periodical Hydro testing should be done for the pipelines
	3. Process upset	1	2	A		3. Periodical inspection & thickness measurement of the Group Header line (12"-P-102-A3A) to be done
2. Isolation valves in the inlet crude oil line to the Group Header (12"-P-102-A3A) are stuck in closed position	1. Pressurization in the upstream section of the pipeline	1	3	C	1. Pressure Gauge (PG) is available for the each line from the wells	1. Pressure Transmitter (PT) to be provided for the Group Header line (12"-P-102-A3A)
	2. Process upset	1	2	A	2. NRV is available for the inlet line to the Group Header (12"-P-102-A3A) 3. By pass lines are available	4. Periodical inspection & maintenance of the isolation valves in the inlet line to the Group Header line (12"-P-102-A3A) to be done

9

For example, let me identify the first node. Name the node as one. Remember this is not a typed excel sheet this is an outcome or a screen saved from basically the software output. So, the software output says node one identified is given as group header which is basically a twelve inches pipe designates 102-A3A class. The deviation from the design intent is low no flow. And the type is a pipe line. So, basically you are talking about a flow, and the deviation could be either there is no flow in the line or there can be a low flow in the line. The design conditions and parameters considered for the study are the following.

The liquid rate is about 2500 cubic meters a day. The gas flow is negligible, the operating temperature in pressure 50 degree Celsius and 10 kg per centimeter square. The viscosity of the oil is about 270 cp. And the density at operating temperature is about 966 kg per cubic meter. For the design intent and the deviation identified for the flow to be either low or no what are all the possible causes, what could be the consequence, what could be the safeguard and what are the recommendations, I will focus this specific column slightly later.

Let us first identify the first class which can result from either a low or a no flow on a pipe segment twelve inches diameter from a group header. There could a possible leak or rupture on the header, if there is a leak or rupture you can very well understand there could be either no flow or there could be low flow. The consequence this leads to a fire and environmental hazard. There can be loss of material, the process can become upset. So, all these possible consequences are subsequently numbered in an order, even all the causes are also subsequently numbered in an order. You may wonder why this numbering is significantly important.

This is necessary, because when we generate a report later by identifying the number I can easily access any specific cause or any specific consequence for any specific deviation in the report. That is electronically possible, because this is software generated report.

So, wherever you see any of these recommendations given it automatically generates a number associated under a specific heading. For example safeguard one for example, a new cause again 1, 2, and so on. So, there is an order, there is a format, there is a protocol which is a software initiates by itself, it is very easy and necessary understand why this has happened.

After identifying the possible consequences for the causes resulting from these deviation on a twelve inches flow pipe line of a group header, which is operating under the following pressure and temperature, let us examine is there any safeguard present in the system. Remember the availability of safeguard is not seen in process flow diagram, you must look for process and instrumentation diagram. Once you looked at the process and instrumentation diagram, you will know what are the possible existing safeguards or recommended safeguards.

For example, these specific case fire protection systems are available in position in the GGS. Considering the due regard for the existing safeguards in the system we recommend the following; the pressure transmitter to be provided for the group header line just to check whether the pressure can record a low flow, because pressure and flow are related anyway quantitatively. So, if my group header has a low flow, because of rupture, if a pressure transmitter is fitted at least from the pressure transmitter reading one will come to understand that there is a problem of this deviation in the line.

Number two recommendation: Do periodic hydro testing for the pipelines. Hydro testing is a physical examination category which will tell how a pressure to be maintained in an existing pipeline. We also recommend periodic inspection must be carried out, and thickness measurement of the line to be done. The thickness measurement will give me an idea about the quality and standard of lifetime of the pipeline, because if this is corroded or is the crude deposit is happening along the surface of the pipeline, because if the diameter is effectively reduced, pressure will enormously increase whereas, the flow will not be affected.

