**Health, Safety and Environmental Practices in Offshore and Petroleum Engineering**
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Module - 02
Operational Safety
Lecture - 16
Hazop IV

Friends, welcome to the 16th lecture on module-2 in HSE Practices and Offshore and Petroleum Engineering.

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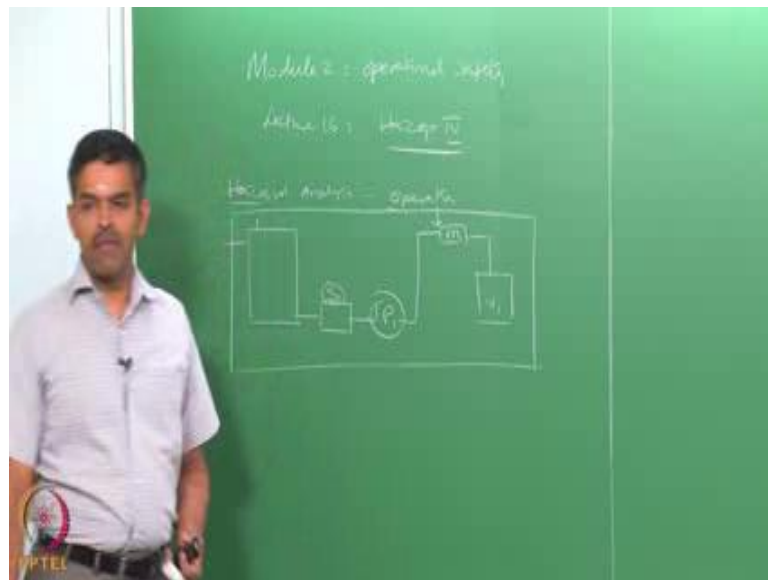
In module-2 as we all know we are focusing on operational safety. In this lecture, which is a 16th lecture in module-2 we will continue with the discussions on hazop study. I will call it as hazop 4 because we are continuing hazop lectures from the previous lectures. So, hazop as we all now know is hazard analysis carried out on system which is in operation. So, hazard analysis for the system in operation is what we call as hazard. We have seen an example where the tanker T 1 is mixing with the doors try to pump through P 1 with a strainer S 1 which supplies with another inlet through a mixer M 1 to that of the tank V 1.

So, we try to do a simple hazop analysis including for this particular segment of the process line. We understood the importance of time variance, secondary key words the design intent and deviation, how they can be combined etcetera. We will elaborate this discussion further in this lecture.

So, let us quickly see the hazop flow chart which will be useful for us to do the study. Let us say the hazop flow chart looks like this.

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As I said, hazop is generally done for a section of the plant. So, select a section of the plant, let us select a section as in this example we selected a small section of the plant. So, select a section of the plant, list all the relevant primary keywords and secondary key words. What does it mean is it is not selection of key words; it is actually identifying the design intent and possible or perceives deviations in the given system. So, check whether the chosen keywords represent the hazard scenario correctly, this is addition box; let us say addition box check whether the chosen keywords represent other scenario correctly. If it is yes then you proceed, if it is no then go back to the system and choose the primary keywords repeatedly.

Then identify the causes or the source of problems for the deviations, check whether the secondary keywords represent the meaningful causes, if yes - proceed, if no - go back to the step again choose the keywords. Let us say we are coming down here, this is yes.

