Health, Safety and Environmental Management in Petroleum and offshore Engineering

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Module No. # 01

Lecture No. # 3

Safety in design and operations

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So, ladies and gentlemen, we have been discussing about two lectures on module one - we gave introduction to HSE - health safety and environmental management in petroleum and offshore engineering. In the first lectures, we discussed about introduction to HSE, then we also discussed in detail about the basic terms and their definitions in HSE. In the last lecture, we discussed about some methods of safety assurance and assessment in two lectures from now - that is, lecture three and four. We shall discuss safety in design and operation and how to organize for safety; however, for completion sake, module one shall have topics on hazard classification and assessment and hazard evaluation and hazard control.

Now, we shall discuss on safety in design and operation. We shall also highlight importance of safety in petroleum and offshore industry. Let us quickly recap what do we understand by importance of safety - it is actually the prevention of death or injury to the worker; it is also discussing about prevention of death or injury to general public; prevention of physical and financial damage to the operating plant is also discussion of safety, and of course, prevention of damage to third party property. I just want to recap on these four points only important for safety or do we recollect the fifth point as well? Yes, that is write you are able to recollect the fifth point - that is prevention of damage to the environment.

So, safety encompasses - personal safety, public, financial and physical damage to the plant, prevention of damage to the third party property, and finally prevention of damage to the environment. So, it is a very big subset of all elements. So, it is not only human health safety, but also financial property, environment etcetera.

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Now, we shall discuss in this lecture what do you understand by safety in operation. I shall take up one example of one major event which happens in offshore industry, which is drilling. I shall discuss very briefly the outline on offshore drilling. What are the design alternative to improve safety in drilling; and what are operation alternative to improve safety in offshore drilling?

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When we understand about offshore drilling, following points are very important in mind. Offshore drilling is highly complex and technically a challenging operation; it uses innovative equipments and techniques; it requires specially individuals to design and execute the drilling operation.

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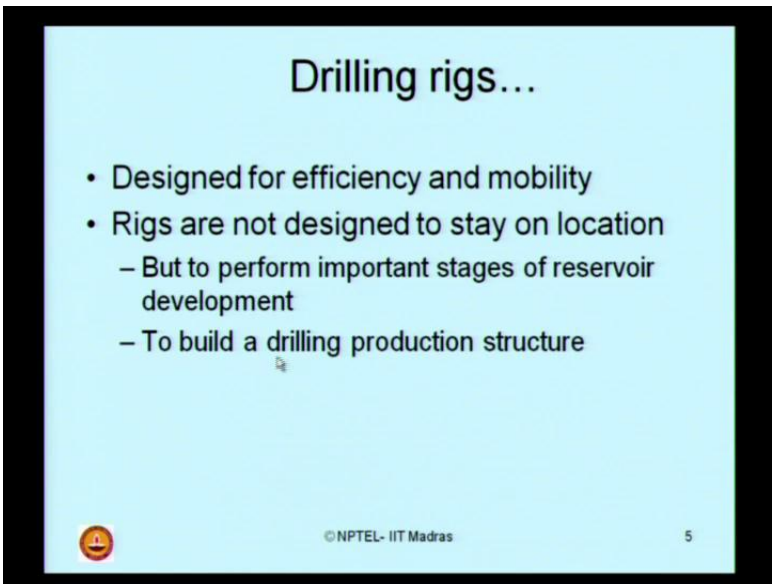

So, when we talk about the equipments used for drilling. The foremost picture comes into play is drilling rigs. Drilling rigs are usefully designed for efficient operation and for high degree of mobility. Rigs are not designed to stay on location, but to perform

important stages of reservoir development and also to build a complete drilling production structure.

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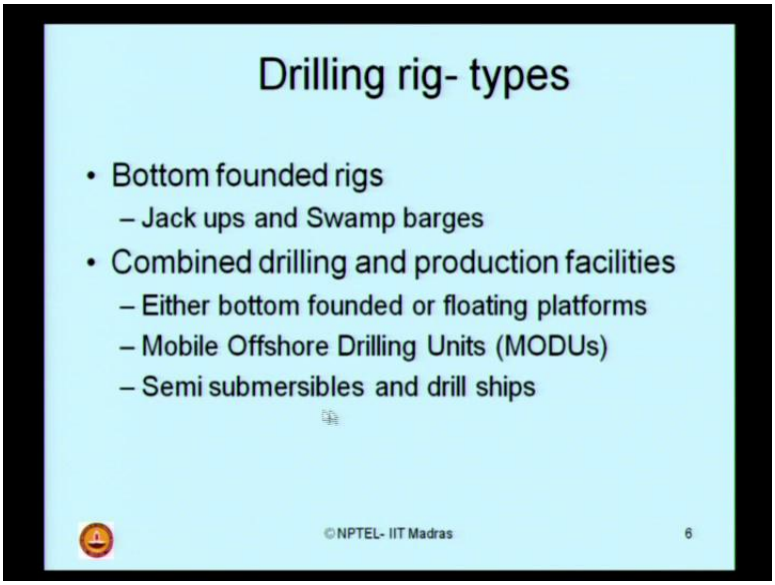

There are different types of drilling rigs and we going to discuss them in detail; we will touch briefly upon them because, if you understand or if you tend to understand operational safety, then drilling rig types are one of the important criteria to understand or to design innovative methods of drilling operation.

Drilling rigs can be classified as bottom founded rigs - what we call as jack ups and swamp barges. Combined drilling and production facilities are also available; they are either bottom mounded or floating platforms; they are called mobile offshore drilling units; there are semi submersibles and drilling ships available as drilling rigs.

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Initially, land rigs were used for offshore oil exploration. They are conventional land rigs exploring water underground; they are useful for shallow waters. They are first type of offshore drilling rigs employed in this industry. They are taken to the shallow waters, placed on the structure for drillin,g that is how the operation was carried out. They were the equipments initially used for offshore drilling.

