Health, Safety and Environmental Management in Petroleum and offshore Engineering

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Module No. # 01

Lecture No. # 07

Hazard Evaluation and hazard control

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Ladies and gentleman, we have discussed about the introduction to HSE. We have seen in detail the basic terminologies and the definitions. We have also discussed in detail about the safety assurance and assessment, safety in design and operation. How to organize for safety, what are all the important parameters we consider when think about safety in oil and petroleum engineering industry?

In the last lecture, we discussed about hazard classification and assessment. In the current lecture, we will discuss about hazard evaluation and hazard control. In all these lectures previously, we have discussed couple of case studies; we have emphasized what is the importance of safety in petroleum and offshore industry. We will discuss couple of case studies in this lecture as well to see how hazard management can be successfully

done and why it should be done. The necessity for doing an hazard evaluation, based on couple of case studies which I will discuss in this lecture as well. When we talk about one of the methods of doing hazard study we discuss HAZOP as a very powerful tool.

In the previous example, we identify how to select primary and secondary keywords, and what is the format by which an HAZOP report is generally prepared, what are all the columns to be filled in an hazard report and how do you fill them? What are all the guide lines to filled up those columns upon a HAZOP report? Now, extending that in a hazard report we have something called full recording versus recording by exception.

In earlier HAZOP reports, only potential deviations with some negative consequences were recorded. There were reasons for doing so, because they were actually been used only for internal purpose of the company, and also most of these reports were handwritten records. Therefore, if they could have done by identifying for all deviations then the report would have become very time consuming. And therefore, in earlier stages of hazard reports only potential deviations resulting in some negative consequences were only recorded.

Such kind of recording where you choose only to record certain deviations which has only certain kind of consequence in a system is what we call as a recording by exception. Because you are eliminating certain potential deviations, which are having certain different kinds of consequences, which you are were not interested because you are using this report only for internal circulation of your company.

Now, as days passed away HAZOP report have started been recorded in a full format, but in the exception method of recording it is assumed that anything that is not included in this report by exception is considered to be satisfactory. That was an assumption made that if you do not indicate any specific deviation purposefully in a recording style by exception. People presume that those cases of deviations were considered or observed to be satisfactory.

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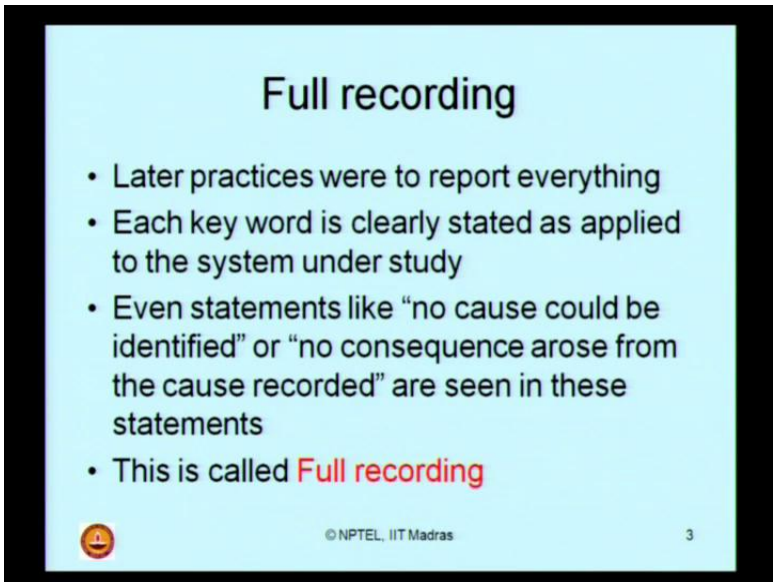

Alternatively people wanted to improve on this existing methodology. They introduce a new type called full recording. Later, practices adapted to report completely and totally everything. Each keyword what you use in a HAZOP report is clearly stated as applied to the system under study. Even statements like no cause could be identified, no consequences arose from the cause recorded are also seen in these kinds of reports.

So, this report which I mean to say by full recording leaves no ambiguity to the reader, because this report completely analyzes in total, the whole and the complete segment of the plant, and try to identify all possible keywords associated with that process. And even statements like even there are no consequences arose they are also recorded. So, such kind of report generally is expected to become very volumetric and at the same time they leave no ambiguity for the reader. This kind of report of recording of HAZOP report is what we call as full recording.