So, you will be able to understand that by measuring thickness. You can also avoid some further more consequences or deviations on the existing line. When you look at the next cause; for example, isolation valves - in the inlet crude oil line. The inlet crude oil line may have an isolation valves, the isolation valves can also result in a consequence. It can result in pressurization of an upstream section the process can be upset. The safeguards could be pressure gauges are already available to tell whether the pressurization is being done or not, a non-return valve is available just to check that the process is not very seriously upset in the lines.

There are also bypass lines available in this GGS, in case any such problem occur, I can bypass this from this line to next line. However, we still recommend the following. A pressure transmitter is to be provided to check whether the pressure is available properly or maintained properly in the line. Of course, we also recommend periodic inspection.

Now, you may see here very carefully that the recommendation column has a sequence number 1, 2, 3. Now, three relates to periodic inspection, four also relates to periodic inspection. So, two qualitative recommendation cannot have the same number, because this is periodic inspection and thickness measurement this is a different kind of recommendation, this is periodic inspection and maintenance of isolation valve this is different kind of recommendation. So, whenever in the report you start typing, these kinds of keywords in the software, the new number is automatically generated.

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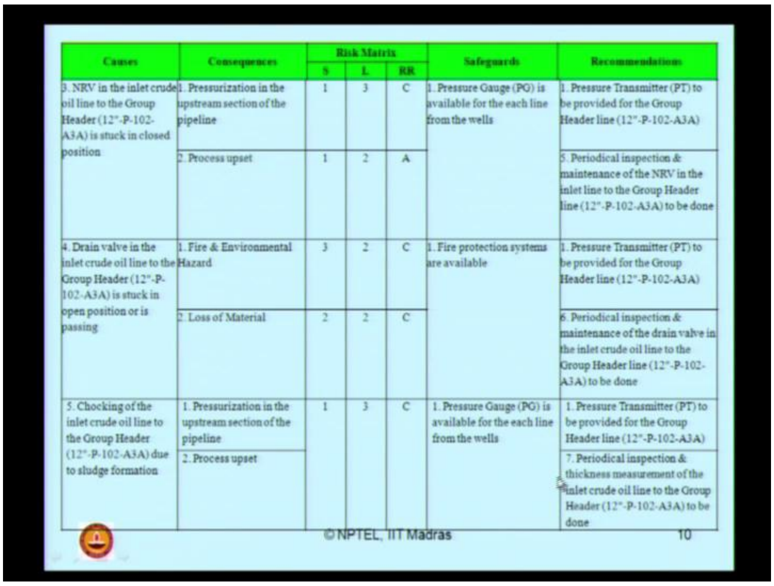

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
3. NRV in the inlet crude oil line to the Group Header (12"-P-102-A3A) is stuck in closed position	1. Pressurization in the upstream section of the pipeline	1	3	C	1. Pressure Gauge (PG) is available for the each line from the wells	1. Pressure Transmitter (PT) to be provided for the Group Header line (12"-P-102-A3A)
	2. Process upset	1	2	A		5. Periodical inspection & maintenance of the NRV in the inlet line to the Group Header line (12"-P-102-A3A) to be done
4. Drain valve in the inlet crude oil line to the Group Header (12"-P-102-A3A) is stuck in open position or is passing	1. Fire & Environmental Hazard	3	2	C	1. Fire protection systems are available	1. Pressure Transmitter (PT) to be provided for the Group Header line (12"-P-102-A3A)
	2. Loss of Material	2	2	C		6. Periodical inspection & maintenance of the drain valve in the inlet crude oil line to the Group Header line (12"-P-102-A3A) to be done
5. Chocking of the inlet crude oil line to the Group Header (12"-P-102-A3A) due to sludge formation	1. Pressurization in the upstream section of the pipeline	1	3	C	1. Pressure Gauge (PG) is available for the each line from the wells	1. Pressure Transmitter (PT) to be provided for the Group Header line (12"-P-102-A3A)
	2. Process upset					7. Periodical inspection & thickness measurement of the inlet crude oil line to the Group Header (12"-P-102-A3A) to be done

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Let us look at the further cause, cause number three. Non return valve in inlet line on the oil group, it can result in pressurization of the upstream section, it can also safeguard is there using a pressure gauge, but we recommend to provide a pressure transmitter and a period inspection of and maintenance of non return valve.