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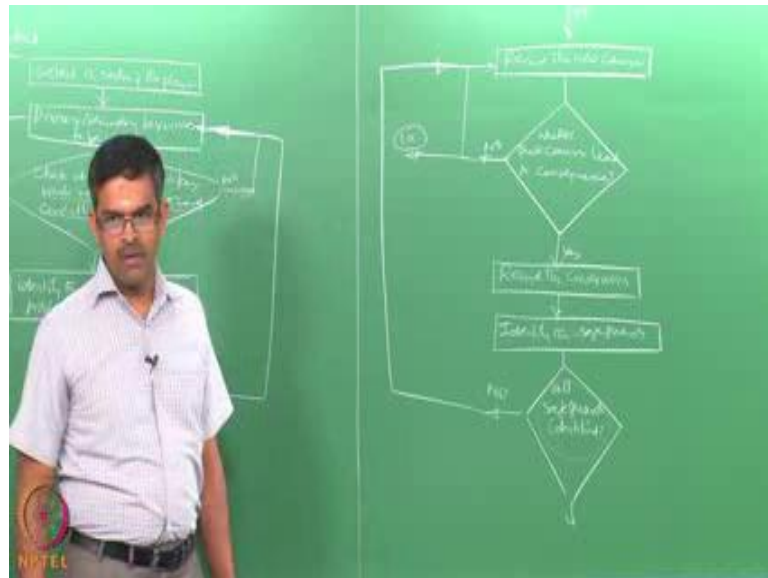
Now, in the hazop report start recording the new causes, check whether these causes lead to significant consequences because as we all agree and now we understand that all causes will lead to consequences, but certain consequences may be acceptable in terms of risk levels. So, check whether they lead to significant consequences if yes, if these no let us say no then record a new causes again. So, keep on working on this.

So, every cause you should be able to identify a significant consequence then only that cause should be recorded in the hazop report. On the other hand if you have selected a primary in keyword, each primary and secondary keyword should give a meaningful definition about the design intent and deviation for which the causes are identified and then these causes result in significant consequence. If they do not in fact, you may have to even have to change the secondary and primary keywords also therefore, I can say this can also be connected to let us say 1 a can be connected to here itself. You may even land up in changing the primary and secondary keywords also because all the primary and secondary keywords chosen by you may not represent design intent and deviations which

has significant cause which result in significant consequence. If they are not significant consequence then change them. If it is yes, then record the consequence.

Then identify the safe guards then check again whether all safe guards identify, if yes - you proceed, if it is no then you may have to again relook the causes. Why because you are choosing only certain section of the plant. The safe guards may not be present within the chosen section of the plant. For example, in this case there may be safe guard which is going to give me a spurious closure of the valve V 1 which is going to cause dry run of the pump V 1. So, spurious closure of the valve V 1 which can result from or which can result to the closure of or the error of pump V 1 can be indicated in the control panel itself which can be one of the interesting safe guards present in the system.

But control panel may not be in this segment of the plant it may be in some other segment of the plant which is not considered currently for that of study. Therefore, please see whether all safe guards in the system are identified, sometimes you may even loose them. For example, in this p and id you may not have indication of control panel which is indicating the closure of the valve V 1. So, you may ignore and say in hazop report of this segment you may recommend certain safeguard which is already present in the given system. So, check all the safeguard identified or not, if not - again identify the causes look for the consequences visit the safeguard layout thoroughly from the entire plant and then give your recommendation.
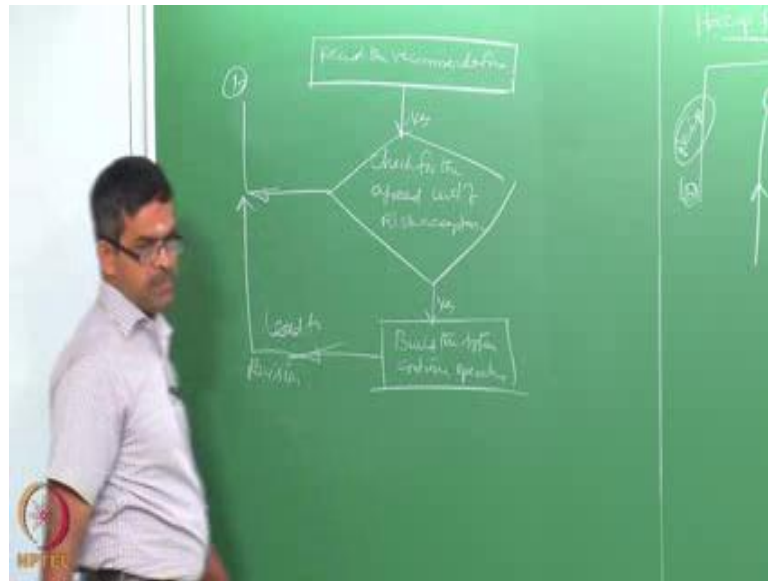
Once it is yes, then record the recommendations then check for the agreed level of risk acceptance. If the agreed level is OK then build a system continue operation, if it is no then I should say 1b, 1b will again come back here and say revise the design because that is going to be one of your recommendation. Build the system or lead to revision which is joined here.