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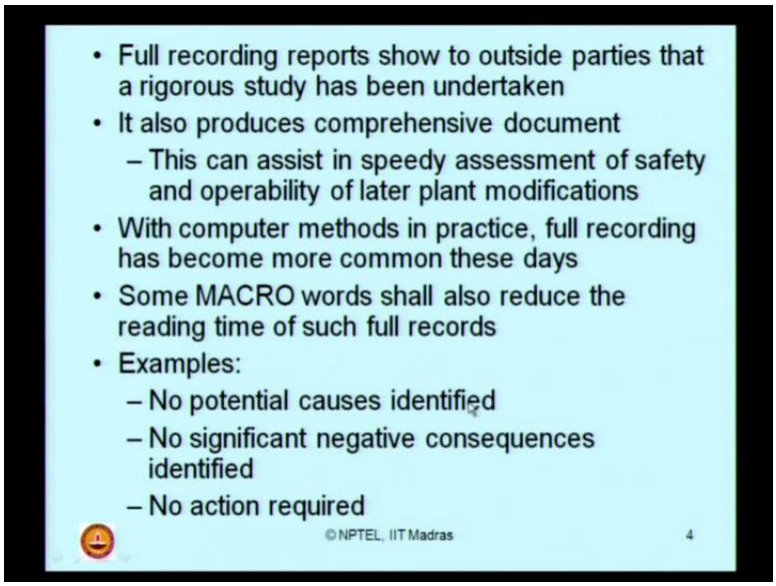

Full recording reports is generally shown to outside parties because it is a rigorous kind of study which has been undertaken. And it reveals this kind of status to the third party who studies this report. It also produces comprehensive document, this can actually assist in speedy assessment of safety and operability of later plant modifications. For example, if you have designed a new plant and conducted an HAZOP study, and executed a full recording kind of report of an HAZOP study, after couple of years if you want to really reassess the safety and operability feature of the existing plant then this report which you prepared couple of years back. If that could have been a full recording module, it will be very helpful for you really assist you in making a speedy assessment of those operability features which you need to modify in the plant. So, full recording gives a complete detail about the existing scenario of the plant. Therefore we can say it is a very comprehensive document.

Now, with computer methods in practice full recording has become more common these days. There are software's by which you can prepare or generate an HAZOP report in a full recording module. We will be discussing that in the next lecture. But with the use of these kinds of software application now full recording has become more common these days. While doing full recording, we sometimes use what we call as MACRO words.

Let us quickly explain, what do we understand by MACRO words? The MACRO words shall also reduce the reading time of such full records I will come to that. There can be

examples to be given for MACRO words no potential causes identified. No significant negative consequences identified. No action required. So, in your action column, in your cause column, in your consequence column of full recording type of HAZOP report. If you see a word of this kind, these words and sentences are considered to be MACRO words, because this reduces lot of reading time of this record. A reader can easily identify and get convinced that no potential causes were identified, for specific plant or specific segment of the plant.

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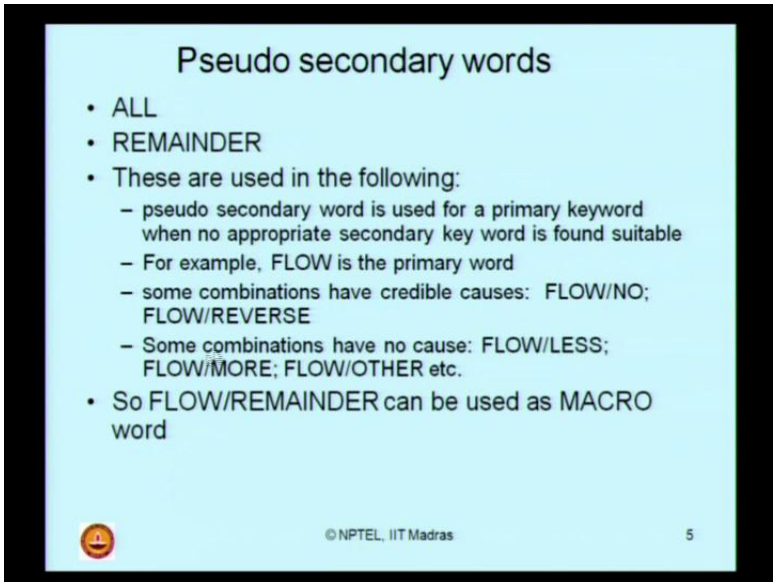

In addition to MACRO words, let us quickly recollect HAZOP report has backbone of two kinds of words. What are they? Can you name them? The foremost important kind of word is what we called as a primary keyword, which we saw in the previous examples; followed by that to support - that is a secondary keyword. Primary key word talks about design intent and secondary key words talks about deviation on that design intent. So, in a segment of a plant you identify the design intent and try to locate the possible deviation of the design intent in the plant. So, couple these two together as primary stroke, secondary key word in your HAZOP report.