Ladies and gentlemen, remember that when you say a recommendation of pressure transmitter is to be provided for a GGS it gets the number one, which is as same as the number one what you already have in the previous recommendations. So, you can easily identify that there is no overlap of this numbering in any such situations, and so on and so forth, keep on analyzing the drain valve, the consequence then the safeguard and recommendation.

Then choking of the inlet crude oil, the consequence could be pressurization, process can be upset, though pressure gauge is available, you put a pressure transmitter has the same number as it has been given earlier. When you enter for the first time in the software any such kind of recommendation it generates a number automatically, and later on when you try to invoke this particular recommendation the number is carried forward as a constant number through and through of the report. So, absolutely there is no overlap of any specific recommendation.

Now, there is a great advantage of this kind of common numbering, because if you really wanted to know what is that recommendation of pressure transmitter to be fixed, simply type this number one in the through and through report, it will easily access and tell me where this recommendations are to be implemented? For example, the recommendation one should be implemented in NRV in the inlet line, in the drain valve in the inlet line, to avoid the chocking of the inlet line; all locations I have to install a pressure transmitter.

So, I can easily know where are the nodes which can address what cause this recommendation is satisfied. So, this numbering is having a very exclusive and explicit advantage in recording. Look at the periodic inspection just for recollection, the moment I say periodic inspection it compares existing number and periodic inspection and thickness of measurement of inlet crude oil line is having a different number seven like this.

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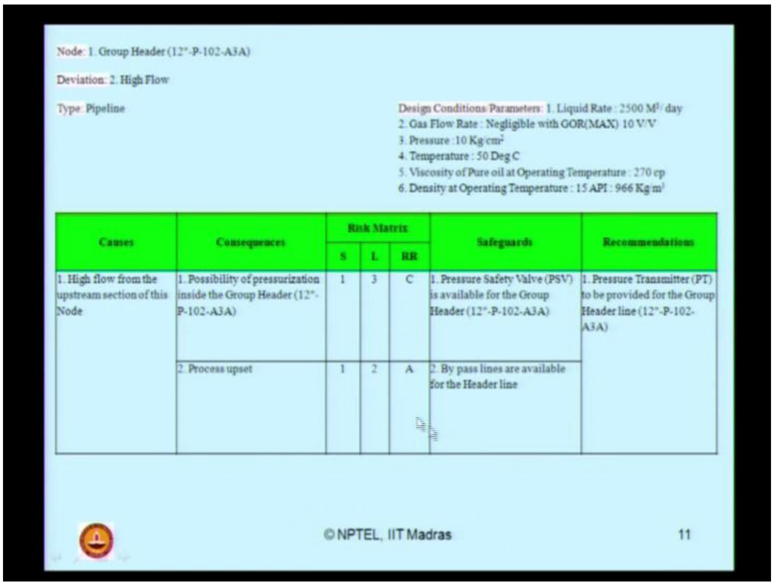
Node: 1. Group Header (12"-P-102-A3A)

Deviation: 2. High Flow

Type: Pipeline

Design Conditions/Parameters: 1. Liquid Rate : 2500 M^3/ day
2. Gas Flow Rate : Negligible with GOR(MAX) 10 V/V
3. Pressure : 10 Kg/cm^2
4. Temperature : 50 Deg C
5. Viscosity of Pure oil at Operating Temperature : 270 cp
6. Density at Operating Temperature : 15 API : 966 Kg/m^3

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. High flow from the upstream section of this Node	1. Possibility of pressurization inside the Group Header (12"-P-102-A3A)	1	3	C	1. Pressure Safety Valve (PSV) is available for the Group Header (12"-P-102-A3A)	1. Pressure Transmitter (PT) to be provided for the Group Header line (12"-P-102-A3A)
	2. Process upset	1	2	A	2. By pass lines are available for the Header line	