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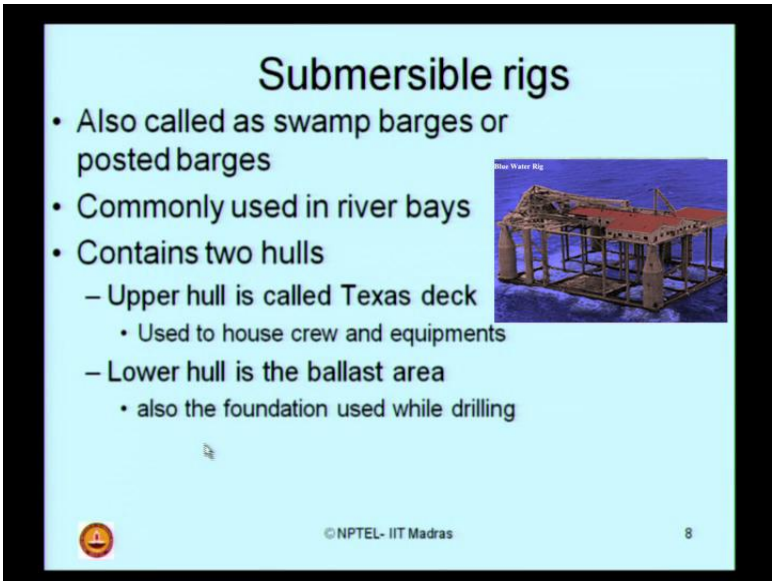

Then came semi submersible rigs. The oldest one which you see in the picture, is a blue water rig, also called as a swamp barge or posted barges. They are commonly used in

river bays; you can see the complexity of the mechanism involved in this kind of rigs. Generally they contain two hulls - the upper hull is famously called as a Texas hull, which use to house the crew and the equipments; the lower hull is the ballast hull, which is also the foundation used while drilling.

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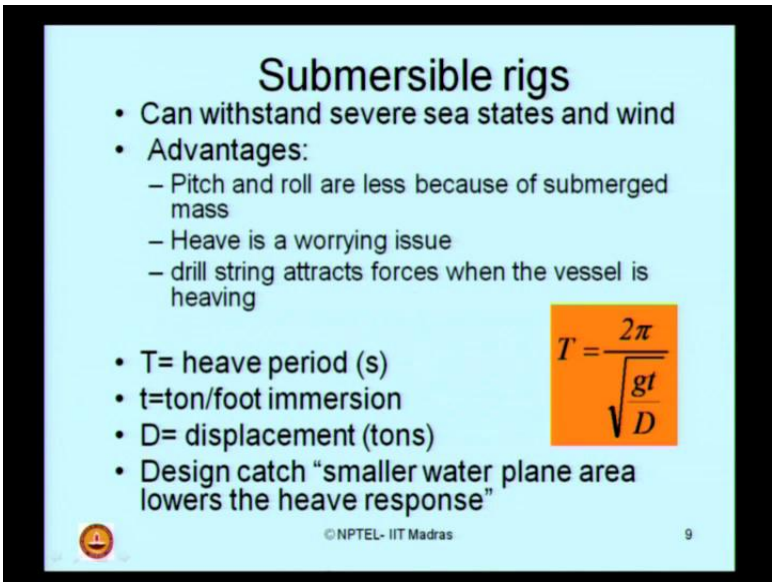

When we talk about semi submersible rigs, we spoke about some design innovation and design limitations in terms of safety. Now, let us focus on that specific issue. Semi submersible rigs are generally designed to withstand severe sea states and wind. The advantages of these kinds of rigs are, the pitch and roll responses are less because of submerged mass; however, heave motion of these rigs or high and that is always worrying issue, for the drill string attracts forces when the vessels is actually heaving; when you look at the design aspect of a semi submersible rig - where safety is one important parameter of our discussion.

The equation on the right side shows you, what would be the heave period of the semi submersible rig, which is a worrying issue which is given by this simple equation. T, in this equation, is given as heave period in seconds; whereas a small t, in this equation, is ton per foot immersion of the rig; D is the displacement in tons - and that is how you will get the time of the heave period of the semi submersible rig?

Now, the designed catch in these kinds of rigs is, smaller the water plane area, lower is the heave response. I already told you, heave is a worrying issue. To limit the heave response, the water plane area must be lower.

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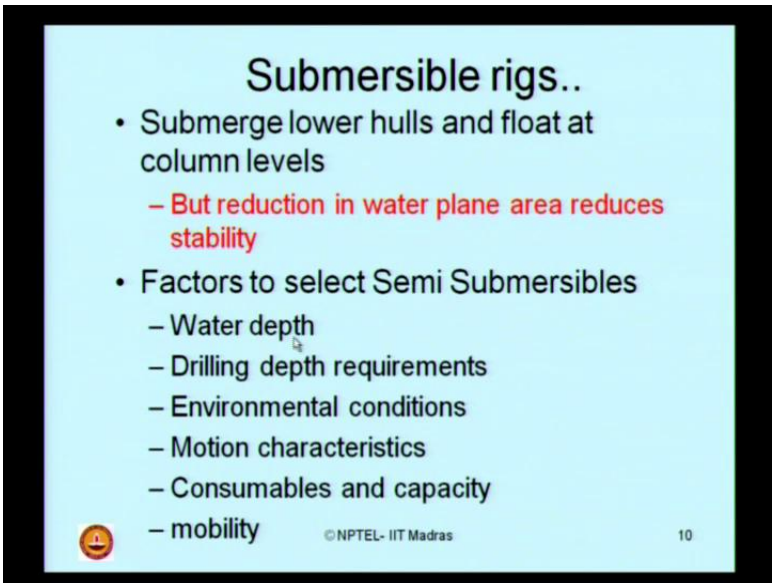

Now what happens, if you reduce the water plane area, submerge the lower hulls and float at a column level? This is how you can reduce the water plane area, but reduction in water plane area reduces stability of risk during operation.

