Health, Safety and Environmental Practices in Offshore and Petroleum Engineering

Prof. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module - 02
Operational Safety
Lecture - 13
Hazop I

Welcome friends to the online course on Health, Safety and Environmental Practices in Offshore Petroleum Engineering. We are talking about lectures on module-2, where we are focusing on operational safety.

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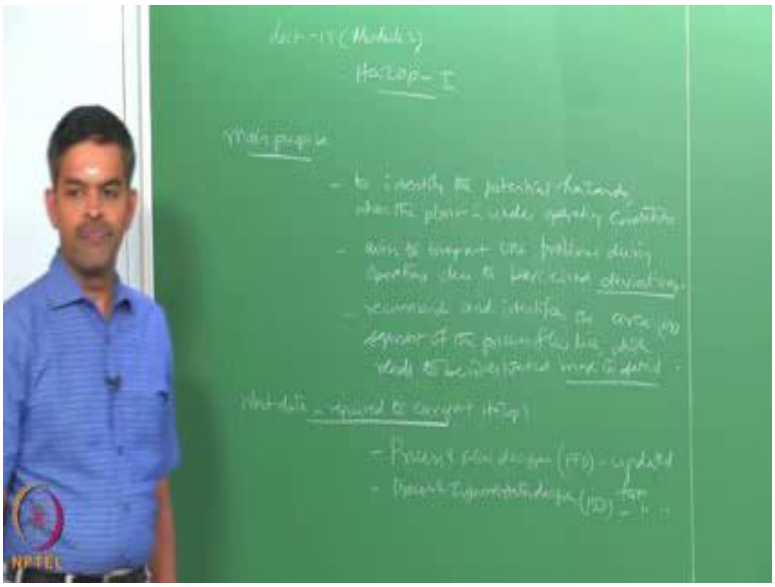

Today lecture-13, module-2 we are going to talk about introduction to Hazop, I will call this as of lecture-1 because there will be couple of more lectures on hazop, including a case study what we will take up and discuss. So, this lecture will go to focus on hazop. We already said hazard analysis can be done qualitatively; hazop expands for hazard analysis and cooperatively studies. So, it is actually a hazard identified and analyzed when the system is in under operation.

So, what is the main purpose of hazop. The main purpose of hazop is to identify the potential hazard, especially when the plant is under operation, operating conditions let us say. So, therefore, hazop aims to bring out the operability problems, we can say the problems during operation due to the perceived deviations. So, we have to explain what is deviation, we will talk about that.

Hazop also recommends and identifies the area or segment of the flow line of the process flow line which needs more attention or which needs to be investigated more in detail. Now the question interestingly asked is what data do you required to carry out a hazop. The following data will be required, one - process and flow diagram of the unit what we call PFD, in its updated form. You also require process and instrumentation diagram which we call PID, of course in the updated form. You also require detailed equipment specifications; you also require details of materials or elementaries being used in the plant. Of course, you also require mass and energy balance equation of the complete process.

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So, hazop study has certain prerequisites in form of its input data based on which a hazop study can be initiated. Now the question comes who can conduct Hazop? Hazop is mainly conducted by a team of experts who are experienced in similar plant. It will also

include technical and safety professionals in the hazop team. What are hazop objectives? I mean what you aim to achieve it. The first and foremost objective is to detect the perceived deviations from the design intend. So, here we have introduced two keywords deviation, design intend, we will talk about that with an example - it will be very clear; during operation.

So, the foremost objective is to detect the perceived deviation, please understand. It is the perceived deviation it is not the actual deviation happening, you are forecasting, you are for seeing, you are anticipating a deviation which may occur because of operational problems and the deviation is significantly different from that of the design intend.

The moment you understand the deviation perceive the deviations then, identify causes for the deviation, why the deviation is occurring? Do you like to know the causes for deviation? The moment you know the causes then also you need to list the consequences arise because of the deviation, the moment you know the cause and consequences then you have got also identify or value the existing safe guards in the system which can of course, mitigate the consequences. For example, the perceived deviation could be very high raise in temperature and pressure the wall may stuck up to open. it may result in explosion, so fire fighting equipments which are present in the given system can be identified as safe guards which can be useful in mitigating the consequences arise from the deviations of the design intend.