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So, let us say, node. The second deviation which is high low, the previous deviation was low or no flow, the type is a pipe line. The conditions of operation remain same. The cause can be if there is a high flow; the high flow from upstream section of this node can cause a pressurization of the line you can already regard for the pressure safety valve provided in the line, but still we recommend to put or install a pressure transmitter in the group gathering line. The recommendation is common for the previous deviation the number is carried forward in the same pressure. Now also remember, if you have already have an existing safeguard like a bypass line etcetera, again the number is carried forward from the previous recommendation.

Like this manner, we can keep on identifying different kinds of primary and secondary keywords, identify the deviation, identify the causes, subsequently consequences, check for the existing safeguards, and keep on recommending, whatever action can be deemed fit to either eliminate the consequence completely or to reduce the effect of this consequence on the process. Let us now focus on this specific column, where I am generating what I call as a risk matrix. This particular column has three sub division as you see here. S L and R R; S stands for severity, L stands for likelihood.

Ladies and gentlemen, recollect from the previous lectures that risk is a product of these two, and I am quantitatively converting - the qualitative statements into a number and based on this number I give a risk ranking, it is not a rank of 1, 2, 3; I am using a rank of A, B, C, D where A, C, B, etcetera have a specific meaning which I will discuss subsequently in the coming slides.

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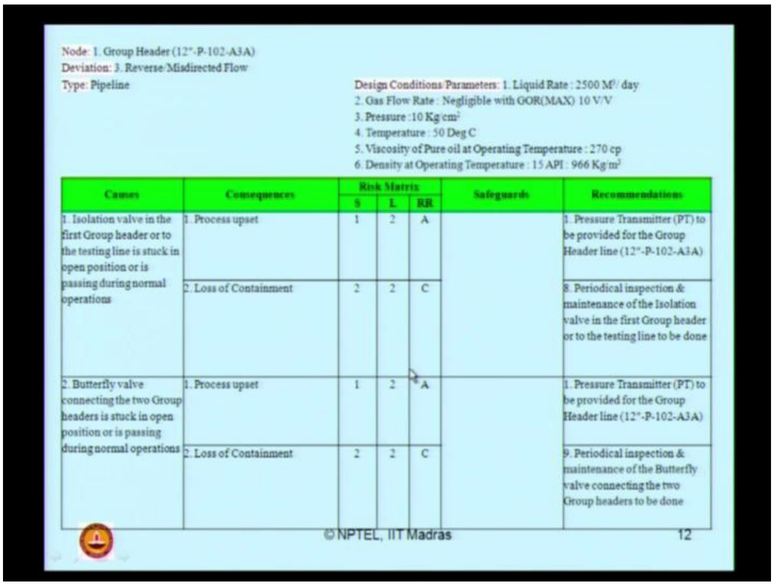

Node: 1. Group Header (12"-P-102-A3A)
Deviation: 3. Reverse/Misdirected Flow
Type: Pipeline

Design Conditions/Parameters: 1. Liquid Rate : 2500 M^3/ day
2. Gas Flow Rate : Negligible with GOR(MAX) 10 V/V
3. Pressure :10 Kg/cm^2
4. Temperature : 50 Deg C
5. Viscosity of Pure oil at Operating Temperature : 270 cp
6. Density at Operating Temperature : 15 API : 966 Kg/m^3

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. Isolation valve in the first Group header or to the testing line is stuck in open position or is passing during normal operations	1. Process upset	1	2	A		1. Pressure Transmitter (PT) to be provided for the Group Header line (12"-P-102-A3A)
	2. Loss of Containment	2	2	C		8. Periodical inspection & maintenance of the Isolation valve in the first Group header or to the testing line to be done
2. Butterfly valve connecting the two Group headers is stuck in open position or is passing during normal operations	1. Process upset	1	2	A		1. Pressure Transmitter (PT) to be provided for the Group Header line (12"-P-102-A3A)
	2. Loss of Containment	2	2	C		9. Periodical inspection & maintenance of the Butterfly valve connecting the two Group headers to be done

