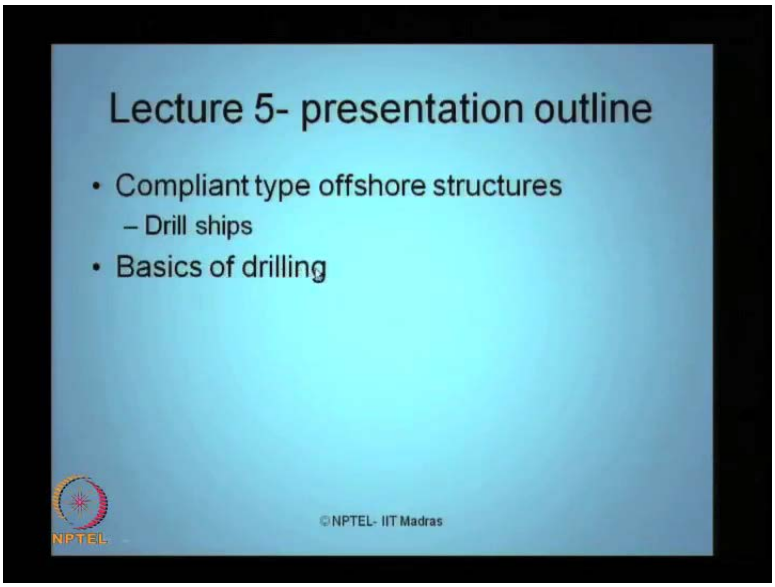
Ocean Structures and Materials
Dr. Srinivasan Chandrasekaran
Department of Ocean Engineering
Indian Institute of Technology, Madras

Module - 1
Lecture - 5
Drill ships and basics of drilling

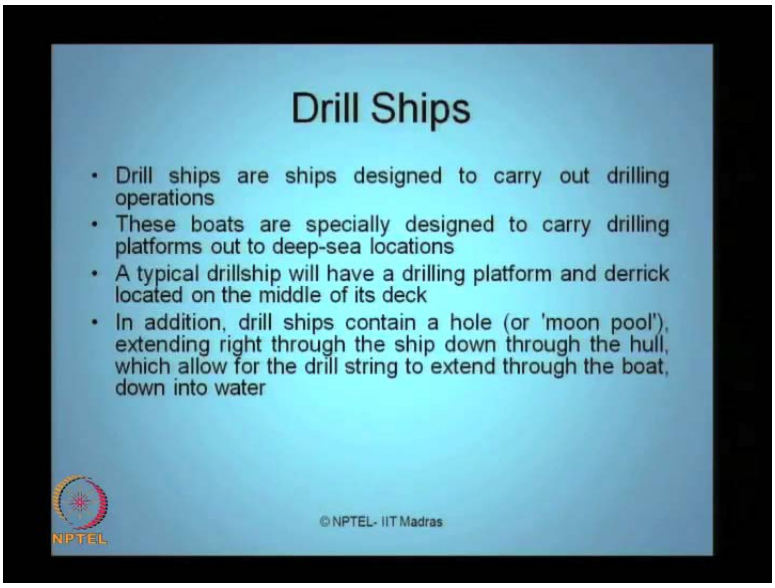
Welcome to the fifth lecture on the first module of ocean structures and materials. I hope you have been following the remaining four lectures, which we discussed in the yesterday's class.

(Refer Slide Time: 00:25)



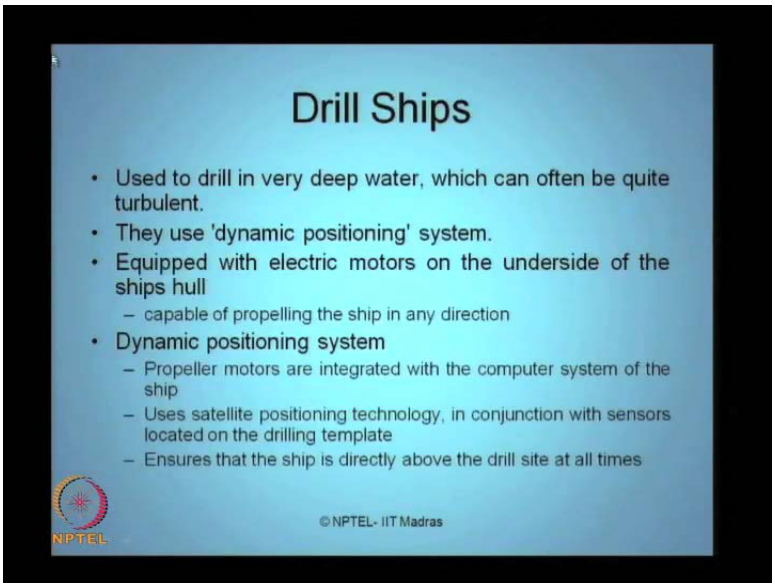
Let us quickly look at the presentation outline of this specific lecture. We discuss in this lecture different complaint type offshore structures under these braces of compliant type of offshore structures; we will talk about drill ships. And further we will also give you some basic outline on concepts of drilling, because if you have got a design or plant for any offshore structure system for the process of exploration of oil and gas one must understand certain basic terminologies and basics activities related to drilling. So, in this lecture we will also focus on basics of drilling.

(Refer Slide Time: 01:18)



Let us talk about the first part of the lecture explaining drill ships. What are drill ships? Drill ships are essentially or ships which are specifically designed to carry out drilling operations. The name is derived directly from drill ships. So, they are nothing but ships men for drilling operations. These are nothing but specially designing the boats which house drilling platform which can carry drilling at deep sea locations. A typical drill ships will have a drilling platform and derrick located on the middle of its deck. In addition, drill ships also contain of a hole which we call as a moon pool. Moon pool is nothing but a hole which is an extending right through the ships down through the hull, this allow drill string to extend through the boat, down into water.