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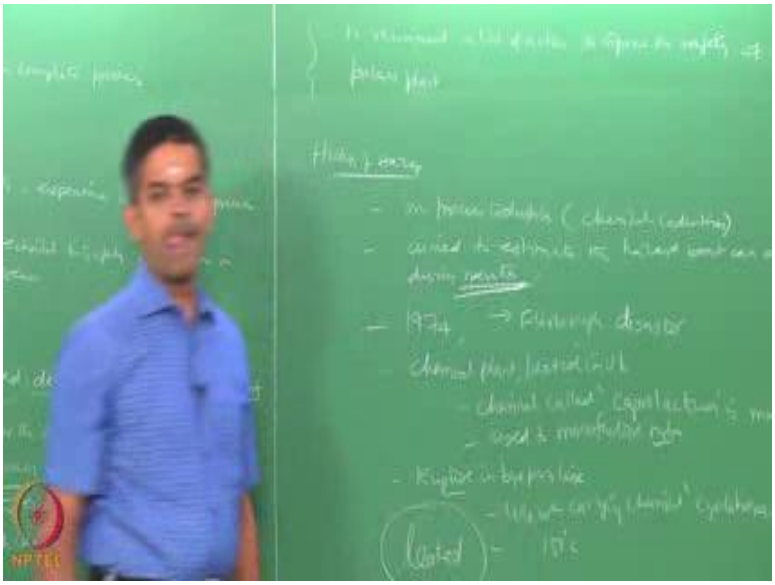

Finally, to recommend the list of actions to improve the safety of the process plant, you have got about 5 objectives which need to be fulfilled on hazop study. Let us quickly look back the history where hazop study actually started. Whether that is important to know when hazop study was first initiated. So, if you know the source then you will be really able to appreciate the value of such studies as qualitative risk analysis which can be used in process industries.

So, quickly let us see the history of hazop. Hazop studies were first conducted on process industries, especially chemical industries. With an objective that it was aimed to estimate the hazard that can be or that can arise during operation. So, intention was to find out the hazardous scenario or the change in hazard scenario especially when the plant is in operation; that is very important. When the plant is ideal, when the plant is shut down, hazop studies are generally not conducted. See initially hazop studies conducted as early as 1974 that was the first study reported in the literature which is done for flixborough disaster.

What is the flixborough disaster? It is a chemical plant located in UK which is manufacturing or which use to manufacture a chemical called Caprolactam. This chemical is actually used to manufacture nylon, an unfortunate instant took place on the

specific here due to the rupture of the temporary bypass line in the given process line carrying. So, there was a rupture in the bypass line, the line was carrying chemical which is cyclohexane and the operational temperature of that chemical in that line was about 150 degree Celsius. And this particular line, rupture and leaked and that caused fire. So, that is the flixborough disaster at which the diagnosis was done based on the hazop studies.

So, it is said in the report of hazop conducted on this particular plant disaster that within 20 to 25, may be within few minutes after the fire has broken out about 20 to 25 percent of the whole invent of the plant was abolished completely. Subsequently, the smoke was spread as a vapor cloud over a diameter about more than 300 meters around the plant and serious consequences is now coming.

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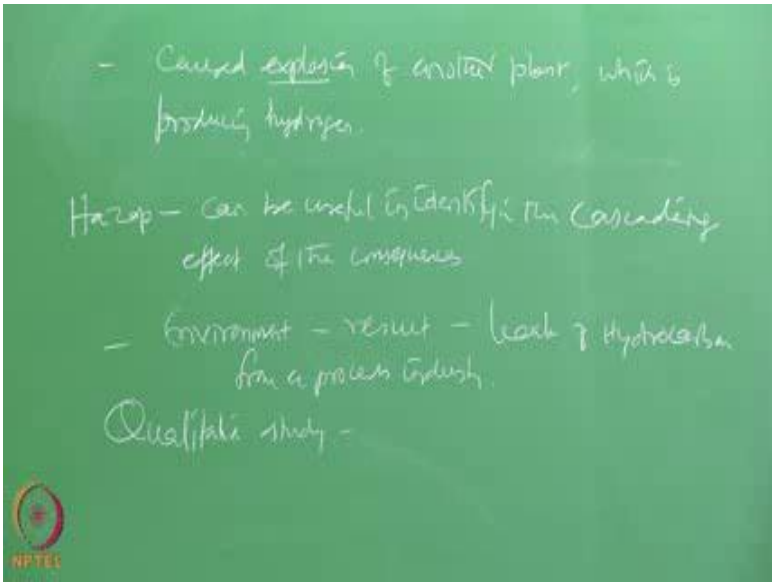

So, this resulted in a vapor cloud which spread to about 200 to 300 meter radius from the plant and that caused explosion of another plant which is located nearby, which is producing hydrogen. This got exploded which is located in the nearby vicinity. So, hazop was illustrated through a study on flixborough that can be useful in identifying the cascading effect of the consequences.