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Let us look at the third deviation; there can be reverse flow or there can be misdirected flow on the group header line of 12 inches P 102 A3A under the same operating condition. The isolation valve in the first group header or to the testing line is stuck. There is a process upset, there can be loss of containment, you may not get the supply at all. This may result in severity of level one, likelihood of level two, whereas the containment is larger severity of two and likelihood of two that results in a risk ranking of C. And this resulted in a risk ranking of a; there are no existing safeguards to check whether we can stop this kind of reverse flow.

So, we recommend the following; provide a pressure transmitter to check the pressure line. Do periodic inspection to check the isolation valve for reverse flow. Do periodic inspection and maintenance of butterfly valve connecting the two group headers to be done. They were all not present in the existing system, these are all recommendations what we suggest to the client, who owns this group gathering station.

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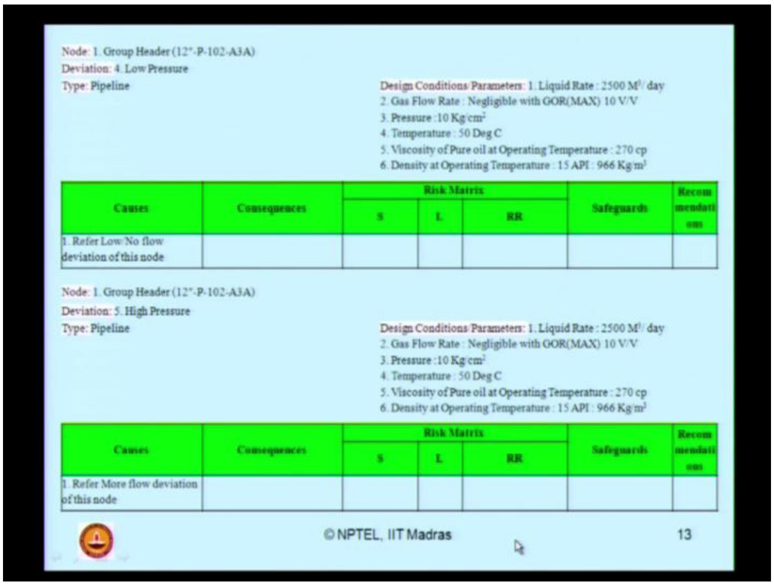

Similarly, the next deviation on the same header line, we can have a low pressure, I have not anyway filled up these two columns, these are all for you has a homework try to locate the low pressure significance on identify the cause. I have identified the causes for you; write down the consequences, pick up the severity and likelihood level of this consequences from the table, which I will show you later. Then identify the risk ranking of them, check for any existing safeguards if you have an access to the process and instrumentation diagram of this problem, and then list down the recommendations as you can continue to do. So, this is a very simple illustration of how to prepare in detail in HAZOP report for a group gathering station on one specific node a group header.

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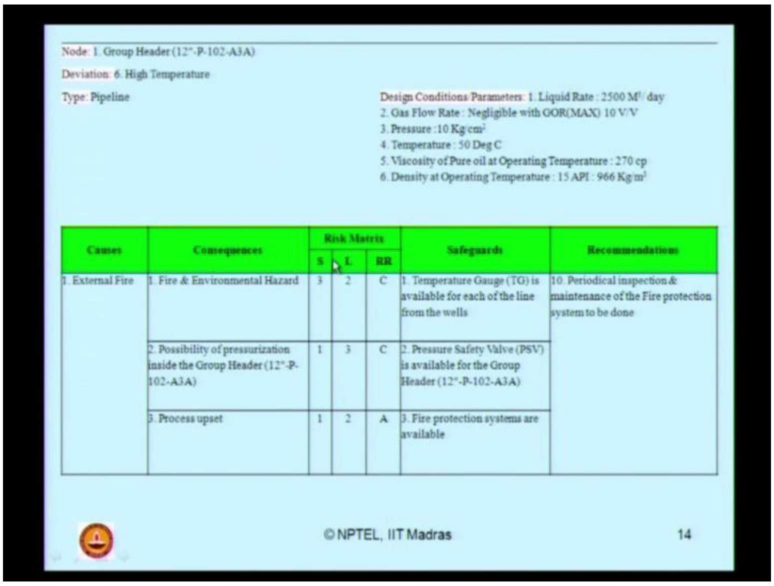