Macro word which we just now saw in the previous slide, helps the reader to reduce the reading time because the consequences, actions are given in special type of sentences. In addition to these three kinds of words, we also have something called pseudo secondary words. Let us see some examples of pseudo secondary words. Some examples are given

here - ALL, REMAINDER. You can clearly understand that these words do not have any meaning, if they are not combined with any of the primary words. Now, remember there is a catch here I already said these words are pseudo secondary words. So, they have to discuss or they have to got the qualify something related to deviation in your plant.

For example, pseudo secondary word is used for a primary keyword when no appropriate secondary key word is found suitable. Let us say, let us pick up a word FLOW as a primary key word. Some combinations have credible causes for example, flow stroke NO. Flow is a primary word no is a secondary key word. So, flow stroke no has a credible cause. On the other hand, flow oblique reverse will also have a credible cause. But some combinations have no cause at all. For example, flow less flow more flow other etcetera. So, flow remainder can be used as a MACRO word to combine all except NO and REVERSE.

Let me repeat again, I have a primary key word flow; I understand the flow can either be reversed or there can be situation of no flow. If the plant has no situation like a lesser flow or more flow or other instead of writing all these things, I can simply say flow remainder and say the causes no cause. So, I can say this particular word reduce the time for the reader to read the remaining key words and this is what we call a pseudo secondary, and this combination is what we call as MACRO word.

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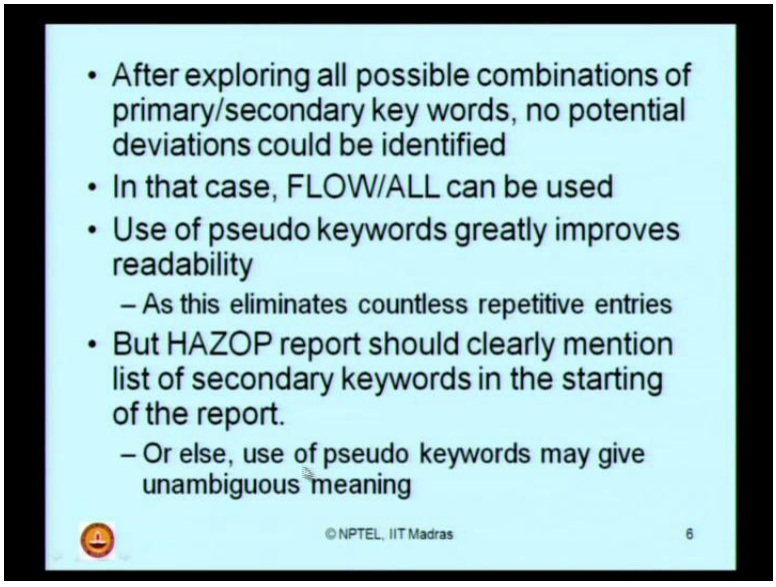

So, after exploring all possible combinations of primary and secondary key words you think no potentials deviation could be identified? Then I can use what we call as a macro word. For example, in that case flow all can also be used if you say that flow can have a possibility of less more other reverse etcetera. All such possibilities are possible to be associated with the primary key word flow then you simply say flow stroke all instead of flow less flow more etcetera. So, use of pseudo secondary key words greatly improves readability, because this eliminates countless repetitive entries. But HAZOP report should clearly mention the list of secondary key words in starting of the report that is mandatory.

Before you start preparing an HAZOP report, apart from understanding the detailed process in instrumentation diagram, you must also mention the list of primary, secondary, pseudo secondary key words in the beginning of the report. Or else use of pseudo secondary key words may give an unambiguous meaning to the reader. So, one must state these words clearly in the report in the beginning itself.

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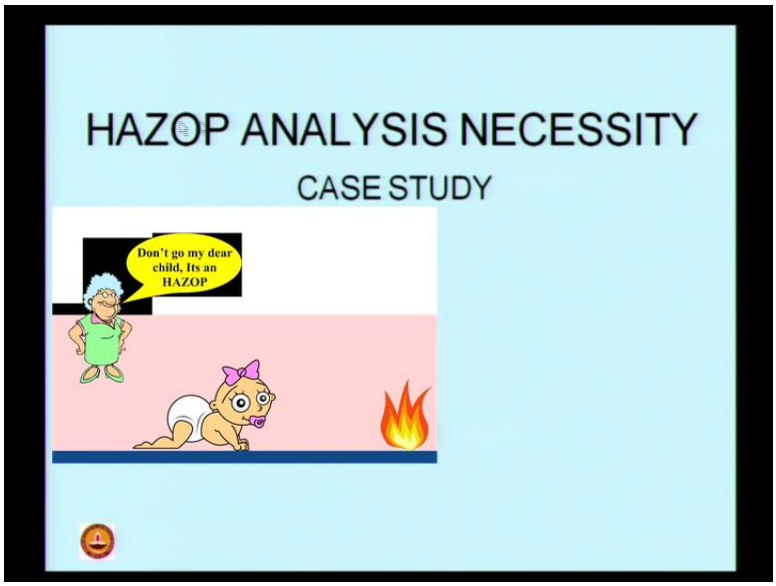