Therefore, ladies and gentlemen, one will be interested to know what are the governing factors to select a semi submersible rig in safety point of view as well as design innovations? Of course, water depth suitability is the most important criteria to select an appropriate semi submersible rig, apart from that drilling depth requirements, environmental conditions, motion characteristics. Just now, we saw in the previous slide, how heave motion is governed by the displacement and tonnage of emersion, consumables and capacity, which this semi submersible rig is capable of, and of course, the degree of mobility which you desire on this operation.

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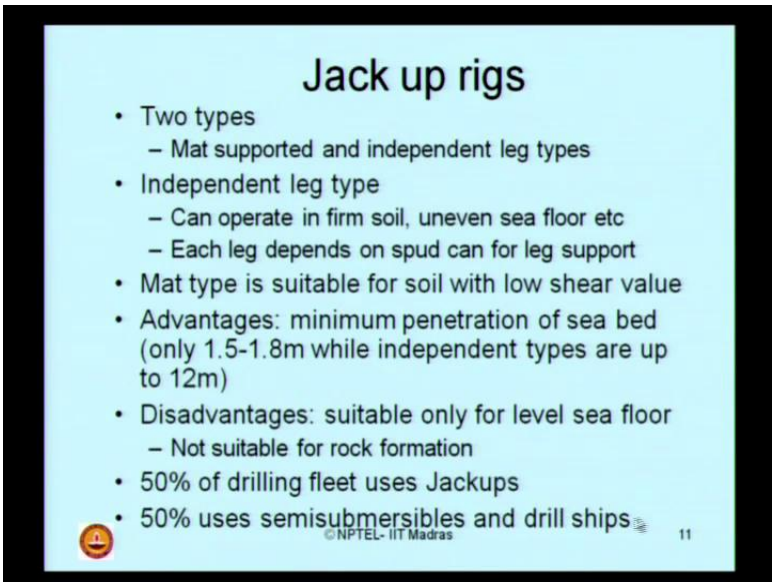

The next type what we call as a jack up rigs. There are two types of jack up rigs - one is mat supported and independent leg types. The independent leg type can operate in firm soil; it can also operate on uneven sea floor etcetera; each leg depends on a spud can for the leg support. Mat type is suitable for soil with low shear value. The advantages are minimum penetration of sea bed is only about 1.8 meter, while the independent leg type penetrates about 12 meter. The disadvantage of the mat type is that suitable only for a level sea floor; it is not suitable for rock formation. If we look at the entire drilling fleet in the world, 50 percent of them comfortably uses jack up rigs; the remaining fifty percent either employ semi submersibles or drill ships.

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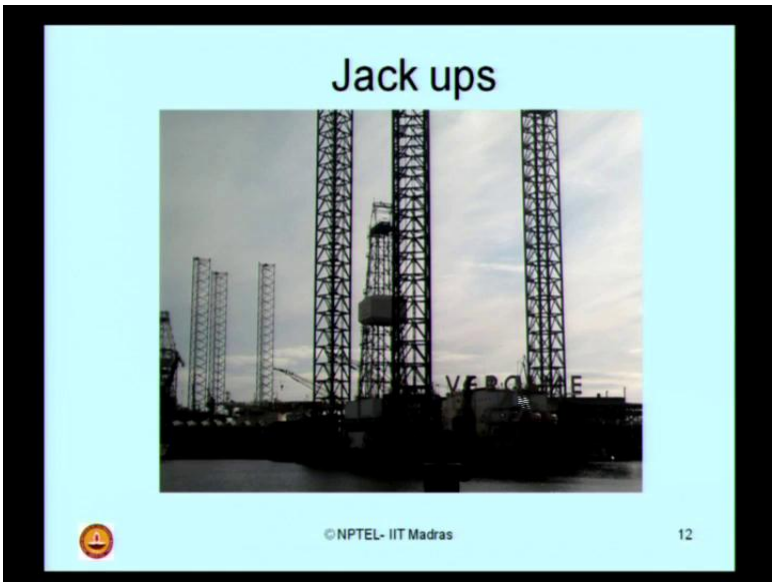

Some of the pictures I would like to show you, just for your knowledge on jack up rigs. This is one of the very famous old jack up rig, came for a deployment, later subsequently for a repair is vermicelli jack up.

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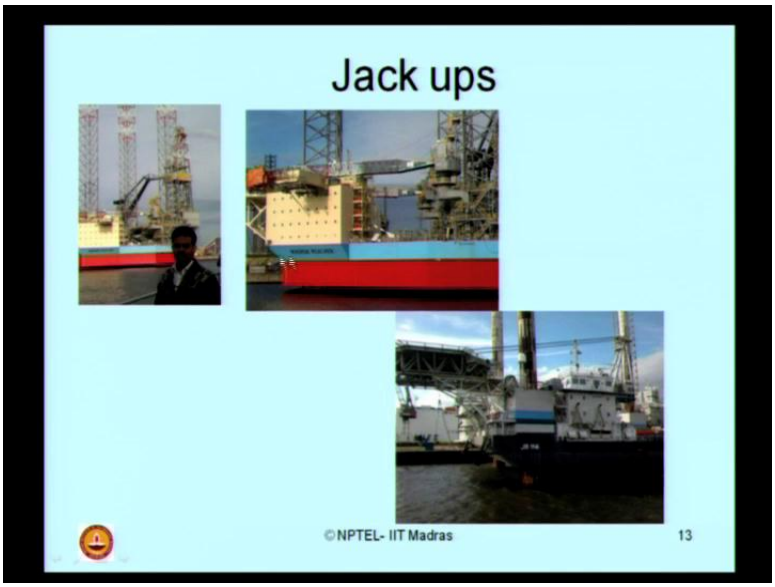

These jack up rigs or pictures, which I have taken from a specific repair yarn in Rotterdam. You can see the trust system which the rig employs, for drilling operation. You can also see the highly compress mechanical devices and systems on the boat, which all add to the complexities of such rigs under operation.