Causes	Consequences	Risk Matrix			Safeguards	Recommendations
		S	L	RR		
1. External Fire	1. Fire & Environmental Hazard	3	2	C	1. Temperature Gauge (TG) is available for each of the line from the wells	10. Periodical inspection & maintenance of the Fire protection system to be done
	2. Possibility of pressurization inside the Group Header (12"-P-102-A3A)	1	3	C	2. Pressure Safety Valve (PSV) is available for the Group Header (12"-P-102-A3A)	
	3. Process upset	1	2	A	3. Fire protection systems are available	

Similarly, you can do for high temperature; high temperature can result in external fire that can result in a fire and environmental hazard. There can be a process upset, there can be a possibility of pressurization inside the fire is having a very high severity, the likelihood is very small lesser than the severity, but risk ranking is C. There are some safeguards to check whether there will be a fire hazard.

There is temperature gauge, but still we say do periodic inspection for fire protection system. Remember that the periodic inspection maybe a common keyword, which you already saw in other deviation, but I am saying do periodic inspection for the fire protection system therefore, it gets a new number ten here. This number is sequentially prepared with the software as you progress for identifying different deviation for different headers or different nodes. There can be variation in composition same fashion you can fill up this area.

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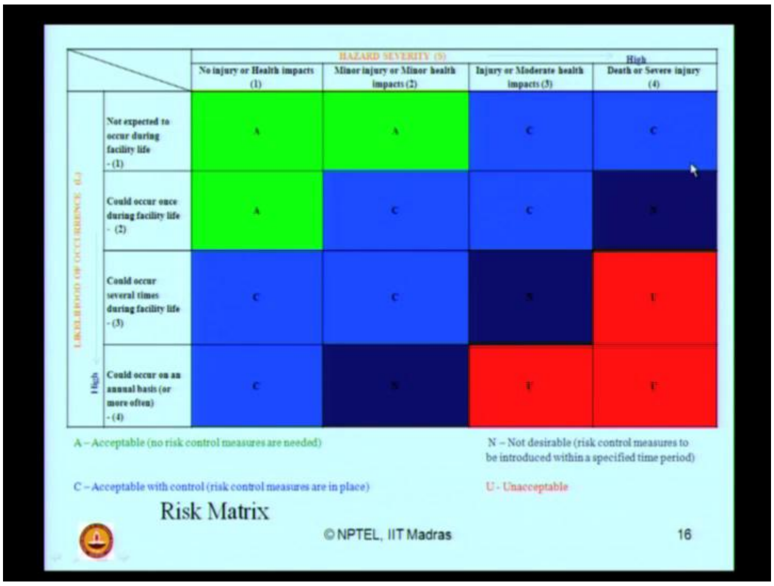

After filling up this, let us now focus on what we call as a risk matrix. The risk matrix is an outcome, what I get? See claim see here the risk matrix is a combination of hazard severity and likelihood of occurrence, which is S and L in the previous columns of the report. Now, if you look at the hazard severity, it has a scale of no injury or health impact, minor injury or minor health impact, injury or moderate health impact, death or severe injury, which we call as high. So, the severity starts from low level to high level, and gets a number one, two, three and four.

Similarly, if you look at the likelihood, starts from low to high level, not expected to occur could occur once during the facility life, could occur several times during the facility life, could occur on an annual basis. So, when it keeps on recording, reoccurring and every year then the likelihood is high; if it is not expected to occur at all, then the likelihood is how. So, again it gets a number of one, two, three and four appropriately.