Let us quickly now understand the necessity of an HAZOP analysis by few case studies. Look at this picture it is interesting. There is a fire block nearby here. The child is crawling towards the fire block. The mother says do not go my dear child it is a HAZOP. So, hazard is a situation. As long as you do not go and touch it, it is not going to harm you, but the baby can get hurt because situation can grow or can ripen into an accident as

well. So, HAZOP is a situation. It can result or can become an accident, and when it becomes an accident it is risky. So, risk assessment or risk evaluation is a step marginally ahead of HAZOP study. Let us quickly see what is the necessity of HAZOP analysis in offshore and petroleum industry. We will pick up few case studies now to explain this necessity.

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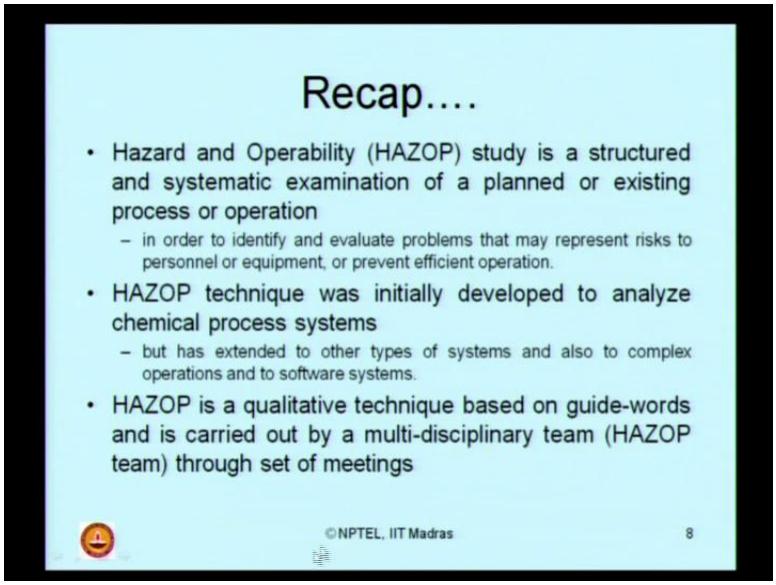

Before we explain that, let us understand a small recapture of what we are seeing so far. Hazard and operability study which I refer always as HAZOP study is a structured and systematic examination of a planned or existing process or operation. On the other hand, HAZOP can be applied to new a planned, existing operation or existing process. Generally, HAZOP is then to identify and evaluate problems that may represent risks to personnel or equipment, or to prevent efficient operation. Hazop technique was initially developed to analyze chemical process systems only. In later stage, this has been extended to other types of system, and also to complex operations and surprisingly even to software systems as well. Hazop actually is a qualitative technique based on guide-words, which we called as backbone of hazard. And it is usually carried out by a multi-disciplinary team, this is generally referred as an HAZOP team. They do this exercise through set of meetings.

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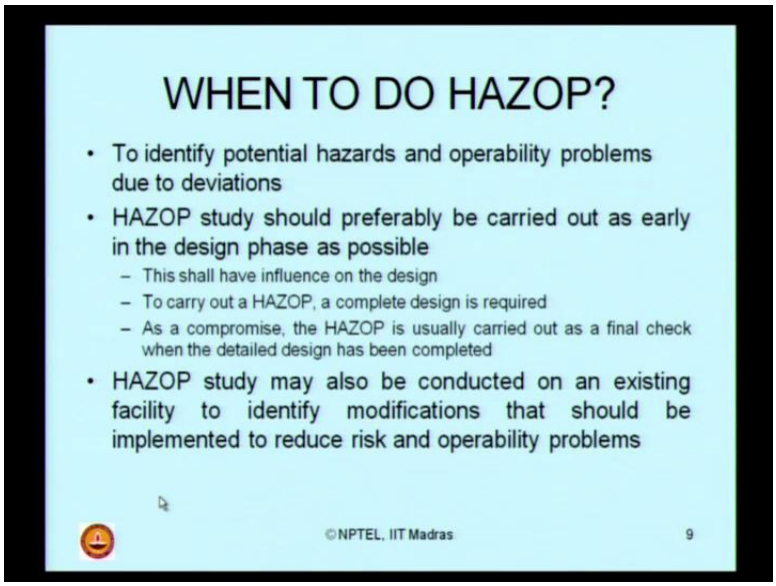

Now, the fundamental questions comes is, when to do an HAZOP study? HAZOP is generally, if you want to identify the potential hazards and operability problems, which may arise due to deviations in the design intent of the plant. HAZOP study should preferably be carried out as early in the design phase as possible, because if you carry out HAZOP study at the early stage itself - that is in the designed phase itself, this shall have a very high influence on the design.