Now, we can easily understand safety in drilling operation is not only in the preview of a human being, but also effectively and inhabitable designing the mechanical equipments function on board as well.

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This is another picture of g s f magi lane jack up rig very famous and very common type of jack up rig deployed by the drilling fleet.

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Can we think of alternative drilling for more safety? The answer is yes. There is a recent develop technique called through-the-leg drilling. This can be seen as an alternative

drilling technique, which has more and improved safety measures compared to other conventional rigs. Let us quickly go through what do we understand by through-the-leg drilling process. Wells are installed through the platform legs; legs can be utilized to protect the surface casings; they also provide stability it adds strength to resist external forces, sea-floor mud slides, calls so withstand ice movement.

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It reduces wetted area of the platform; reduces the hydrodynamic profile and savings in platform structural weight and cost. Monopods are one of the solutions, which are generally employed for ice problems. The picture what you see here is Alaska's Cook Inlet monopod platform - which is being employed or catering ice problems.

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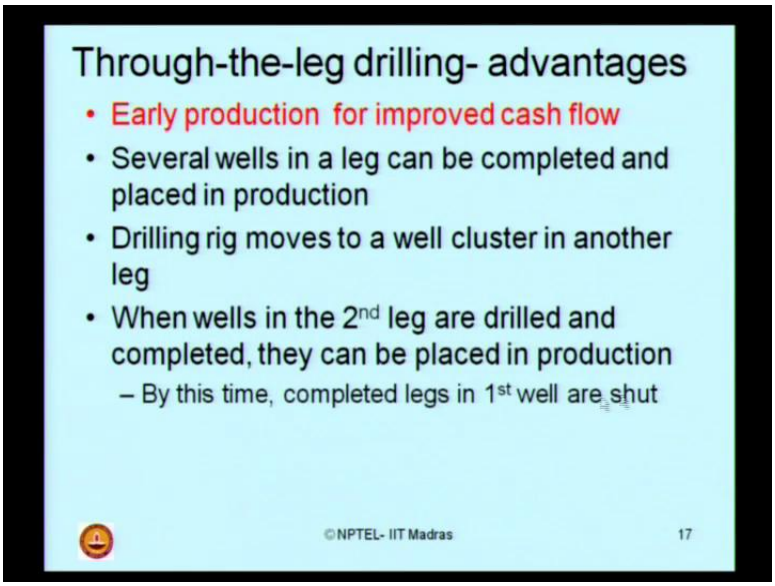

Through-the-drilling process has couple of advantages. It leaves to early production for improved cash flow. There are several wells in a leg that can be completed and placed in production. The drilling rigs move to a well cluster in another leg. When the wells in the second leg are drilled and completed, they can be placed in production - by this time the completed legs in the first well are already shut.

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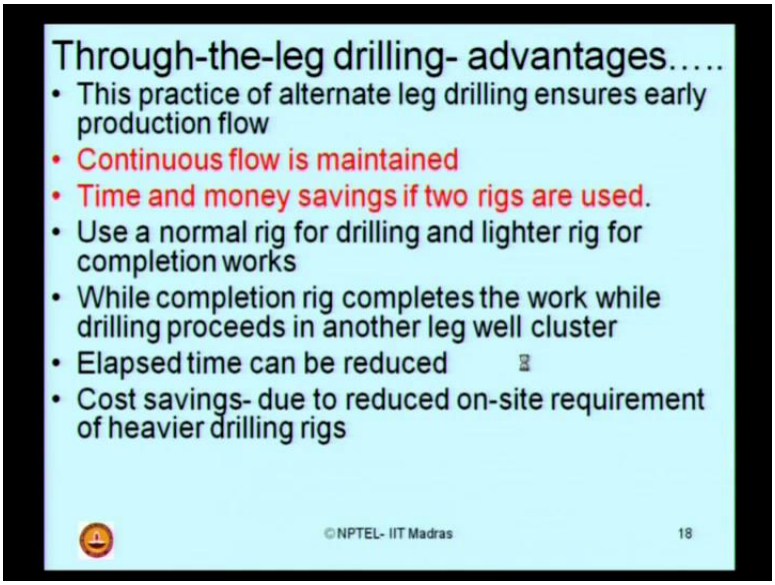

This practice of alternate leg drilling ensures early production flow. Further, continuous flow is also possible, time and money savings, if two rigs are employed. Use a normal rig

for drilling and lighter rig for completion works - that is what we say two rigs are to be employed. While completion, rig completes the work while drilling rig proceeds in another leg well cluster. Elapsed time can be reduced between the successive operations. It saves in cost due to the reduced on-site requirement of heavier drilling rigs - that is why we say use lighter rig for completion works.