Friends, it is very interesting for us to appreciate that hazop can be considered useful tool to really find out the damage to environment which can result from the leak of hydrocarbon or any chemical from a process industry. So, this is one of the qualitative study which is very powerful, very common and very popular. In all process industries especially in the downstream in oil and gas sector and hazop reports are very often revise and revisited at least once in 6 months, to really know the updates about the hazardous improvement changes in the scenario caused because of the plant in operation.

Probably this is one of the effective studies which can be applied to a process industry when the production line is on; there are no comparative studies which can match the quality of results which a hazop study can give. An hazop study was successfully applied may be 3 decades earlier also in a chemical raising plant which show a very interesting outcome that the study is powerful to look also into the cascading effect caused by one plant on the other in the near vicinity.

Followed by this subsequently another study was reported.

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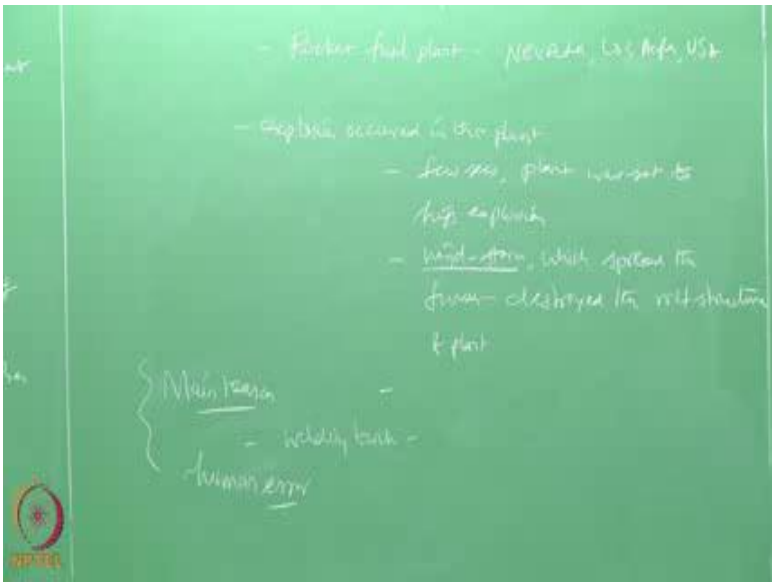

The second I should say the second initial study of hazop, was reported - the rocket fuel plant located in Nevada, Los Angeles - USA. It is very interesting for you to know that

there was an explosion occurred in this plant, the plant was set ablaze in few seconds of the initial explosion. In few seconds the plant was set to high explosion there was a wind storm unfortunately, which spread the fumes and destroyed the roof structure of the plant.

Interestingly friends, if you look at the diagnosis of this particular case study in the open web domain you will notice that the prime main reason - the primary reason for this accident was nothing but an employee was using a fire torch or the welding torch; an employee was using a welding torch to weld a specific element or a component of the structural roof and the fire was initiated from this torch in the windward direction. So, it is essentially and mainly a human error, it would not say even it is an error it can be oversight.

So, even a small mistake which you unknowingly do, when the conditions favor it may result in a very serious catastrophic loss to the human life as well as the business asset. So, this study was also interestingly reported through hazop in the literature and it was able to capture the perceived deviation from the design intend through the detailed analysis of this accident. So, hazop were used as useful tools in various chemical release plant to understand the hazardous situation that may arise when the system or the flow line is in operation which generally cannot be perceive any other study as of now available in the literature.

So, ladies and gentlemen if you look at the screen now, the graphics captures a similar explosion of rocket fuel plant located at Nevada in Las Vegas.

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You can see here black smoke spread very quickly for a larger area and the whole plant epicenter here was completely brought to explode locations in very few seconds. So, it is very interesting that because of a human negligence, because of oversight of a small error caused by a person or set of people in doing the welding of one of the roof elements in the plant which set fire because you are using a welding torch and the welding torch was placed in the windward direction, that caused serious fire. So, as we have seen that comfortably and confidently hazop studies can be applied to chemical release plants. Let us quickly see what are the merits if you do a hazop study.