It can correct the errors which can otherwise get unnoticed or which can become noticeable only during the process. HAZOP can also be used to carry out a complete design if required. As a compromise, generally HAZOP is usually carried out as a final check when the detail design has been completed. This is a useful practice what company follow they prepare a preliminary design. We understand and analyze the design by different process system. Once the final design is ready, a HAZOP is usually carried out in detail to check whether the final design, which is going to be executed is satisfactory.

Hazop study may also be conducted on existing facility. If you have a plant under operation already for that plant also you can still conduct an HAZOP study, because that will help you to identify the modifications that should be implemented to reduce the risk and operability problems present in the existing process industry.

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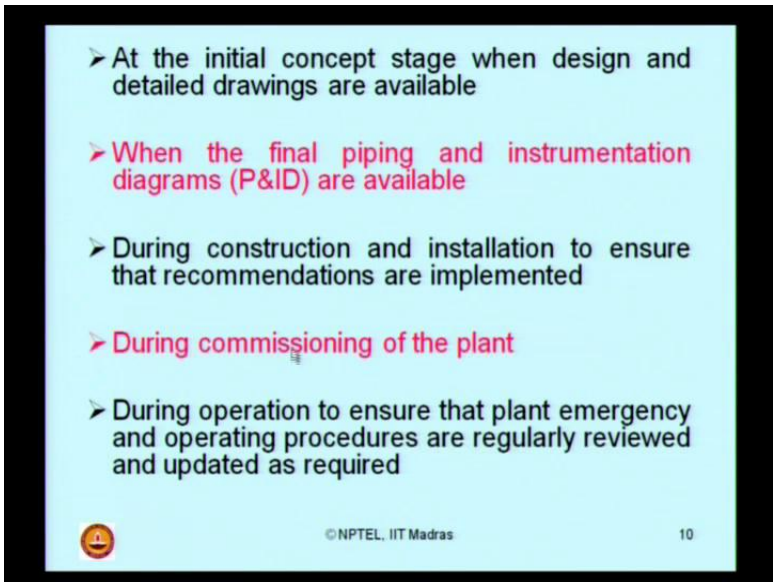

At the initial concept stage when design and detailed drawings are available, HAZOP can be done. HAZOP can also be done when the final piping in instrumentation diagrams are available. HAZOP can be also done during construction and installation to ensure that the recommendations of the report are all completely implemented. HAZOP can also be done during commissioning of the plant. HAZOP can also be done during operation to ensure that the plant emergency an operating procedures are regularly reviewed and updated as required. So, HAZOP can be done in different stages can be employed in a study at different levels as discussed here.

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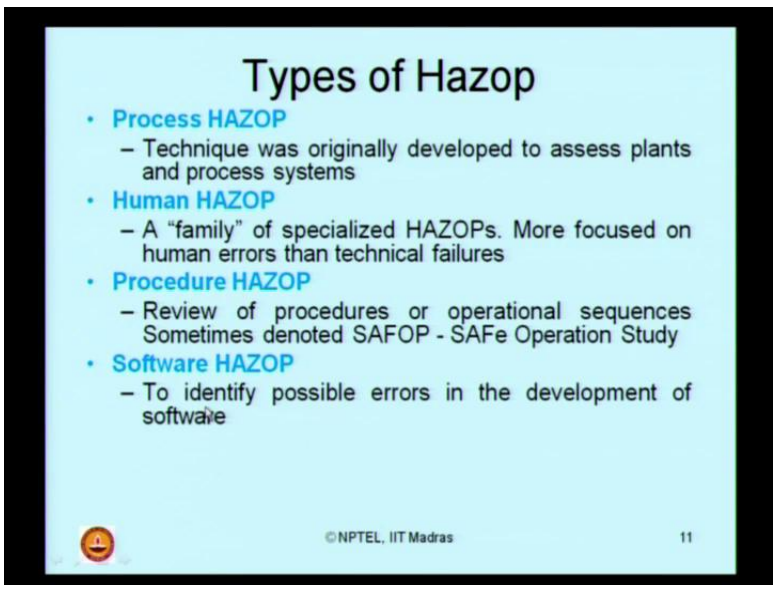

There are different types of HAZOP study one can carry out. What we call as a process HAZOP, it is a technique which was originally developed to assess plants and process systems. We can also carry out what is called as human HAZOP - a family of specialized HAZOPs they are more focused on human errors than technical failures in a process industry. We can also carry out what we call out as procedure HAZOP - the review of procedures or operational sequences put together is what we call as procedural HAZOP. Sometimes procedure HAZOP is called as SAFOP - safe operation study; that is a different name given in the literature for a specific kind of HAZOP, we focus on procedures or operational sequences.