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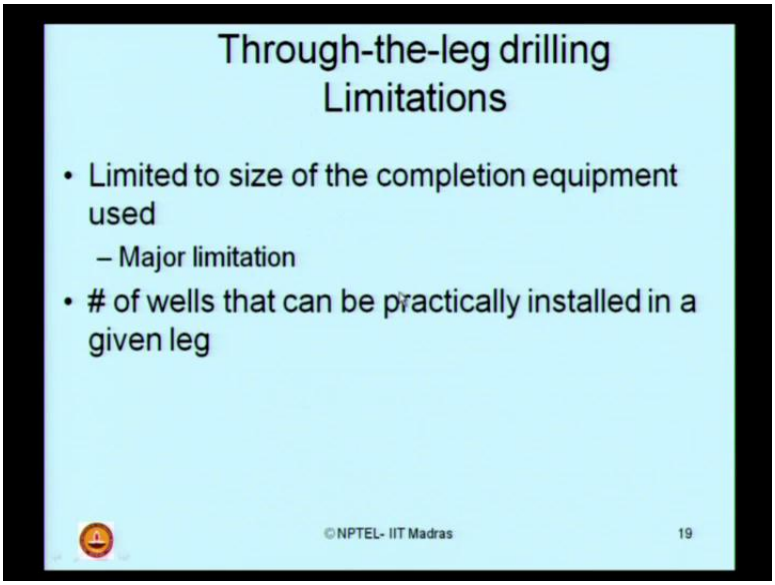

Of course, this process has certain limitations. It is limited to the size of the completion equipment used; it is considered as one of the major limitation in drilling process. The number of wells that can be practically installed in a given leg, is also one of the major limitations of this kind of drilling process

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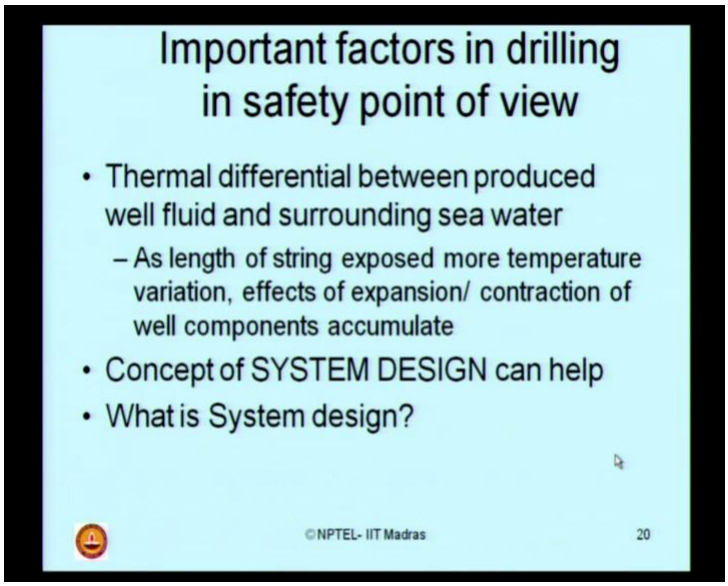

Let us quickly look at the important factors in drilling in safety point of view. There exist, the thermal differential between produced well fluid and the surrounding sea water. As length of string exposed to more temperature variation, effects of expansion and contraction of well components get accumulated. How to solve this issue? Now, in the recent development of drilling people introduced what is called system design concept. Now what is a system design?

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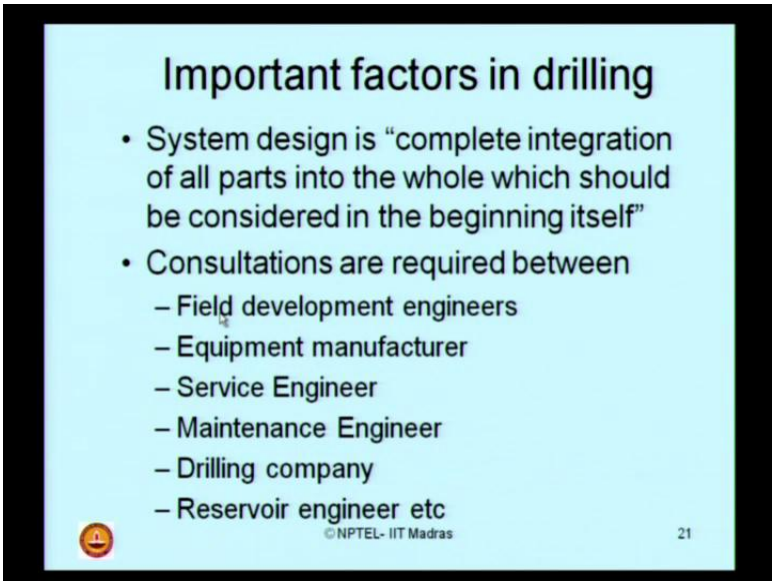

System design is a complete integration of all parts into the whole, which should be considered in the beginning itself. To employ a system design in drilling, consultations are required from many expertises. We shall involve field development engineers, equipment manufacturers, services engineers, maintenance engineers, and of course, different drilling companies and reservoir engineers etcetera.

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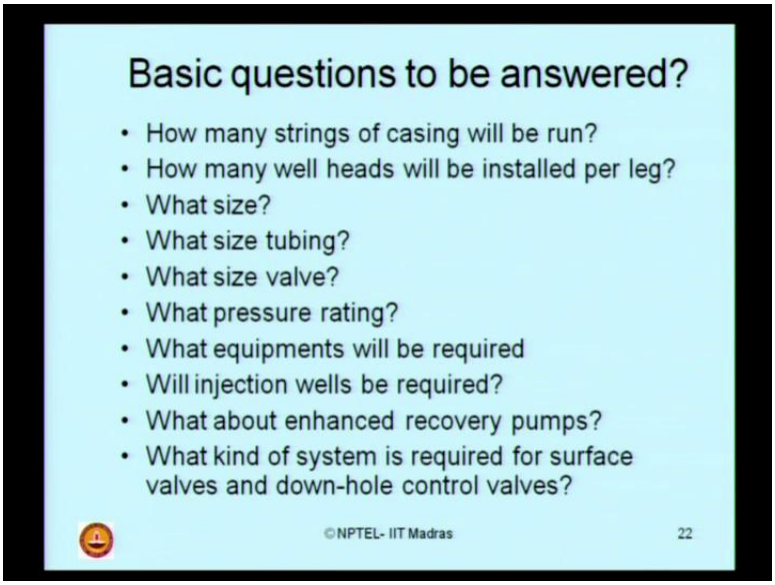

Now, there are few basic questions to be answered before we start selecting a drilling ray for design innovation or operation safety. How many string of casing will be run? How many well heads will be installed per leg? What size? What size tubing will be used? What size valves will be used? What pressure rating are we looking at? What equipments will be required? Will injection wells be required? What about the enhanced recovery pumps? What kind of system is required for surface valves and down-hole control valves?