So, the hazop layout or the flow chart you will see that selecting a segment of a plant does not mean hazard study is conducted only for that segment of the plant, because the consequences, the causes, the safeguards and recommendations, are generally done for the entire plant not for the segment of the plant. It for your convenience you divide the plant into segments and do hazop analysis. Then you will ask me a counter question – sir, why do we divide the entire plant in the segment and do hazop analysis, however, we are anyway considering the safeguards, consequences, recommendations, for the entire plant then why cannot we do hazop analysis for the entire plant.

Friends very interestingly the recommendation what you make in a segment, the consequences what you identify in the segment can be always interconnected to the entire plant even though you do hazop analysis in pieces. That is all about the hazop report which I will take up an example and show you. Therefore, it is very difficult for

you to remember what recommendations you made for segment a, what safeguard you took advantage of segment b and so on.

Therefore, hazop reports are generally supported by computer software, because it will be easy for you to generate a data compare the existing data and then interlink the generated data and existing data and see whether anything is superseding, anything is overwritten, anything is becoming a duplicate, all can be checked automatically when you do this attempt through a software. Therefore, hazop report though looks very simple in the flowchart in reality it can be very confusing because only one reason hazop report is done on segments.

Now, answering your question why it cannot be done on the entire plant. If you do hazop report for the entire plant, the instrumentation diagram for the entire plant can be very confusing you will not be able to pay attention. So, the original idea of hazop report is dividing the hazard scenario of the whole plant into segments and viewing the hazards in micro detail; that was the objective. So, with that objective if you again go back to hazop report and say I am going to do analysis of the entire plant then you will not be able to have a micro view of the hazard scenario present in each segment of the plant.

The very idea is to divide the whole plant into comfortable number of segments though hazop analysis for each segment, but however, it is important that you should interconnect these segments and get a final report of hazop which will give me the full recommendation, full consequences and causes of the entire plant. Therefore, friends you will now agree that interlinking hazop reports of every segment into a final report through either software or through some intelligent source of interconnecting the data of segment 1 with that of segment 15, with that of segment 17 and so on so forth is very mandatory.

Therefore, hazop report is generally generated using software. So, we will see an example how it can be done that we will see later. But the flowchart clearly shows that a study though it is segment wise your recommendation should be on the whole plan because the recommendation whatever you make will economically affect the whole

layout of the plant not the segment of the plant alone, that is very important you must agree on this.

In hazop flowchart, hazard studies are therefore not carried out on the whole layout of the process plant, but in segments of the plant. Usually segments are identified through preliminary studies. You will not know which segment I should take, where should I cut my segment where should I start the segment. So, you need an experience you look at the whole plant first identify the cross instrumentation diagram of the entire plant, understand the process feel the consequences, if any process line goes wrong then identify the locations where you need to do a micro detail analysis.

So, these are all done preliminary by an experienced and expert team. Then the segments of the plant are identified. Therefore, hazop procedure is done though on segment of each plant, but recommendation should any way interconnect all the segments together as a whole; that is important. While doing this we have two options - one is what we call full recording, other is what is called recording the exception. Let us see what is this.

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Hazop report has two options now - one is what is called full recording, other is recording by exception. Let us see what is this. In the earlier periods when hazop reports

were initially prepared they were hand written. Mostly hazop reports prepared earlier days were hand written, hand written in sense type written or computer generated not using the software. So, they were promoting partial recording of causes and consequences. What we mean partial recording? Partial recording in sense the causes and consequences are local to the chosen segment, but inter connected manually to the whole segment or to the whole process layout. So, that is very important.