The last kind of type of HAZOP report or study is what we call as a software HAZOP; this is a beneficial extension of HAZOP report or HAZOP study. Initially HAZOP are meant for only for chemical plants. Now, it has been extended to a greater extent that even software industries start using HAZOP study. So, software HAZOP is to identify possible errors in development of a software.

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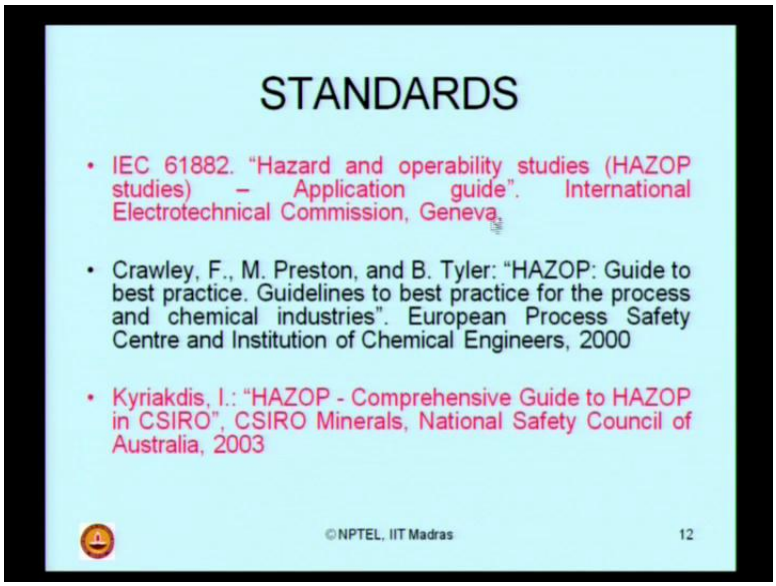

There are some standards by which you can check your HAZOP report prepared. IEC 61882. Hazard and operability studies - application guide given by international electro technical commission, Geneva. You can also refer to Crawley Preston and Tyler, HAZOP guide of best practice. Guidelines to best practice for process and chemical industries published by European process safety centre and institution of chemical engineers in the

year 2000. You can also use Kyriakdis HAZOP comprehensive guide to HAZOP in CSIRO, CSIRO Minerals, National Safety Council of Australia published in the year 2003. These are some few standards with the help of which you really understand what are all the basic guidelines, along which you can carry out an HAZOP study for your plant.

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Now, let us look at some few accidents of offshore structures. We already said accidents are landmarks for people to understand how to correct the errors for the future benefit of improving safety in the process industry like petroleum industry. Ladies and gentlemen, let us recollect that petroleum industry is one of the most expensive investment a public sector can do for societal benefit. So, any loss resulted in a petroleum industry directly affects the social life of any country. In that context, accidents occurred in the past really give us a learning experience of whether these accidents could be avoided. Let us look at one case of Sleipner platform, which is a Condeep type platform. It is a concrete gravity base structure consisting of 24 cells with a total base area of about 16, 000 square meters. The platform was installed at a depth of 82 meters. It was producing oil and gas in the North Sea.

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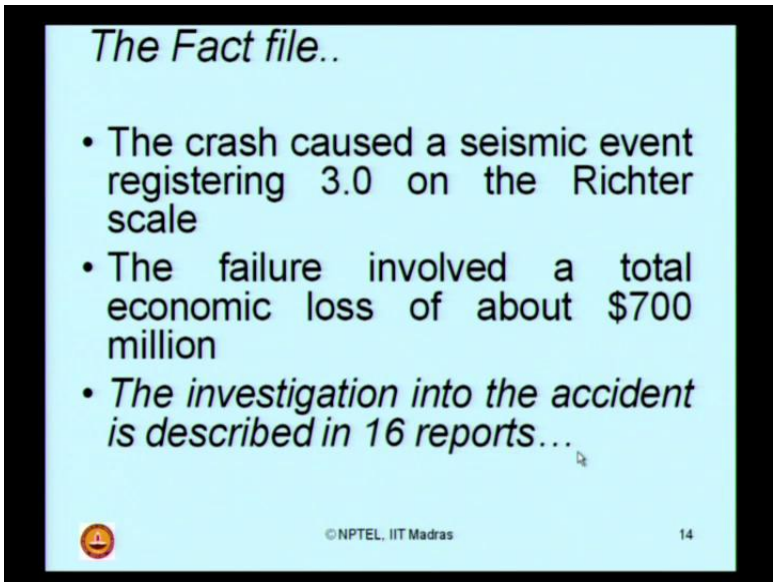

When you look at this platform, if you look at the accident scenario occurred to this platform, there was a crash caused to this platform, and this crash was reported to be equivalent to a seismic event registering 3.0 on the Richter scale of an earthquake signal. The failure involved the total economic loss of about 700 million US dollars. The investigation into the accident is described in about 16 reports available in the standard literature in the public domain.