Now, let us look at, what are these alphabets A, C, N and U doing here? A means the risk level is acceptable; it means no risk control measures are required. For example, if you have any event, whose severity does not cause any injury, and it is not expected during the lifetime of the process plant, then that kind of risk is what we call as an acceptable risk. Similarly, if you have a risk level of C, we say the risk level is acceptable with a control measure. It means you have to recommend certain control measures in position to make this risk an acceptable. For example, if a risk causes injury or moderate health impact on the personnel on board, and if it is not expected very frequently, then I can call this as an acceptable level. But if that injury is happening to the health impact on the people on board; and it keeps on occurring very frequently at an higher level of occurrence, then I must say this risk is unacceptable.

Now, there are certain risks, which are non desirable at all. So, the risk control measures to be introduced within a specific period of time that is very, very important; they are not desirable at all. For example, any risk which is causing a very severe or death injury to a person, even though it could occur only once in a facility life, still we say it is not desirable.

So, ladies and gentlemen, remember that petroleum industry though the risk level is slightly high, but all precautionary measures are taken in terms of identifying the risk level, and trying to recommend certain control measures in detail analysis and study, so that the petroleum industry can be accorded as one of the very intelligent mathematically protected process system, which can be executed safely. And you need not have to bother about the safety part, because there are methods, there are tools, there are people, there are systems, which put this risk under control. So, this is the significance of the risk matrix, which has been derived from the HAZOP report as an additional benefit from the HAZOP study.

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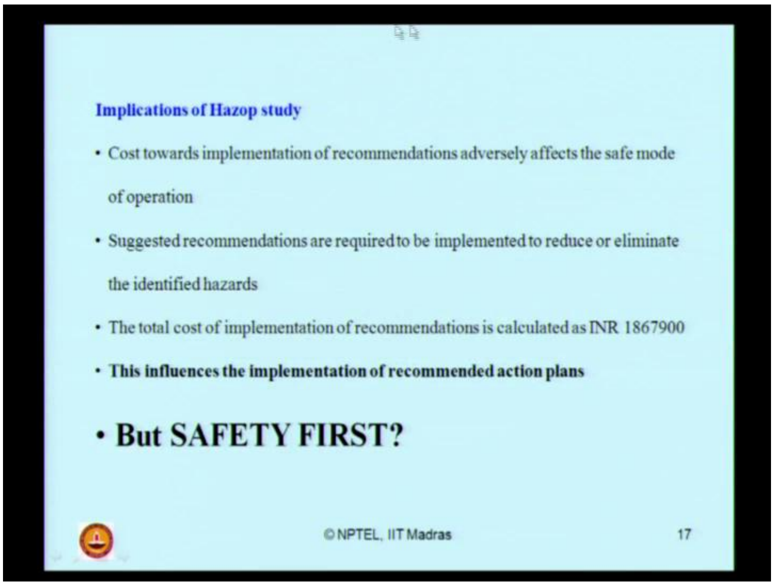

Let us look at the implications of HAZOP study for this case study. Cost towards implementation of recommendations, generally adversely affect the safe mode of operation. The suggested recommendations are required to be implemented, if you want to eliminate or reduce the identified hazards. Of course the total cost of implementation will affect adversely the investment of the plant. In this specific example, it has been arrived at that the total cost of implementation of recommendation is coming to 1867000.

This of course, influences the implementation of the recommended action plan, because this figure as it goes and grows alarmingly high, then the investor will look at the necessity of this investment to reduce the risk, but of course, we all agree that safety is first. There is no compensation of trained people on boards, whose health can be at risk. So, safety first therefore, it is mandatory that anyway this cost has got to be implemented or got to be spent to reduce the risk level within the acceptable standards. Remember that petroleum industry cannot have a zero risk at all, there is always risk present, but we say that it should be within the level of acceptable standards