So, there were some demerits of this type. Some negative consequences which were noticed were also found that is one par. Though they were useful for the audit purposes, but they were found to be repetitive, ultimately when they are interlinked they are found to be null and void because that particular segment did not have safeguards to overcome the consequences, but the whole plant has a central control console which could overcome this consequences which was noticed subsequently when the interconnection has happened. So, such methodology of recording was called recording by exception.

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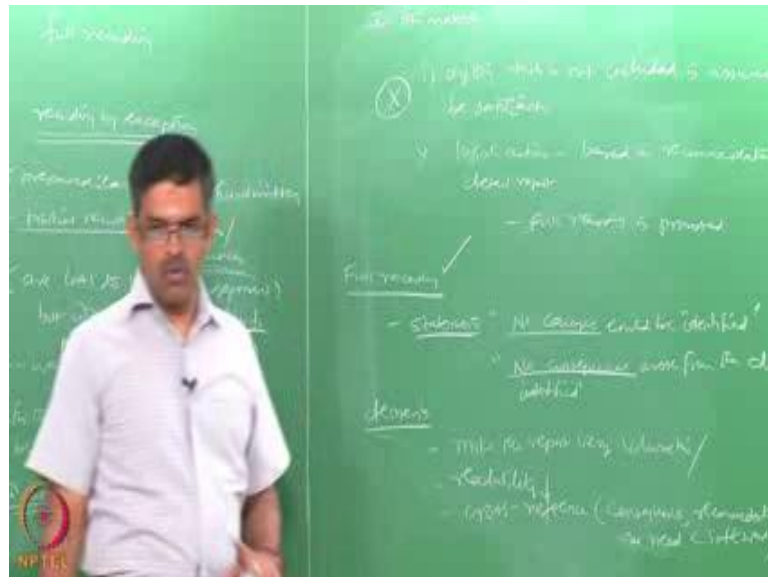
In this method that is recording exception, it is assumed that anything not included is assumed to be satisfactory, anything which is not included is assumed to be satisfactory. But however, logical actions which are taken based on recommendation require detail

report therefore, full recording is promoted. So, now, presently the hazop reports are on the full recording.

Now, what do you mean by full recording? I can give an example; you will also see statements like this if there are no causes for a given deviation, so statements like no causes could be identified can see a statement in the hazop report. Alternatively no consequences arose from the deviations identified. So, reports including such statements was seen in the hazop reports, they are called full recording. Full recording in sense the hazop report does not leave any ambiguity saying that whichever is not written is constructively satisfactory, it is an ambiguity statements it is not preferred.

Therefore, full recording will even include statements like this no causes identified no consequences arose. So, they are explicit in writing these sentences and therefore, full recording actually became very useful. But some demerits of full recording - one it will make the report very volumetric having readability will be reduced, the moment you have volumetric report 600-800 pages readability will be inferior. Therefore, for cross reference especially consequences recommendations etcetera one needs software which can interlink the database of different segments together. Therefore, full recording is feasible is interesting and useful only when hazop reports are prepared based on the software, because any volumetric method of generating report will result in inferior readability. But there are some facts which are good about the full recording.
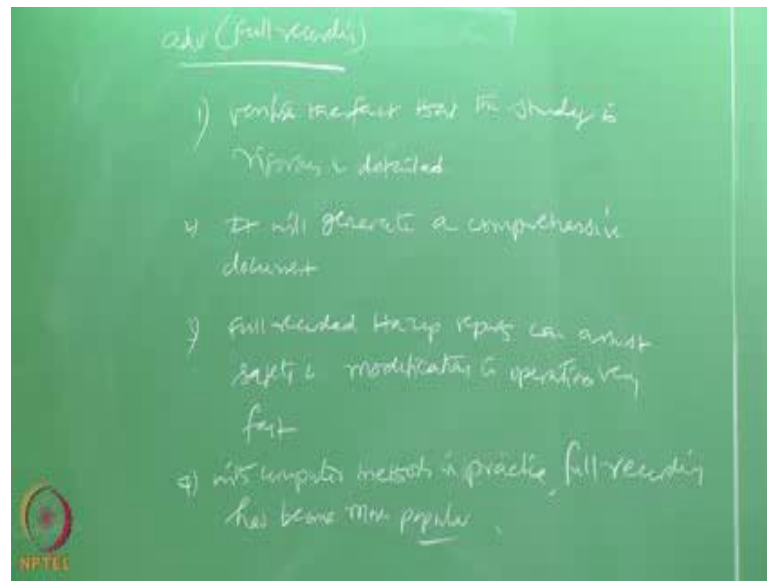
The advantages of full recording – one, it verify the fact that the study is rigorous and done in detail. It will form or it will generate a comprehensive document such full recorded hazop reports can assist safety and modification in operability very fast. Now with computer methods in practice full recording has become more popular. So, now a days you will not have hazop reports which are partial recorded you do not have them or recording the exception. You always have only full recording reports, but even in full recording people use something called macro words.