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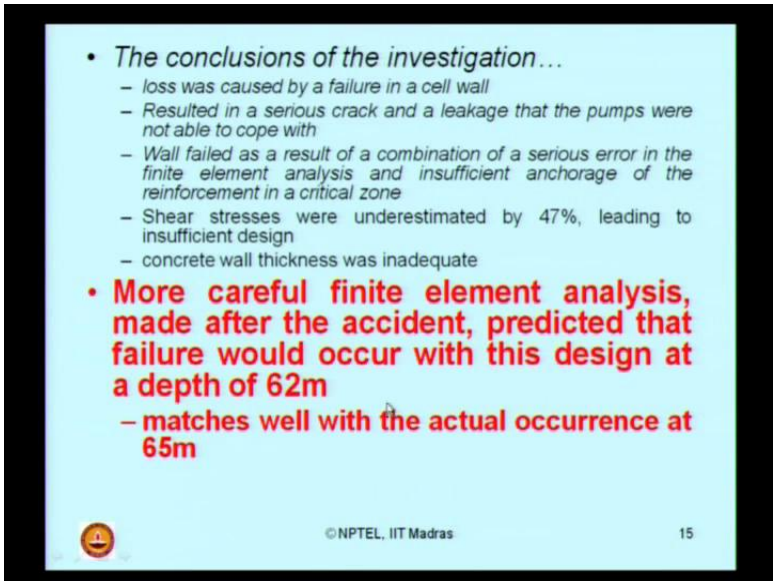

When you look at these reports, I am just trying to only give the brief conclusion of those investigations. The loss was identified to be caused by a failure in a cell wall of the platform. It resulted in a serious crack and a leakage that the pumps were not able to cope up with. The wall failed as a result of combination of serious error in the finite element analysis carried out and there were insufficient anchorage of the reinforcement in certain critical zones. Remember that it was a concrete, reinforce concrete platform the finite element analysis showed there has been some insufficient anchorage of reinforcement in the critical zone.

The shear stresses in analysis were underestimated by about fifty percent leading to insufficient design practically. The concrete wall thickness which was design from this analysis was inadequate. You may wonder that how such an inadequate design was deployed in (( )) platform. They were all investigations carried out after the accident occurred that is what I am trying to insist here. So, you are more careful finite element analysis could have avoided this, which was subsequently made after the accident and that predicted the failure of this platform who would have occur with this current design at about 62 meter depth.

And the actual scenario of accident occurred when it was at 62 meter depth. So, then there has been in a closed match of what people interpreted later after the accident has occurred and through the same process which they have carried out earlier as well. So, if one starts attempting at a detailed analysis more careful in the beginning such accidents would have been avoid. So, this is an example of HAZOP study in the design stage.

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Let us look at another platform, which is a thunder horse platform. The thunder horse production platform is located in about 1920 of water in Mississippi Canyon Block at about 150 miles southeast of New Orleans. The construction costs were approximately around five billion US dollars. The platform is expected to operate for about 25 years. The platform hull section was constructed in the year 2004. You can imagine the investment what the company make to build such a platform. You can also know that the expected life of this platform under operation for a critical sea state of 25 years is quietly amazing.

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In July 2005, when the hull construction was completed in the year back, let us say, thunder horse was evacuated in face of an Hurricane Dennis. There was a Hurricane Dennis. So, the thunder horse was evacuated expecting a catastrophic damage during that time. After the hurricane passed, inspection teams found no hull damage - Thunder horse had not taken on water from a leak through its hull; this became unnoticeable. So, it all resulted because an in correctly plumbed just six inch long pipe. A six inches long pipe, which was incorrectly plumbed allowed water to freely flow among several ballast tanks of the platform. And this initiated the platform to tip into water. This event boosted the world price because of speculation of further oil shortage in the nearest future. The platform was fully righted about a week after the Hurricane Dennis and subsequently Hurricane Katrina strike the platform, but did not damage the platform. So, this is an example where we can say a careful inspection of process in instrumentation diagram, pipe and flow diagram which is an HAZOP study could have avoided. Here interception of what we are looking at for this kind of platform.