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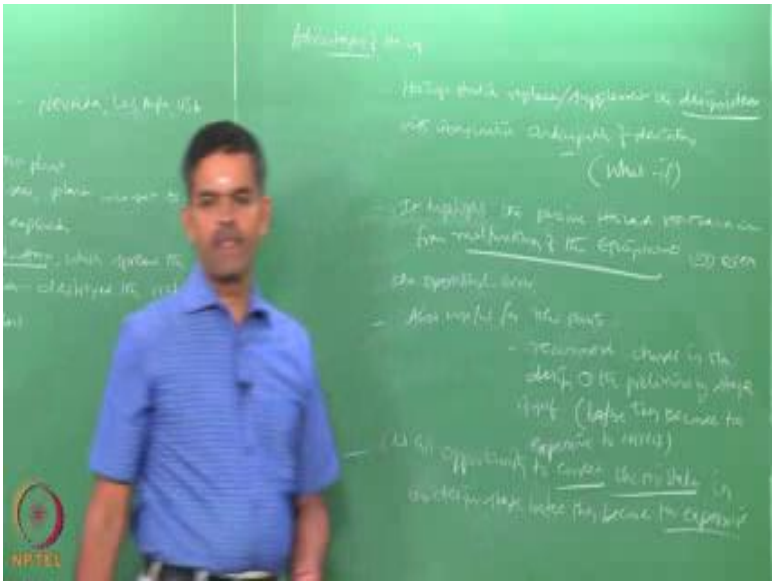

Let us quickly see what are the merits or advantages of doing a hazop study. First and foremost advantage is - hazop studies replace or supplement the design ideas with imaginative anticipation of deviation. So, there is a parallel study which is also available in the literature which can also do this. If you recollect the previous lecture notes you can easily understand that what-if studies are also capable of giving a similar outcome as that of a hazop study, but hazop study is more professional compared to what-if or what-if is answering series of questions which have been posted based on expertise and experienced inspection and check list. Whereas, hazop study is has got no check list it has got a very detailed diagnosis, when you do a hazop study for a specific case example you realize how it is more professional.

The second advantage what hazop study would could be, it highlights the possible hazard that can arise from malfunctioning of the equipment. It also addresses something about the working methodology of the equipment or even the operational error. If you really want to apply a hazop study for a new plant it is also useful for new plants also useful for new plants because generally at the design stage people may oversight certain errors and do mistakes in the process lines which can ultimately result in very serious hazard situation. So, hazop study force is all those perceived deviation and anticipation and advises, recommend changes in the design at the preliminary stage itself before they

becomes too expensive to correct.

It is very interesting for you to understand and believe that if you want to recommend any deviation the existing process line may be a bypass line, may be introducing a valve, may be introducing a new line for service requirements, may be want to divert the existing line to another location etcetera an hazop report conceiving all the deviations in the original plant lay out is mandatory as per the rules and regulations of oil and safety industrial directed. You have to submit a hazop report, the hazop report should perceive all the possible deviations which is perceived and anticipated by team of experts which include chemical engineers, mechanical process, production, manufacturing naval (Refer Time: 25:28) structural, civil, electrical, electronic instrumentation, safety executives.

The report will be very very descriptive, which should explain the reasons for deviation, the causes for the deviation, the consequences if the deviation is done, the safeguards which can take care of in case the deviation is random in accidents and what are the final recommendations - can we go ahead with the deviation or not and if not, why; if yes, how and why. Hazop study does not touch the economical prospective of the whole issue therefore, hazop studies are not as powerful and as popular and as commonly accepted in oil industry as that of a quantitative risk analysis because risk analysis will also touch up on the economic prospective.

Please understand risk is nothing but, the product of consequence with that of the magnitude. Here also you are understanding the consequences, the magnitude will be anyway looked into. The only issue here is you are looking everything on qualitative scale whereas in risk analysis you would love to convert these issues on the economic perspective in terms of numeric values or numbers. So, we will try to grade them, try to alter them, you will try to ascend them descend them, so that you will really know what would be the influence of these failure economically on the business whereas, hazop study will not give you that.

So, hazop study may be considered as a pure technical outcome of a risk whereas, risk analysis is a financial, an economic outcome of a hazard. So, both are inter connected. But however, one difference the other without one other is meaningful meaningless, but

however, each one of them can be also independently have its value. So, one of the serious advantage of hazop leads will be it can tell you some useful recommendations even the design stage itself which can say lot of expenditure when these deviations are mistakes the design stage we get matured enough to cause accidents. Therefore, hazop can be seen as an opportunity to correct the mistakes in the design stage before they become let us I should say too expensive.