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So, even in full recording which is supposed to be an elaborate report macro words are used, what are macro words? Example, no potential cause identified, no significant negative consequence identified, statements like this can be suitable for many studies that are carried out as part of the routine maintenance. So, they are very useful in case of hazop reports done on maintenance.

So, one can also use what is called pseudo secondary keywords, what are pseudo secondary keyword? Pseudo secondary keywords are those which are used along with a primary keyword, when no appropriate secondary keyword is suitable I can give an example. Let us say the primary keyword is flow that is the design intent. Some combinations of secondary with primary have some meaning for example, flow no is meaningful there is no flow, flow reverse has a meaning because the direction of flow is reversed, flow less, flow more etcetera, flow others may not have any consequences or there are no causes identified with these operations. So, one can use a pseudo secondary keywords like this.

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So, when I write an hazop report let us say flow no I have to write a cause, I have to write a consequence, I have to measure a safeguard, I have to give a recommendation that is what a hazop report is. I am able to identify the cause write some sentences, I can identify the consequences because of this cause. I can able to identify the safeguards present in the system which can take care of the consequences. Therefore, I may recommend may not recommend; that is fine.

Similarly, flow reverse because they have meaningful cause, significant consequences, I can identify the safeguards, I can give recommendations, but there are certain combinations which have either - no cause or no significant consequence, so flow less, flow more etcetera. So, I can even say flow reminder. So, no cause, no negative consequence, safeguards are sufficient, no recommendations, so the remainder includes remaining all secondary keywords. For example, less, more, other, all will be included in one sentence. So, one can report in this form also using a macro word reminder which is also known as pseudo secondary keyword.

The pseudo secondary keyword conveys the same meaning that is conveyed by set of combinations of primary and secondary. Example, reminder, all - are examples of secondary keywords. So, what is the advantage of using secondary keyword? Secondary

keyword actually improves the readability, it avoids confusion it avoids repetitive entries in the report, so the report can become concise and smart, so that is the use of secondary keywords. But be careful that whatever secondary keywords you want to use you must declare them in the beginning of the report, it is very important if you do not declare them and use secondary keyword 'all' in your report it may give a very unambiguous meaning. So, be careful about that.

Now let us ask a question, when to do an hazop?

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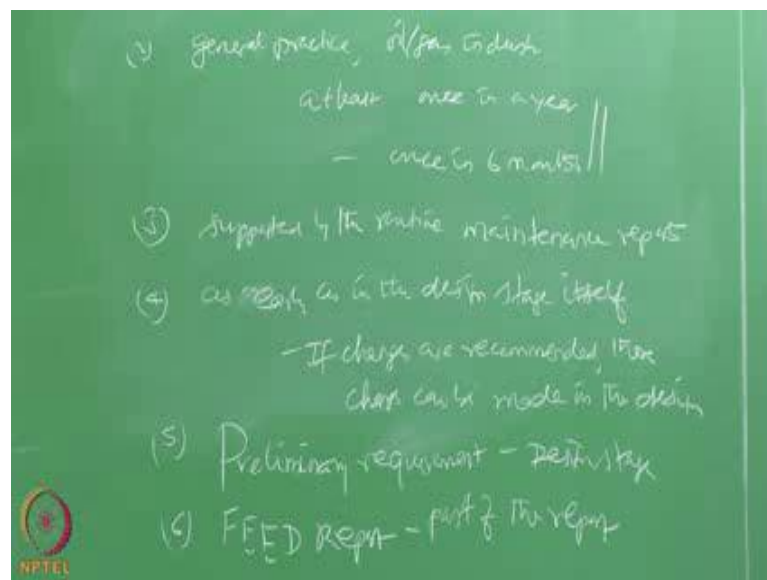
Hazop studies are generally carried out to identify the potential hazards and operability problems passed over the deviations those arise from the design intent. In particular, if there are major deviations present or they are made in any recent modifications of the plant then the hazop should be conducted. One, if any major modifications are done to the flow line of the plant then one should do hazop report, hazop study.