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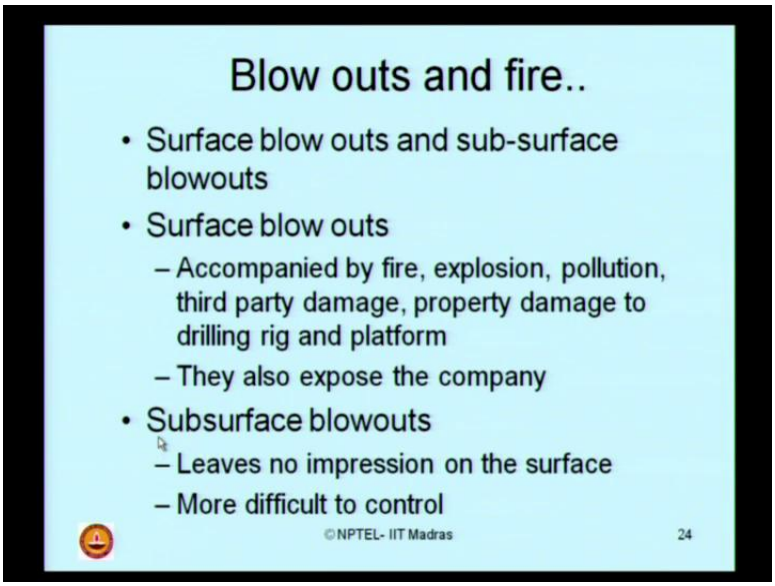

Let us quickly look at the safety during operations. Take again an example of drilling. When we talk about safety during operation, the major terminology which comes into play, is blow out and fire accidents. Blow out accidents and fire accidents or if it all occurs in drilling operation, are considered to be highly catastrophic.

Now, let us quickly look at what do we understand by blow outs. There can be two kinds of blow outs - one what we call as surface blow out; the other one what we call as sub surface blowout. Surface blow outs generally are accompanied by a fire, explosion, pollution, causing damage to third party, property damage to drilling rig, and the platform as well. This is one aspect of safety what we looking at. The major aspect is also there on such kind of blow outs; they also expose the name of the company in offshore industry. Whereas, on the contrary, subsurface blowouts leaves no impression on the surface at all, but it is very difficult to control such blowouts in comparison to surface blowouts.

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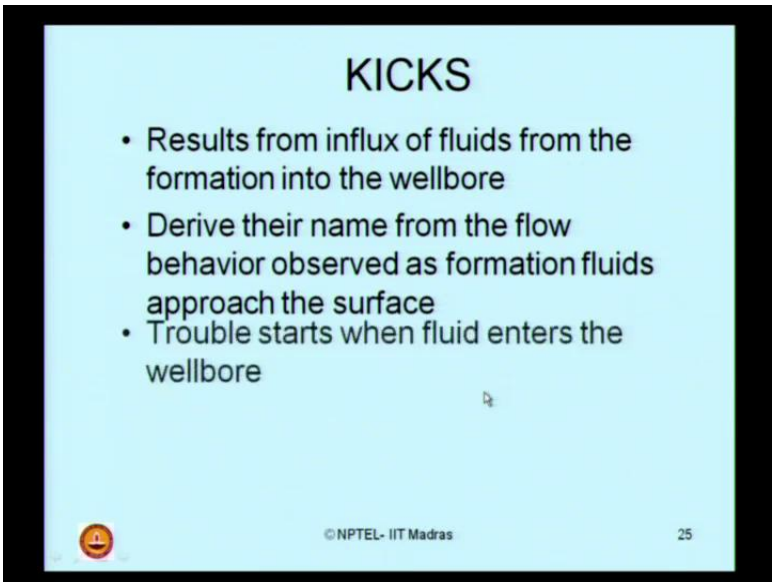

When we talk about blowout, there is a terminology which will come up to your mind - what we call as KICKS. Now what is a KICKS? It usually results from an influx of fluids from formation into the wellbore. There is an inflow of fluid from the formation into the wellbore, that is what, which may choose to be a KICKS up. This derives the name from the flow behavior observed as formation fluids approach the surface. The trouble starts when this fluid enters the wellbore.

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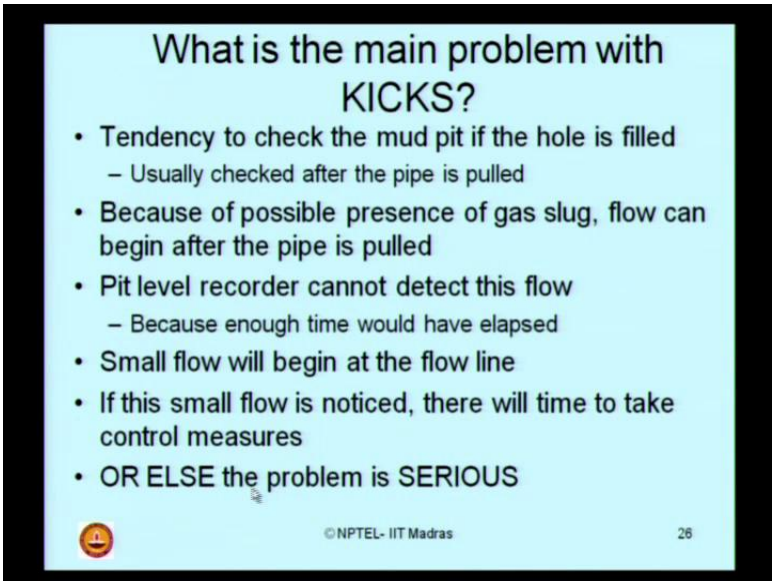

What is the main problem with KICKS? It has a tendency generally to check the mud pit if the hole is filled. The tendency is to check the mud pit, but usually the checking is done after the pipe is pulled off. Because of the possible presence of gas slug, flow can begin even after the pipe is pulled. The pit level recorder, which is consider to be one of the safety devices, cannot detect this flow. It is because, enough time would have elapsed by this gas slug being started. Small flow will begin at the flow line; if this small flow is noticed, there will be time to take control measures; if this becomes more vulnerable, then the problem becomes very serious.