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So, this is an another classical example where HAZOP could have saved this disruption of oil production. The third case studies is what we say is Timor Sea oil rig. The leaking Timor Sea oil rig caught fire on second of November of 2009. The cause of fire was not known, but one safety thing is that personnel on board were moved out very safely. There was no life damage because of this fire accident on Timor Sea oil rig, but it resulted in severe environmental damage resulting from the oil spill of the rig.

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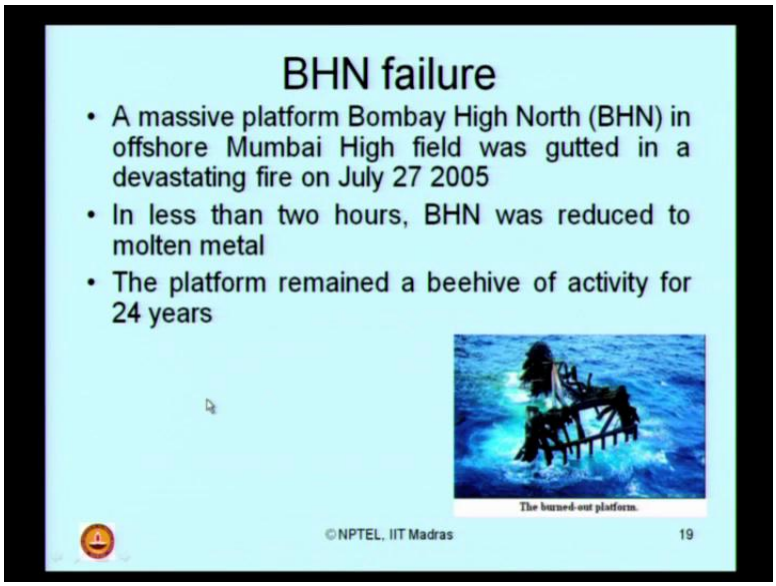

This is another classical example of BHN failure, which could have been avoided. A massive platform Bombay high north in offshore Mumbai high field was gutted in devastating fire on July 27, 2005. In less than about two hours, BHN was reduced to a molten metal completely. So, what happened to that is, the platform remained beehive of activity for about 24 years. So, a careful inspection investigation assessment in the design and process stage which we call as an HAZOP or a repeated assessment during operation which we also called an HAZOP could have definitely improved the safety standards and the operability features of any kind of platform.

The examples discussed here are not just too explicitly tell what went wrong in these platforms. We pick up these examples in a good faith that we learn from these incidents. So, that this accidents can be avoided if you employ one simple hazard analysis study like HAZOP.

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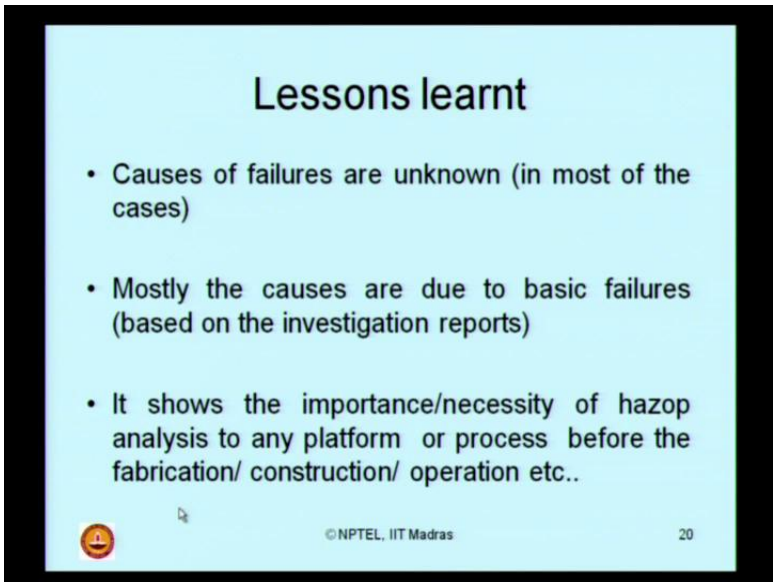

So, we learn the following lessons from these studies. Most of the cases the cause of failure are unknown. Mostly the causes are due to basic failures - that is what investigation report generally brought out. It shows that there exist a very serious importance and necessity of an HAZOP analysis to any such platform or a process before fabrication, construction, operation takes place. So, this brings us to the end of lecture seven where we discussed in detail about the hazard analysis with few case studies. You will be interested to know your total case study discussion on any one in detail where we can do an HAZOP analysis. So, wait for the next lecture in lecture eight, we will discuss one full case study and derive an HAZOP report for the benefit of the readers.

Thank you.