(Refer Slide Time: 02:23)

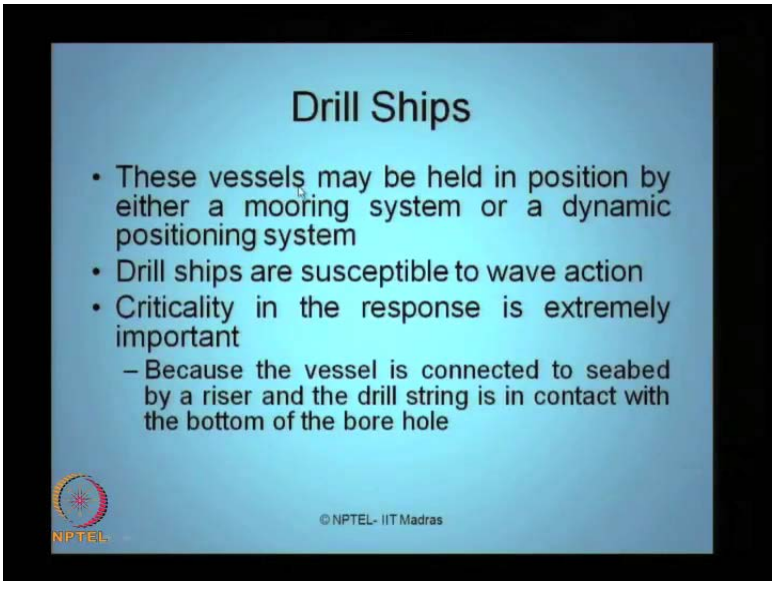


Drill ships are actually used in very deep water, which can be quite often turbulent. In that cases to keep them positioning we used what is called dynamic positioning system because of the turbulent effect in deep water. What is a dynamic positioning system? Dynamic positioning system is a complex algorithm which is equipped with electric motors on the underside of the ship hull. It is capable of propelling the ships in any desired direction you want. The dynamic positioning system comprises of propeller motors which are integrated with the computer system of the ships. Now the computer system that is integrated with the propeller motors; use satellite positioning technology, in conjunction with sensors located on the drilling template. The very objective of bringing alignment of the drilling template with that of propeller motors of the ship hull is to ensure that the ships is always position directly above the drill site at all times during drilling operation.

(Refer Slide Time: 03:49)

It is an adaptation of a standard seagoing ship of mono-hull from. Drill ships are nothing but standard ship of mono-hull type. There are some additions to this standard ship, additions are actually the substructure which contain a moon pool; cantilevers from which the drilling operations can be carried out. The drill ships are nothing but large vessels which are equipped with additional means of positioning the unit over the drill center. If you may wonder why I have to position the drill ship exactly over the drill hole, it is required to establish of close contact with the bore hole in the seabed.

(Refer Slide Time: 04:37)

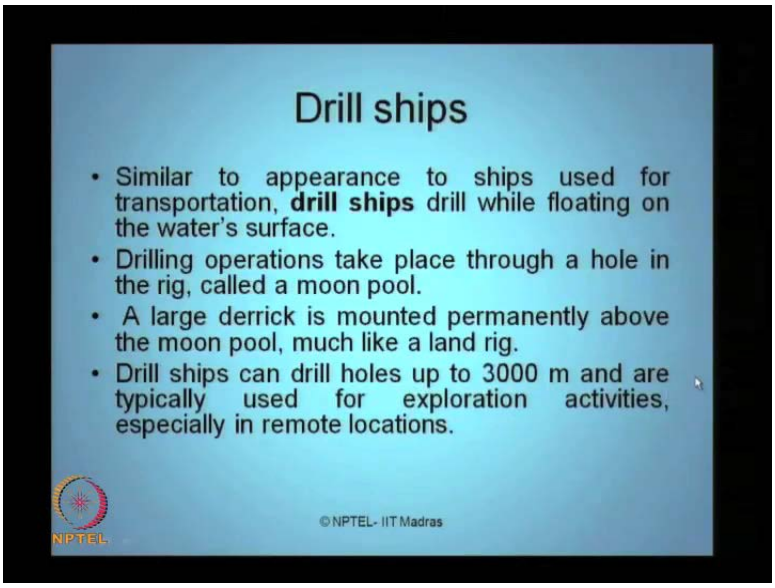


Drill ships are nothing but large vessels, which are held in position either by the mooring system or a dynamic positioning system as explained the previous slide. You may wonder why drill ship required a special mooring system while performing drilling operations. Drill ships are highly susceptible to wave action. Criticality in the response is extremely important, because the vessel is connected to seabed by a riser and the drill sting is in contact with the bottom of the bore hole. Now there exists a strong coupling between the motion of the vessels with the top motion of the riser under environmental or lateral loads cost by waves and current. Therefore, the response of the ship with the coupled motion of the riser dynamics becomes critically important.

(Refer Slide Time: 05:40)

Drills ships are designed to carry drilling operations are greater distance offshore and in very deep waters. A drilling platform and derrick will be located in the middle of a large, open area of the ship, the remaining recollect terminology which is middle, large, open area in the ship which a called as a moon pool. Moon pool is nothing but is hole extended through the hull through which the drilling rises will be placed through the hull to the drilling template.

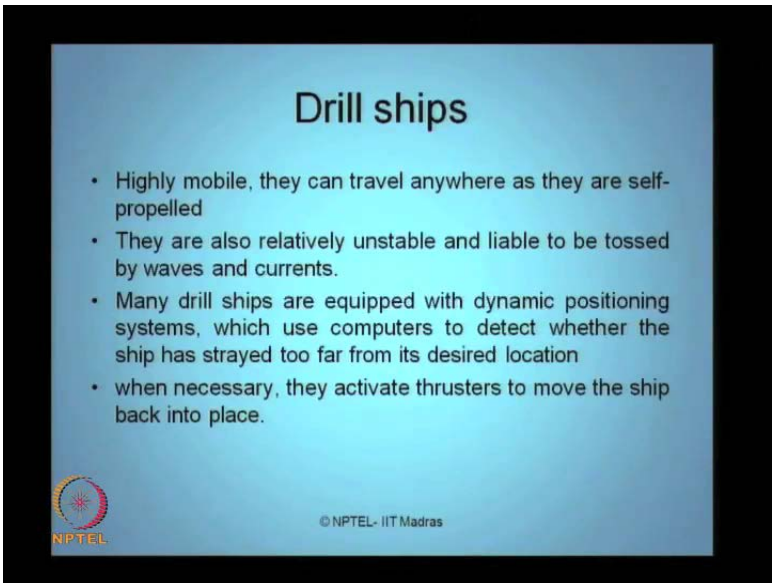
(Refer Slide Time: 06:12)



Drill ships have similar to the appearance to ships except that drill ship drill while floating on sea surface. During operation, the drilling takes place through a hole that we call as moon pool. The large derrick is mounted permanently above the moon pool, which is similar to that of land rig. Drill ships can drill holes up to 3000 meter deep, and are typically used for exploration drilling. Remember the drill ships are never equipped or never adapted for production drilling.