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So, the basic aim of hazop study is to aid loss prevention, it supports loss prevention; it initiates ideas towards loss prevention. Therefore hazop is considered as a preferable tool for risk evaluation. There are two reasons for this – one, it is easy to learn you will all do hazop study very easily when I show an example to you; second, it can be easily adopted let say follow to almost all operational changes in any process plant. So, I should say it is highly practical study.

So, therefore, some set of people in process industry do argue that experienced professionals believe in hazop studies, inexperienced mathematicians believe in risk studies. Though this argument is very controversial and crude to learn and understand, but some people do believe because hazop studies are always prepared by experienced set of professional who believe that whatever statements they are made in assuming the

perceived deviations and anticipation or value and they will be very highly value towards risk mitigation or loss prevention. So, therefore, they say in effective hazop study can prevent risk even before initiation therefore, risk analysis is of no use at all because risk will never occur that is what their argument is.

An interestingly intelligent hazop study which is very descriptive in detail can aid in fact, should aid at loss prevention or risk mitigation. Therefore, hazop is considered as one of the most powerful tool for risk evaluation, if you really want to evaluate risk in a given process plant you have to and you must do hazop study. So, that is the importance of the study in the oil and gas industry because the study is very highly practical.

But there is good news about the study. The study requires no special qualification, but it needs experience and knowledge about the process that is all. It has got one serious limitation I should tell you that, this is successful when applied for contamination problems; it is very successful, but not good for explosion problems. So, essentially hazop can handle the environmental pollution problems very easily, what does actually hazop do?

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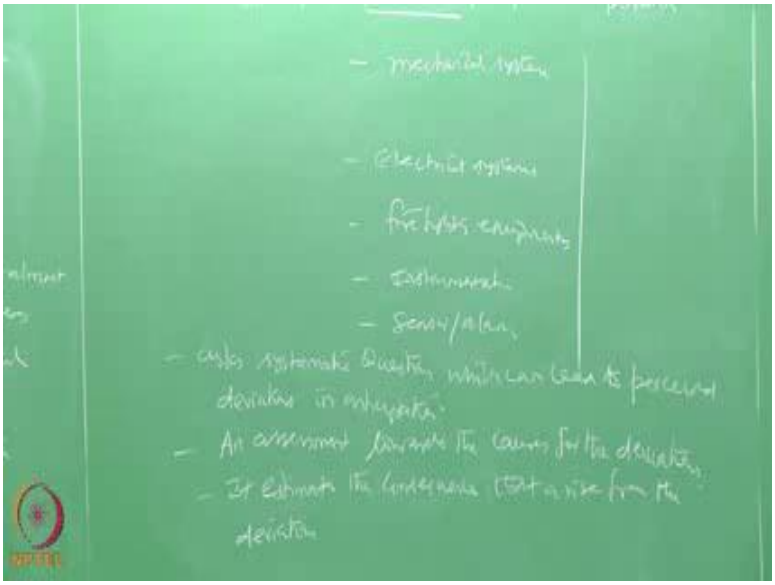

Hazop actually investigates full details of the plant in operation, the full detail include

the mechanical systems, the electrical systems, firefighting equipment instrumentation sensors and alarms it means, it diagnoses completely the plant. While diagnosing the plant it asks systematic questions which can lead to perceive deviations in anticipation. Once these deviations are identified from the hazop study at the first level then it makes an assessment towards the causes for these deviations, the consequences that arise from the deviations and it examines the existing safeguards present in the system.

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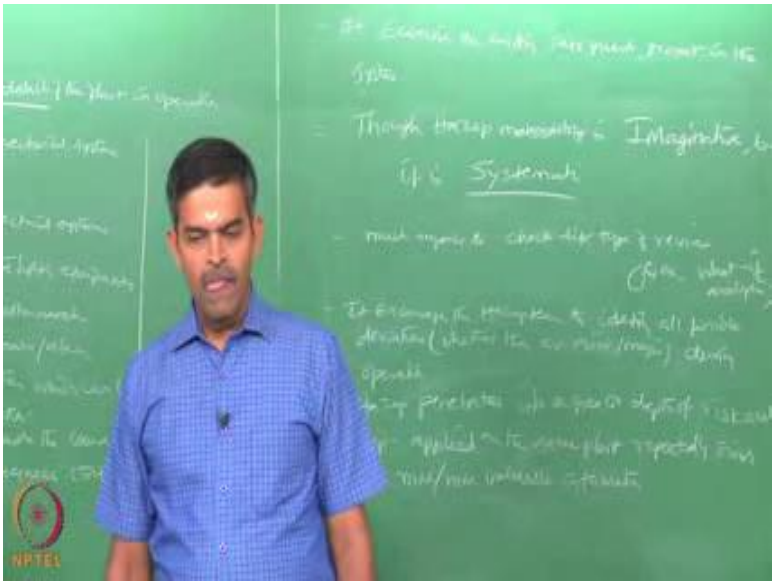