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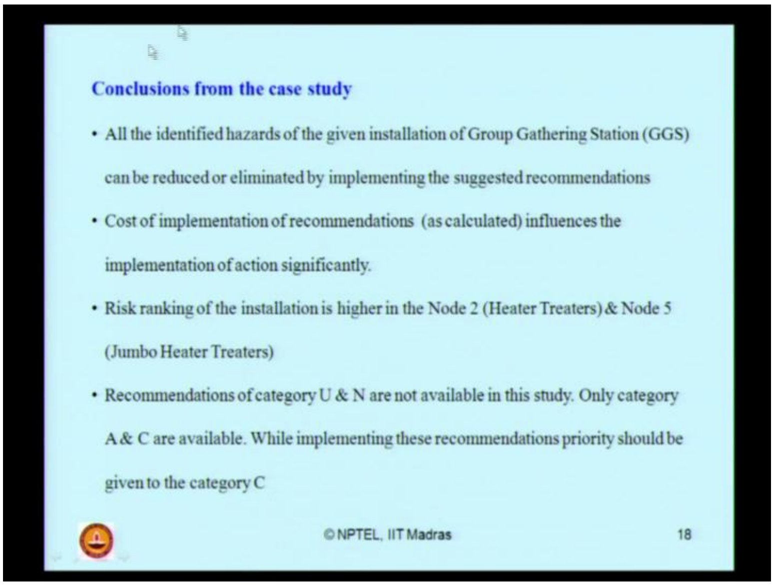

Let us quickly conclude, what we understand from the case study? All the identified hazards of the given installation on a group gathering station can be reduced; it is possible to reduce them. They can even be eliminated of course, by implementing the suggested recommendation. The cost of implement of recommendation influences the implementation of action significantly, it means the cost goes high; then one will really think whether we can revise the action column significantly.

The risk ranking of installation is higher in node two that in heater treaters, and node five that is jumbo heater treaters. If you see any recommendations of u and n of course, they are not available in the present study only the category a and c are available, because this specific node selected for the study does not have anything like undesirable or non acceptable at all. However, even if you have an acceptable and unacceptable with certain risk implementation, then priority should be given to category C; those recommendations to be implemented first than those recommendations given in A.

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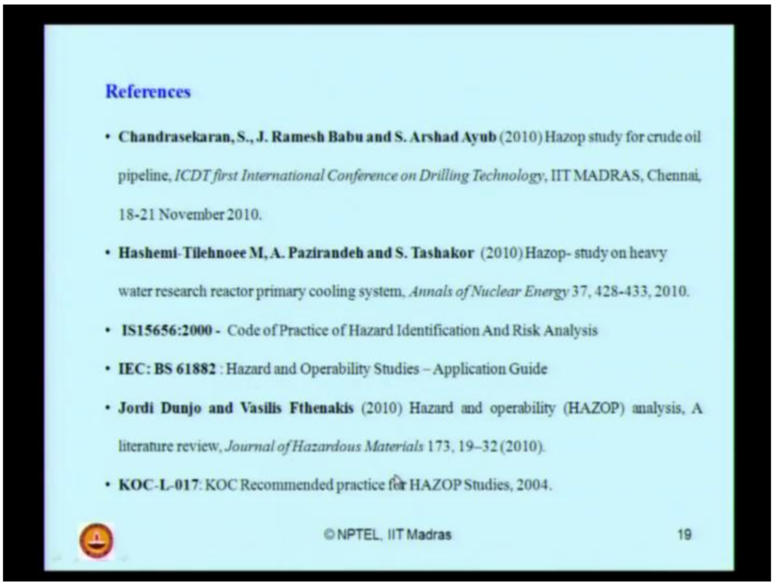

There are certain references kindly go through them. With this overview, we have discussed in detail, how to prepare an HAZOP report for an existing process system like a group gathering station? In the next lecture, I will summarize the important points related to HAZOP study; we will also give you some tutorial sheets and question papers for your self evaluation. Then we will summarize certain important points related to the complete lecture on module one, and that will complete the first exercise of module one on HSE.

Thank you.