Now you may wonder different kinds of offshore platform have different specific application in explorations. Some are used for production, some are use production and storage, while there been designed some of them having a fixed base, some of them floating nature, some of them have a hybrid combination, which is for example, like a TLP. The drill ship have great advantage of drilling in greater depth, but essentially only for exploration activities in remote locations.

(Refer Slide Time: 07:25)

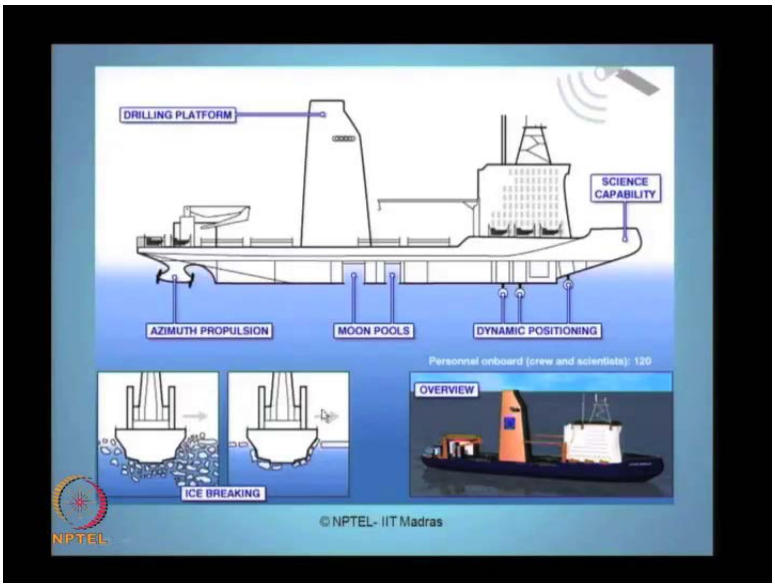


Drill ships are very highly mobile therefore, this can be considered has one of the important advantages of drill ship in an offshore application. Essentially drill ships can travel anywhere has they are self-propelled similar to the (( )) ship. They are also relatively unstable and liable to be tossed by waves and currents. Therefore, you must be very careful in implying them in rough sea states, while the ship is in motion when the drilling is not carried out the ship has high degree of stability, but when the ship in positions the drilling carried out they can become unstable and they can liable to be tossed by the wave and currents.

Many drill ship are equipped generally with what we called dynamic positioning system. We can recollect what is dynamic positioning system referred as DPS in the literature. Dynamic positioning system use computers to detect whether the ship has strayed too far from its desired location or the ship is located exactly above the drill hole. Whenever it is necessary, these dynamic positioning systems which are computer controlled algorithms activate thrusters which are located at bottom hull of the ship, and the ship will be moved to the desired location in place.

Therefore, dynamic positioning system held to establish continues contact between the drill ships thrusters with that of the template on the drilling base. Therefore, it is to be ensured that the drill ship is located physically vertically exactly above the drill hole which is to be drilled.

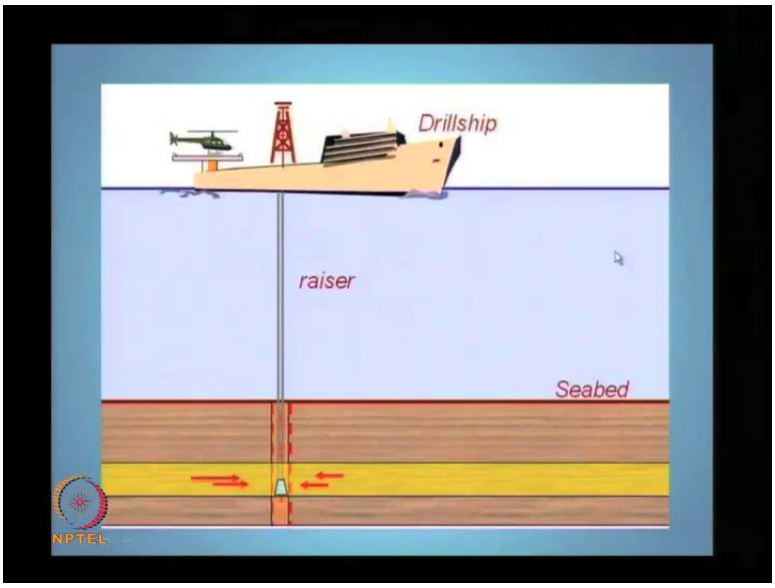
(Refer Slide Time: 09:18)



Here is conceptual picture of a drill ship we to see here. As I said the conventional form of large vessels like a ship shaped vessel, the vessels contain derrick which are used or which are necessary for doing drilling. I put them as a drilling platform. The vessel also has moon pool which are nothing but holes created through the hull through which the drilling rises will run. Of course, it is got azimuth propulsion that are used for maneuvering the ship while motion, but not while drilling. Of course, these units what you see here other standard components the residential quarter, the housing blocks, the turbine generated etcetera which is standard equipments of a conventional ship.

As you see here, the ship is also housed with what we called dynamic thruster, which is nothing but computer control dynamic positioning system which will enable the ship to turn any direction has a desired. So that ship is always, stay exactly vertically above drill hole to ensure more efficient drilling. The maximum number of crew and scientist who could be placed on board in a typical drill shape cannot exceed 120; that is the limitation here. Of course, drill ship can be recollects understand that they are only used for exploratory drilling and not for production drilling. This is again schematic over view of a drill ship when it is on float. Drill ships are also having problems associated with rough sea state, in case of ice breaking etcetera.

(Refer Slide Time: 11:15)



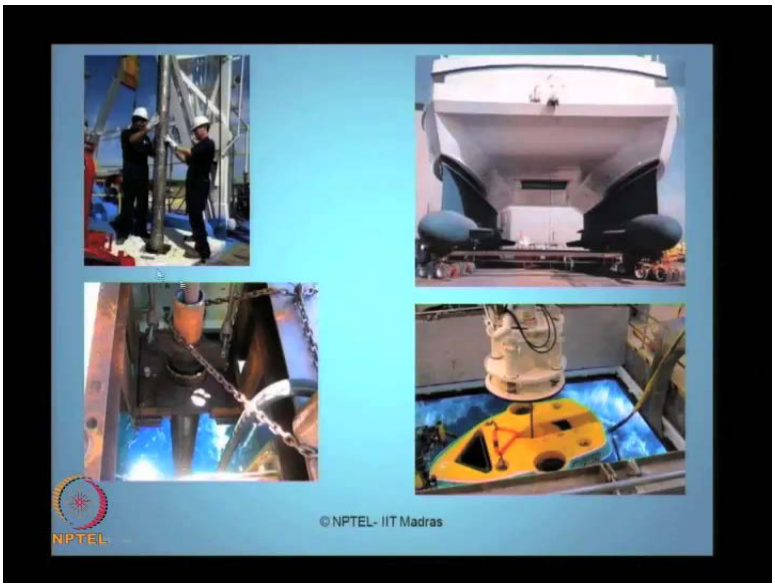
It is another typical figure, which shows how drilling operations are carried out in drill ships. You can see here the red line shows me the seabed. These are the drilling risers; this is where may hydrocarbons is being happening to shore to the drilling bit. This is may helipad which is enabling in helicopter launching on the drill ship. This leaving quarter the mechanical and electrical equipment is used for maneuvering the ship. The red one what is see here is the derrick, which houses all necessary plants and equipment that are required for drilling. The dynamic positioning system which are housed at the under hull of this will enable the drill ship to be the positions exactly vertically above the drill hole where the drilling has to take place.