So, I should say a very sarcastic statement here, though the method is imaginative systematic that is very very important. Therefore, this is much superior to a check list type of review for example, what-if analysis, so it is very superior to that. It encourages the hazop team to identify all possible deviations whether they are big or small, whether they are let say minor or major does not matter; all possible deviation during operation that is very very important.

Hazop study for a working plant cannot be conducted in a day or a two or a week, you need to inspect the plant regularly over a period of time, the period of time can be one month, can be two months, can be even few months. You have got a key point noting down the deviations that occur at different timings of the working of the plant, at different situations when the operation temperature and pressure are varied, at different

locations when the temperature conditions are different and their environmental conditions are different - like weather, cold weather, hot sun, etcetera. So, you have to include all these parameter to really summarize, the possible, the anticipated, the futuristic deviation which could cause accident, understand. So, it is a very thorough diagnosis on a given system.

Therefore hazop study is not done sitting on a work bench or a table or software and can be easily done, no; it is based upon the experienced people inspecting the field or the plant when the plant is working. Therefore, I should say hazop penetrates into a greater depth of risk analysis. The most interesting feature is hazop study applied on the same plant repeatedly gives you more and more valuable information that is very very important. Repeated studies on the same plant improves the knowledge about the working of the plant actually, the potential failures which were not noticed in the first level study will not get noticed when you repeat the study again.

Therefore, hazop study is generally conducted as a systematic method of check review or safety review process. In every process industry once at least a year or twice in a year has a periodic inspection. So, hazop study reports are generated as a part and parcel of the safety review system of any process industry, nevertheless for sure oil and gas industry do follow these and they keep a record of hazop reports which are available for inspection in case of any accident matured later subsequently that why this deviation was not perceived or anticipated early.

So, diagnosis done based upon the existing of the hazop reports to really find out the reasons for such accidents if at all the accidents could occur; however, hazop reports carefully done could prevent occurrence of risk in the beginning initiating stage itself. So, hazop studies are very very powerful tool, very easy to follow, very simple to prepare, very simple to understand and does not require a special qualification to be an hazop manager or hazop leader etcetera, except that you should have thorough experience and knowledge about the entire flow line; that is very important. You need not be a chemical engineer, can be even a chemistry graduate, can be a mechanical engineer, structural engineer, civil engineer, because everybody plays an important role in the whole process line of any given process industry as we all understand.

So, what are the steps involved in hazop study? How a hazop study is generally carried out? If it is applied on to a problem how do we actually find out the design intend and deviation. How do you write a report? What is the format for an hazop report? Then is any software actually to write an hazop report. Is it required to write an hazop report through a software. what is an advantage of using software? All these questions we will answer in successive lectures where we are going to talk about hazop study in very much in detail for about at least couple of lectures from now onwards.

In this lecture friends, we have understood through the lecture notes that why hazop study is important, what are the advantages of hazop study although the advantage are very long it has got certain limitations usually and successfully it is applied to chemical plants essentially to capture the environmental pollution part not on the fire and explosion part, we require the different models for doing this. We will talk about that in subsequent modules and lectures.

So, hazop study also analyses consequences therefore, it is never the less infuriate to risk analysis. Of course, hazop study do not directly give you an outcome on the economic prospective where as risk analysis do. Therefore, hazop and risk are always fighting against each other which is superior of the other. So, hazop is more or less technical whereas risk is more or less financial, but both need technical personal and financial executives to really understand the consequences severity of the deviations.

Hazop study if done carefully and detailed analysis carried out it can be an interesting tool for risk evaluation in fact, risk mitigation itself. Carefully done hazop study could picture very clearly the possible risk which can be encountered in the design plant, which can be very easily stopped averted which can be controlled even before the risk is getting matured from the hazard scenario. So, hazop studies are very very interesting and very useful tool in process industries like oil and gas sector.

Thank you very much.