As a general practice, in oil and gas industries hazop report is done at least once in a year, once in a year - good to have once in 6 months. Hazop reports are supported by the routine maintenance reports. Hazop study should be preferably carried out as an early in the design stage itself. So, that if any changes are required, if changes are recommended

those changes can be made in the design. So, hazop is a preliminary requirement of any plant. It will be a part of feed report.

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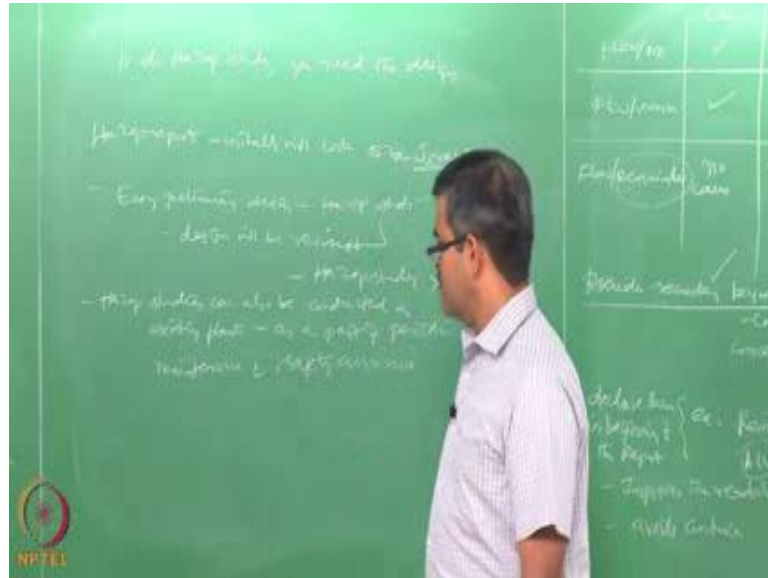
But unfortunately, to do an hazop report or to do an hazop study you need a design. A hazop study verifies the design so they are interlinked therefore, hazop reports initially will look to be slightly iterative, but in reality it is not so, because every preliminary design will have an hazop study and then the design will be revised. Once the design is revised there is no need for another hazop study because the recommendation need by the study is already incorporated in the revised design.

Further, hazop studies can also be conducted on existing plants as a part of periodic maintenance and safety assurance. Generally under following situation hazop studies will become very necessary.

In the next lecture we will talk about where are those instances where hazard studies are mandatory then, we will take an example of a real life problem of hazop study and see how this can be done, different types of hazop studies, what are different types of hazard norms, then we will take an example and try to solve generate hazop report using a software very quickly and then we will understand the hazop studies in detail.

Friends, in this lecture we understood when to conduct an hazop study, what are the use of primary and secondary keywords, what do we understand by full recording and recording by exceptions, why recording exceptions will cause ambiguous reports, in the present trend why full recording is preferred. We have also seen how hazop studies though conducted in segments can be interlinked we agree that they should interlinked. Full recording we can do it, but however, even in full recording people can use macro words and pseudo secondary keywords to make the reading more concise and to avoid repetitive entries and hazop report can become a very explicit, detailed, interesting and concise document. We have seen a simple example of a strainer attached to a tank T 1 and wrote a hazop report quickly for one of the design intents and one of such deviation.

In the next lecture we will try to pick up a real life problem and see how hazard report can be prepared for this in detail, how that can be extended for further discussions.

Thank you very much.