(Refer Slide Time: 12:09)

The photograph shown here are few examples of drill ships, which are in operation. For example, you see in the left side, the drill ship you see here is named as ultra-deep water drill ship. The name derives the specific depth of water at which the drill ship could be deployed. Can see the mechanical systems are highly complex in nature, the top side is has complex and has facilitative has that of any fixed offshore type platform as well. You can see the complexity involved in the derrick here, this is derrick. There must be moon pool exactly below the derricks; the drilling has to be take place in this direction.

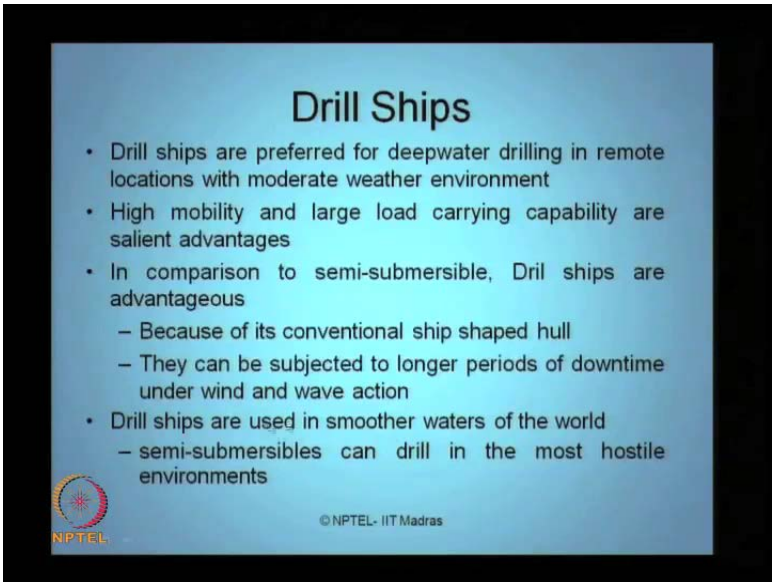
You can see the leaving quarters here; you can see cranes used for facilitating the equipments or placement of equipments overboard. You can see a helipad here facilities landing of helicopter in case of any emergency. The other example for photograph what is you can see here the discovered India drill ship which is being used at depth of 2.95 kilo meters. Again can identify the components here; this is a drilling derrick. There must be moon pool below here where the drilling will take place. I can see a helipad here; you can see the crane here. You can see a complex mechanical system on the top. The third photograph what you see here the very famous sager valley drill ship, which is used by ONGC in India.

(Refer Slide Time: 13:40)



These are some of photographs which show you the details of moon pool. You can see here moon pool is nothing but hole, which is driven the top of the hull which passes through and through. You can see here the hole through and through, you can see the waterbed here, and you can see the sea surface here. This is the very specific drilling mechanisms or the drilling rises are connected in pieces has the drilling progress deeper and deeper.

(Refer Slide Time: 14:13)

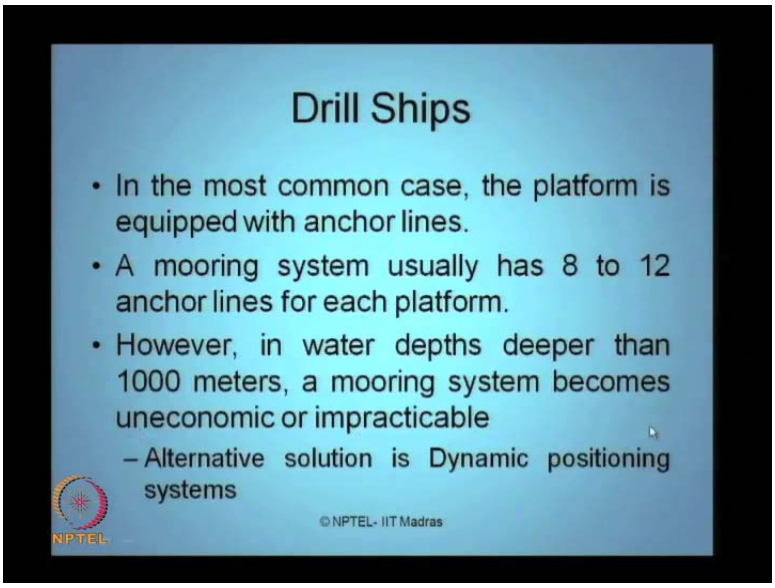


The drill ships essentially are preferred for deepwater drilling. The application of drill ships can be very helpful in remote areas where the weather environment is moderate. Remember very carefully drill ships cannot be used in critical sea state. In critical sea state, drilling operation cannot happen because drill ships are highly susceptible to tasking by the wave and the current action. High mobility and large load carrying capacity are considered salient advantages of drill ships. As you see drill ships are very large in size and the load carrying capacity is substantially high, and as a ship it has got high degree of mobility and maneuverability.

In comparison to semisubmersibles, let us try to compare how drill ships stand in comparison to semisubmersibles. In comparison of semisubmersibles drill ships are advantages, because the conventional ship shaped hull enable easy maneuvering or easy movement or easy mobility in compare to semisubmersibles. Drill ships can be subjected to longer periods of down time under wave and wind action. What you understand by down time? Down time is the time of operation, where the drill ship will remaining sea while drilling is takes place; whereas in the semisubmersibles the down time where the drilling operation takes place is highly limited and lesser in comparison to that of drill ships.