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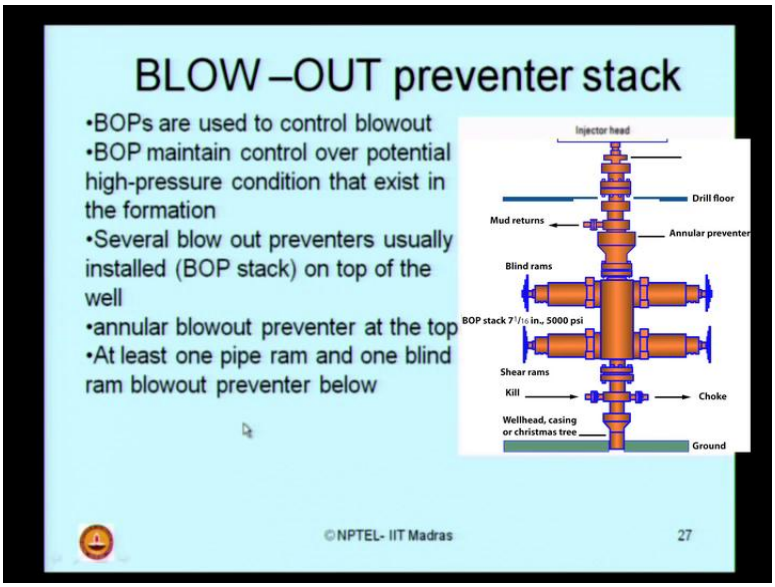

Now, when such KICKS happen in blowouts, we generally use what we call a blow out preventer. What we see in the picture, is a blowout preventer stack. This stack has an assembly of annular preventer, shear rams, blind rams, mud returns, etcetera. All assembled on a single stack. So, that is why this assembly is what we call as BOP stack. The blow out preventer, what we address as BOP, are used to control the blow out. In the previous slide, we understand what is blow out. BOP maintains control over the potential high-pressure condition, that usually exists in the formation. Several BOP(s) are usually installed on the stack, on the top of the well. So, all of them put together is what we called as group of blow out preventers, otherwise known as BOP stack. The annular blowout preventer is usually fixed at the top you can see here. At least one pipe ram and one blind ram blowout preventer will be located below; you can see a blowout a blind ram located here.

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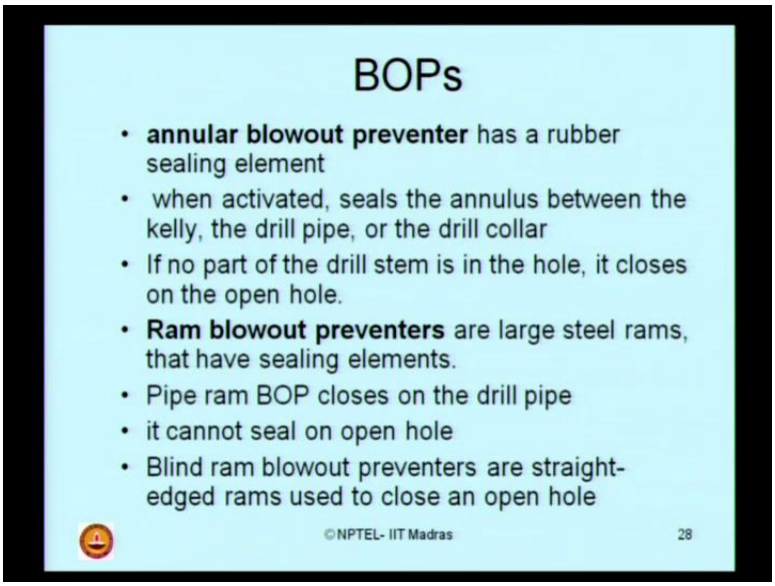

The annular blowout preventer has a rubber sealing element. When activated, seals the annulus between the Kelly, the drill pipe, or the drill collar. If no part of the drill stem is inside the hole, it closes on the open hole. While the ram blowouts preventer are basically a large steel rams that have stealing elements. The pipe ram BOP closes the drill pipe; it cannot seal on open hole of course. The blind ram blowout preventers are straight edged rams used to close an open hole.

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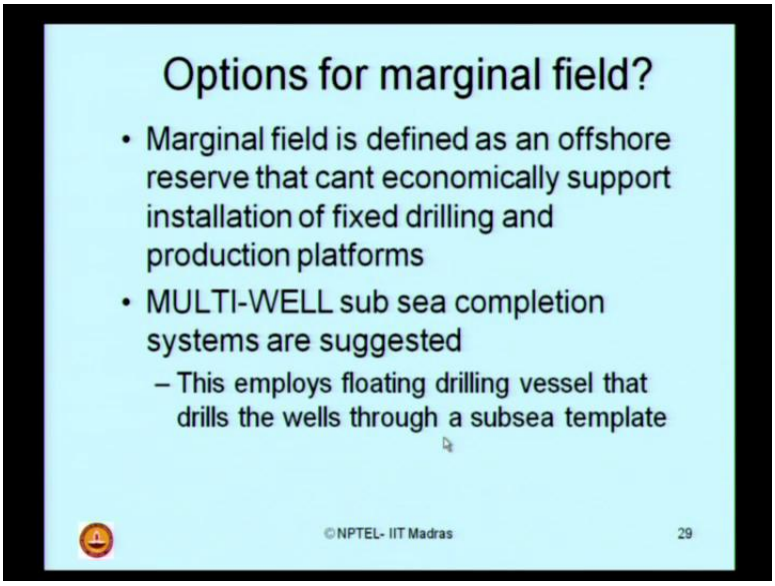