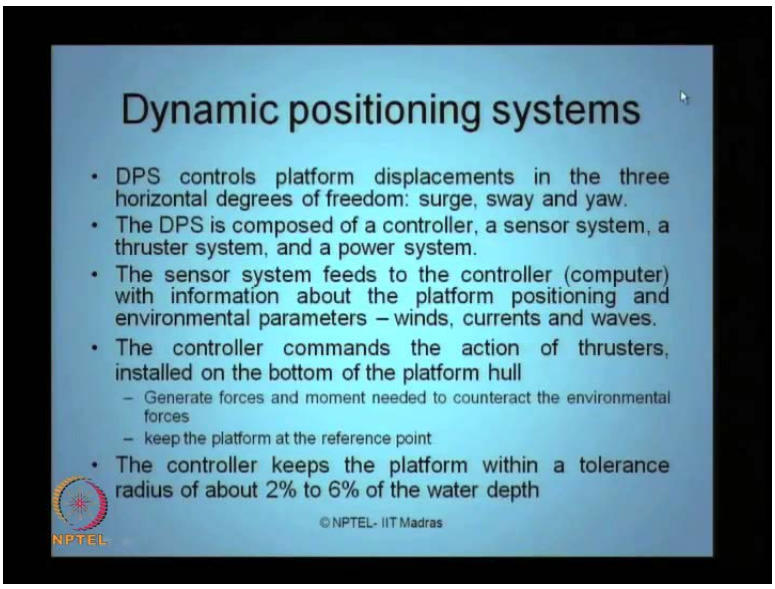
Drill ships are essentially used for smoother waters, because you do not want a rough turbulent weather. Though you may wonder in turbulent weather dynamic positioning systems will enable the drill ships keep are stay in position, but performing a drilling operations in a rough critical sea state will always cause stability problem to the ship as such. Therefore, the drill ship cannot be used in rough sea state, so it is recommended that drill ships can be used in moderate sea state. The semisubmersibles, however, can drill most hostile environment. Therefore, they are some merits of drill ships in comparison to semisubmersibles there are some advantages of semisubmersibles in compared that of drill ships in term of it working weather environment.

(Refer Slide Time: 16:45)



In most common case, the platform is generally equipped with anchor lines. A mooring system are generally order has above 8 to 12 anchor lines for each platform. However, in water depths deeper than 1000 meters, a mooring system becomes uneconomical or impracticable. Now one may wonder what you do, if you want go for drilling beyond 1000 meters, obliviously alternating solutions is dynamic positioning systems.

(Refer Slide Time: 17:16)



What are dynamic positioning systems? DPS is basically is a control which activate the control systems of the platform which control essentially a displacements in three

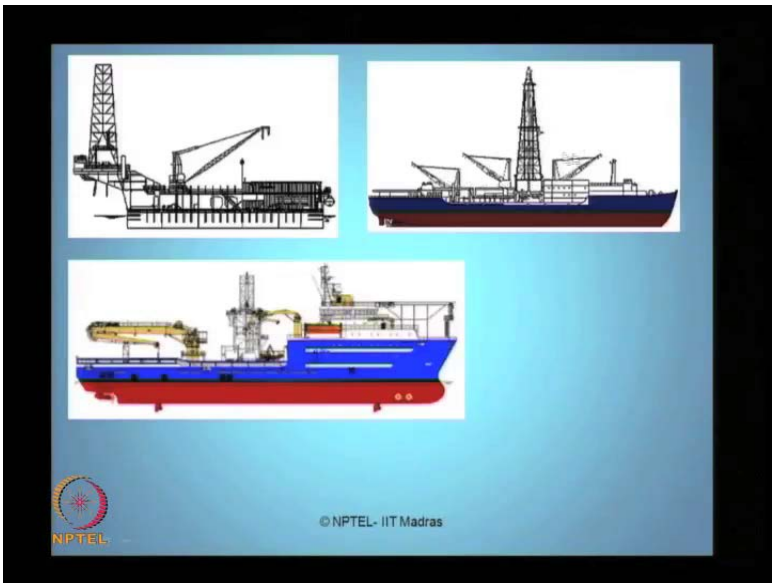
horizontal degrees of freedom is namely surge, sway and yaw, because these are the degree of freedom where the responses of the drill ship can be large during drilling operation. Therefore, dynamic positioning system develops the control algorithm even to limit this responses as well under the wave action.

DPS is composed of a controller, a sensor system, a thruster system, and a power system to put together is what we called dynamic positioning system. The sensors system actually feeds to the controller with information about the platform positioning and the environmental parameters. The senses keep on reading the estimate of wind, current and waves load exerted on the ship or on the drill ship, as well as the geographic and geometric positioning of the ship with respect to the GPS location.

Therefore, these two data will be integrated, will be compared and will be fete and feed forward by the sensor system to the computer controller. Once the controller receives this information, it compares the GPS position of the drill ship with that of the actual position of the drill hole. The controller commands the action of thrusters in directly, so that the ship could be brought back the original required destination. The thrusters are generally installed at the bottom of the platform hull. This thruster actually generates forces and moment required to counteract the environmental forces.

You may wonder how the ship recognizes the environmental forces acting on the hull, basically, the sensor systems which is fixed will recognize the forces impose by the wind, waves and current. They will be activating the thruster in opposite direction to counteract environmental forces acting on the ship. Therefore, this reversal forces will now keep the platform at the reference point or at the desired location. Now the controller keeps the platform within a tolerance radius of about 2 to 6 percent of the water depth. As you go deeper and deeper, the tolerance level with which the DPS will enable positioning of the drill ship on the drill hole will be above 6 to 10 percent. So, as you go deeper and deeper the accuracy of positioning the ship exactly over the drill hole will be deeper and deeper.

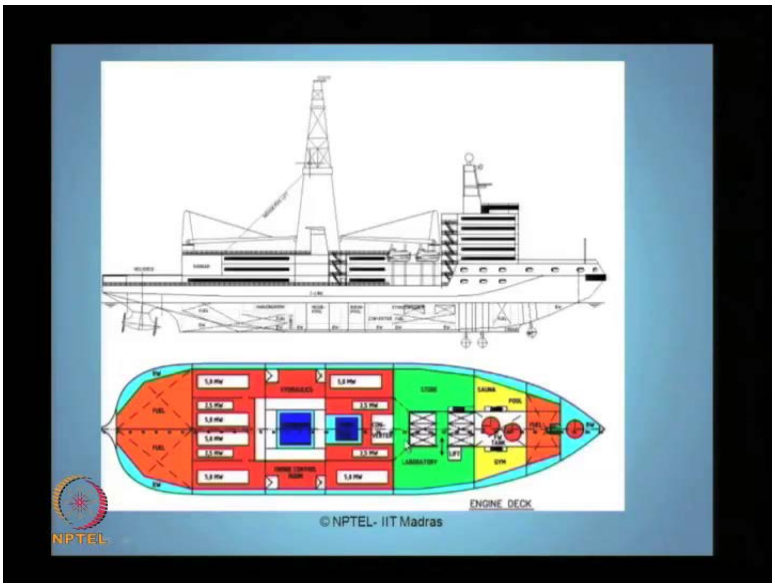
(Refer Slide Time: 20:19)



We have some of the photograph, which I wanted to show you, as the drill ship is concern. Of course, you have seen the real drill ship in operation. So, this is the typical ship what I want to you appreciated see the length on dimensional of the ship compare to any standard offshore platform. So, they are very large in size, and they are no problem in floating; they are very stable when at least they are not doing drilling operations. You got a high drilling rig mast fixed at the top hull. They havegot very serious moon pools through which going to drilling. And these all are different cranes which are been used for lifting and placing the mechanical equipments. I will also have different other arrangements on the hull as we saw in some of the examples.

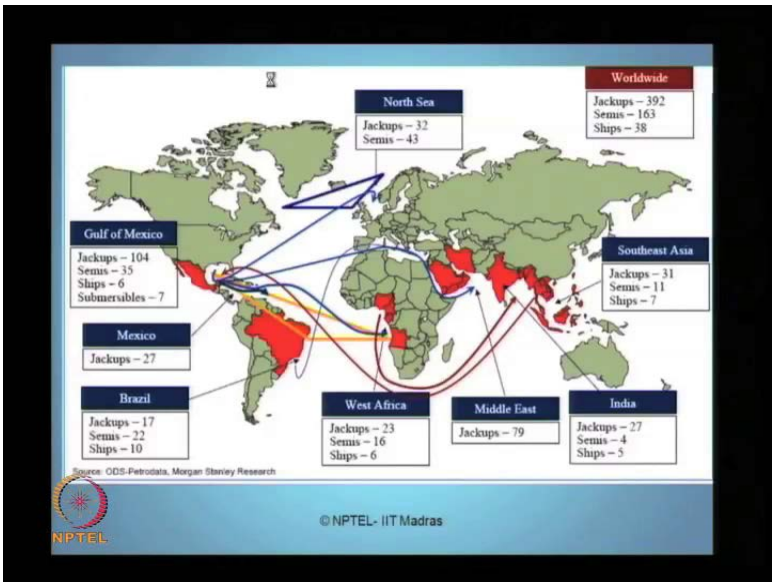
What you can understand here is, the drill ship may be a conventional ship, which is converted for drilling operations. The additions are a drilling mass, tools and equipment, which are required for drilling in deep sea.

(Refer Slide Time: 21:25)



The plant and elevation view of a drill ship. Naval architects can easily understand an appreciated the necessity of this plant. can see this is basically the plant of a ship, which is conventional, but I am here making alteration to put derrick over this. So, essential alteration is a very big moon pool in the centre and one more moon pool on the side. So, I can do two parallel drilling operations in this case. So, only through the hole drilling is possible as well as drilling ship are concern. You got the engine deck here, you got laboratory located here; you got all other top side deck facilities is like (( )), pool, gym etcetera to facilities people working on board.

(Refer Slide Time: 22:14)



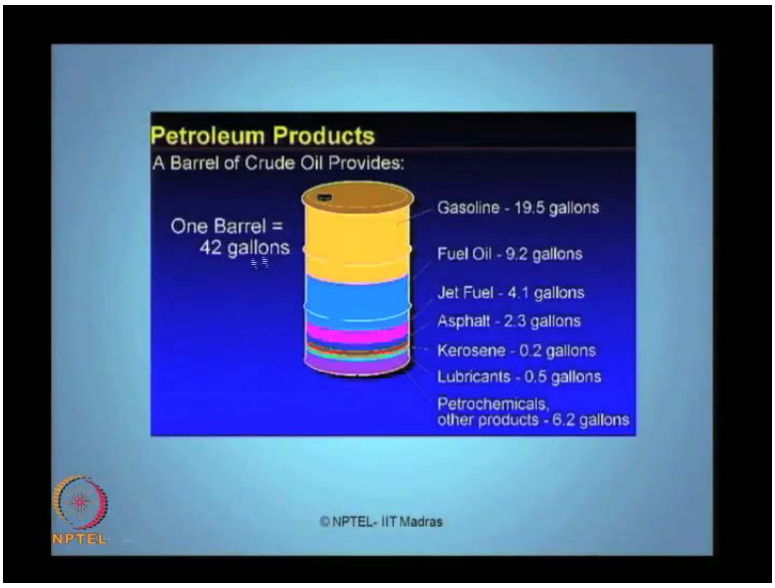
This picture shows a global information about different kinds of platforms located worldwide. Worldwide if look at the simple statistics, there are above 393 Jackups platform, 163 semisubmersibles and about 38 to 40 drill ships. We look at the Southeast Asia segment, we maximum used 31 jack up, 11 semisubmersibles and 7 ships. If you look in particular India, India uses predominately jack up rigs and very less number of semisubmersibles and ships. We look at the Middle East people used only one kind of drilling rigs is nothing but jack up rigs. If we look at the West African coarse, the people used jack up rigs substantially high and semisubmersibles, ships are also equivalently higher.

If we look at the Brazil, the people used lot of semisubmersibles and drill ship in comparison into the jack up rigs. Look at the Mexico, people used predominantly jackups rigs has that of Middle East. If we look at the Gulf of Mexico, which is hub city or the hub location for exploration and oil production; they used majority of jack up rigs, semisubmersibles substantially high, drill ship lesser and submersibles further lesser. Look at the North Sea, people used jackups on the whole very high.

Therefore, this gives very interesting information for you, the jackups predominately commonly used and deployed around the world by many agencies and many countries. Next to that followed by which is semisubmersibles followed by which are the drill ships. So, one may wonder why the statistics that not shows what are the platforms install in these locations. If you look at my previous lectures, I gave an interesting statistics about the number of fixed platforms, complaints platforms, architectural towers gravity based structures etcetera install around the world. Especially predominantly in gulf of Mexico and United states and other countries as well.