Now, we have something called a marginal field in offshore drilling. What options can we do or can we select for an marginal field? First, let us try to understand what do we know as a marginal field. Marginal field is defined as an offshore result that cannot economically support installation of a fixed drilling and productions platform as well. Therefore, the solution could be MULTI-WELL subsea system. The MULTI-WELL subsea completion systems are usually taken as an alternative for marginal fields. This employs floating drilling vessels that drills the wells through a subsea template.

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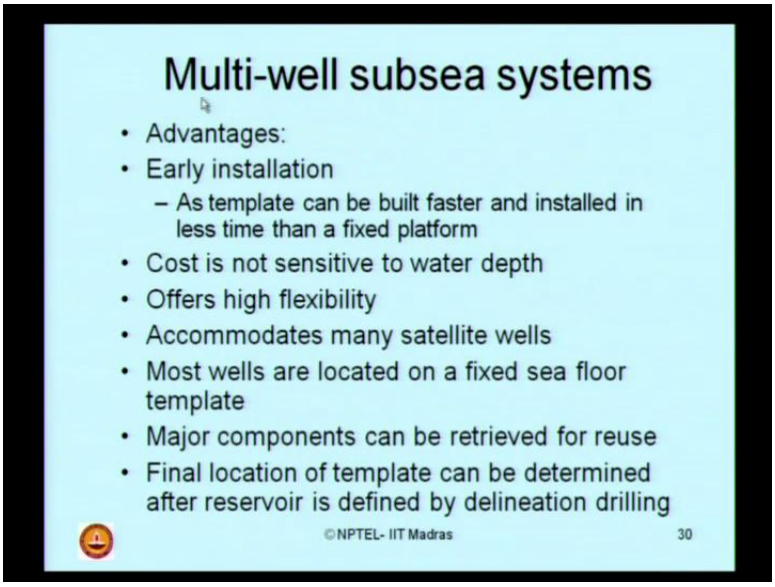

The MULTI-WELL subsea systems have many advantages. They have early installation possible, because they have a template and a template can be build much faster and installed in lesser time than a fixed platform. It is not cost sensitive to the water depth. It offers high flexibility; it accommodates many satellite wells - most wells are located on the fixed sea floor template. Major components can be retrieved for reuse. The final location of template can be determined after the reservoir is defined by delineation drilling. So, marginal fields can have an alternate drilling procedure using what we call MULTI-WELL subsea systems.

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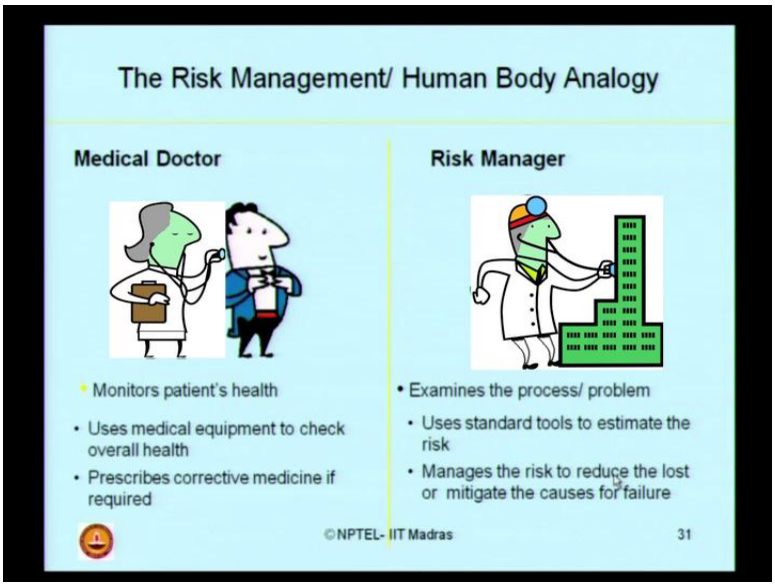

When we look at the risk management involved in offshore industry, which is closely addressing the safety issues in drilling operation, or in general, in offshore and petroleum industry. What we call is the risk management. Now, we can compare the risk management with the simple human body analogy for our better understanding. Look at the human body analogy, a medical doctor examines the patient's health using medical equipment to check the overall health, and then prescribes corrective medicine if required. Similarly, you look at the risk manager, he examines the process and the problem involved in offshore and petroleum industry - uses standard tools to estimate the risk, then he manages the risk to reduce the lost or to mitigate the causes for failure.

Just for a recap, we have discussed some basic terminologies involved in health safety and environmental management. We will discuss some important safety assurance and assessments, which we saw in the previous lecture. In today's lecture, we discussed about safety in design and operation. I had taken exclusive example of drilling rig production; we also discussed about the innovative methods in design; different types of drilling operation, their suitability then their selection procedure related to safety.

In the next lecture, we discussed about organizing for safety in HSE. We also have couple of tutorial exercises at the end of this module. I have already given you one tutorial exercise in the last lecture on safety assessment. Once we discuss organizing for safety, we will talk about hazard classification and assessment.

Now, ladies and gentlemen, it will be very interesting for you to understand, what are the differences between risk and hazard. How do we classify risk, how do we classify hazard, how do we assess hazard, how do we control hazard, and if at all the hazard and risk are going to be different - how hazard can become a risk? These issues we will discuss in the following lecture.

Thank you.