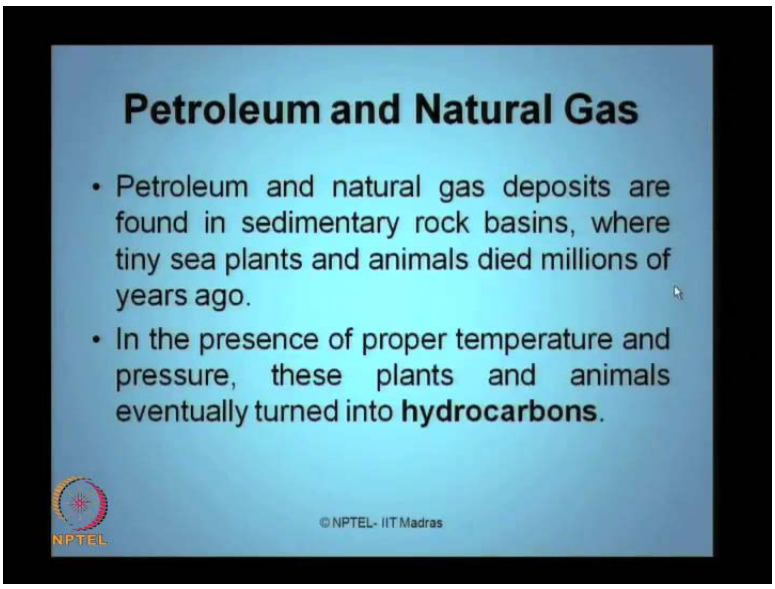
Now, ladies and gentlemen, we have to come to end of this lecture instance that we have discus different kinds of offshore platforms used for drilling. As I told in beginning of this lecture, to design, understand, develop, plan and designing of an offshore structure. One must understand certain basic concept of oil drilling platforms as well.

(Refer Slide Time: 24:56)



Let as look into some basic concept of oil drilling. Start form a petroleum product, petroleum product comes actually a barrel of crude oil, which is composition of 19.5 gallons of gasoline, 9.2 gallons of fuel oil, 4.1 gallons of jet fuel, above 2.3 gallons of an asphalt, above 0.2 gallons of kerosene, and above 0.5 gallons of lubricants and above 6.2 gallons of other products. So it comes in a barrel which is approximately base 42 gallons.

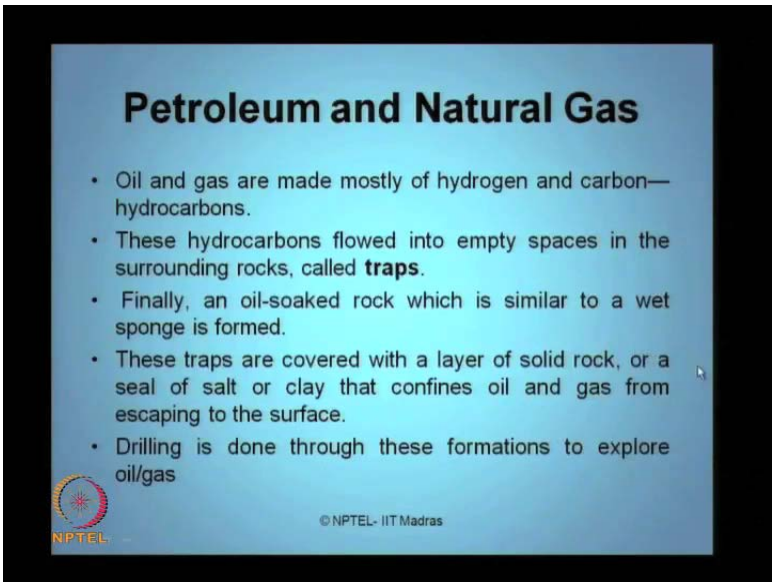
(Refer Slide Time: 25:33)



If we look at the petroleum and natural gas, petroleum and natural gas deposits is actually found in sedimentary rock basins, where tiny sea plants and animals died

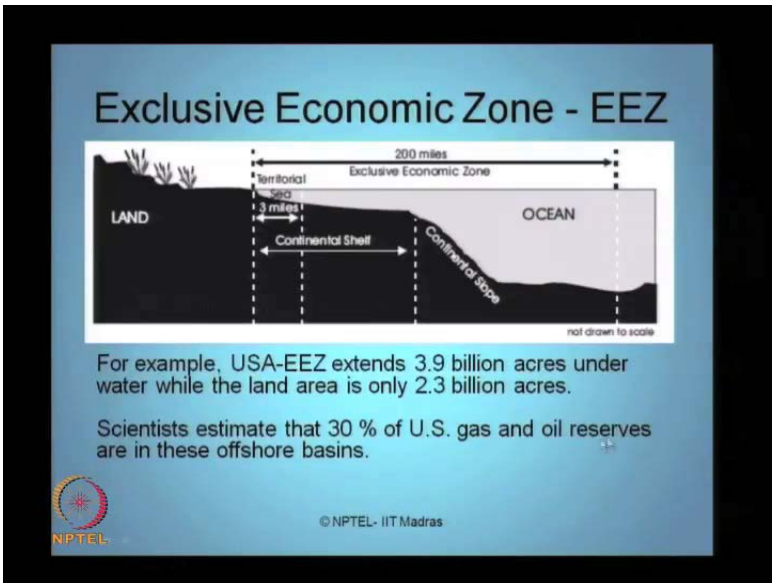
millions of years ago. In the presence of proper temperature and pressure, these plants and animals eventually turned into what we called hydrocarbons reserves.

(Refer Slide Time: 25:55)



Oil and gas are made mostly of hydrogen and carbon that is why they are called hydrocarbons reserves. These hydrocarbons flowed into empty spaces in the surrounding rocks, these empty spaces are called traps. Finally, an oil-soaked rock, which is similar to a wet sponge is formed. These traps are unfortunately covered with a layer of solid rock, or a seal of slat or clay; this confines oil and gas from escaping to the surface. So, oil and gas which are formed naturally by the death of animals and decay of plants which are traps in the surrounding area and empty spaces. They get confines by solid rock over and above them. So our purpose of drilling is just drill through these rocks to reach these traps. So, drilling is done through these formations to explore oil and gas from this traps.

(Refer Slide Time: 26:57)

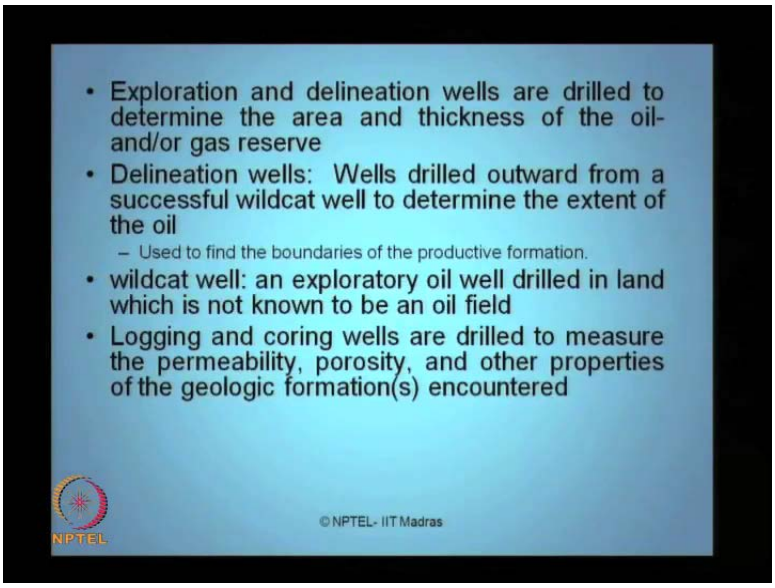


There is some important terminology is called exclusive economic zone which we called EEZ. The picture shows you how EEZ is defined, for examples you got a land from the land 200 miles beyond into the ocean, we have got definition for exclusive economic zone which can be used offshore drilling. For examples, till three miles from the shore, we called this as territorial region; and then up about 20 to 25 miles, we called them as continental shell, and beyond that we call them as continental slope. And the specification of the EEZ lies above 200 miles away from the offshore. If we look at theUnited States EEZ standard or statistics, for example, USA-EEZ extends by above 3.9 acres under water. If we look at the land area it is only 2.3 billion acres, which means that the economical exclusive zone of United State which is about 3.9 billons acres under water which is larger than the land area is going to serve as about 30 percent reserve of the US gas and oil reserves in these offshore basins, so that is the great advantages what US basis have.

(Refer Slide Time: 28:26)

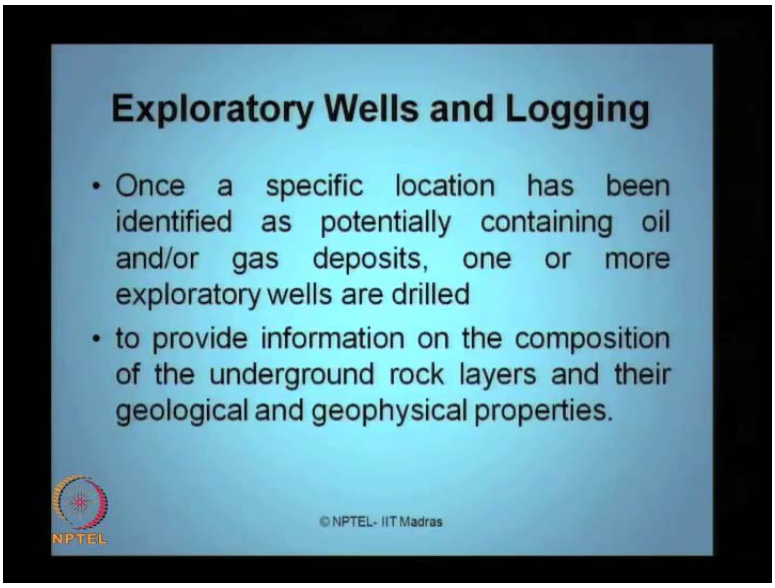
If we look at the steps and effort made to oil and gas explorations. Oil and gas exploration is actually time and effort intensive process. The rely on the collection and detailed analysis of extensive geologic information. You may wonder what are those geologic information required to proceed before oil and gas exploration is done. Surveying and mapping of the surface is done and the surface is also done, it shows geologic features. You can say what are the techniques used for doing surveying and mapping on surface and subsurface geologic features, techniques such as seismic reflection is one of the predominantly used techniques to identify hydrocarbon traps. The potential of geologic formation is estimated to compute the economically producible oil and gas from the traps. The best locations are then identified to carry out exploratory drilling to test these traps.

(Refer Slide Time: 29:37)



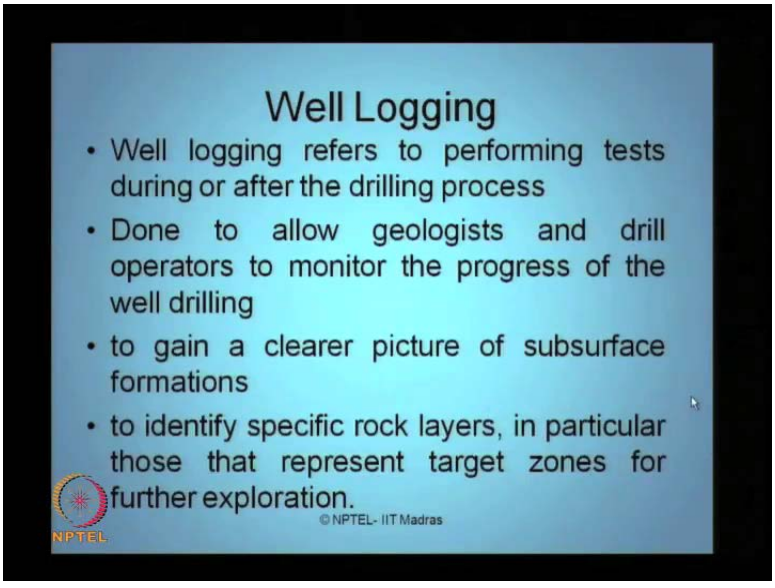
Exploration and delineation wells are drilled to determine the area and thickness of the oil and gas reserves on the exploratory wells, which are identified from the survey. Now one may wonder what we understand by delineation wells. The delineation wells are wells drilled outward from the successful wildcat well to determine what the possible extent of the oil formation is. Actually, delineation wells essentially used to find the boundaries of the productive formation. Now one may wonder now, what are the wildcat wells. Wildcat wells is nothing but an exploratory oil well drilled in land which is not known to be an oil field, for example, do not know whether the specific location where I am drilling well field in oil. So, if you do that I do exploratory oil well drilling I called that kind of well as a wildcat well. Logging and coring wells are other type of wells which are drill to measure the permeability, porosity, and other properties of these formation.

(Refer Slide Time: 30:48)



Once a specific location has been identified as potential space, which contain oil and gas deposits then one or more number of exploratory drills are drilled. To provide information on the composition of the underground rock layers and their geological and geophysical properties, surveys are carried out.

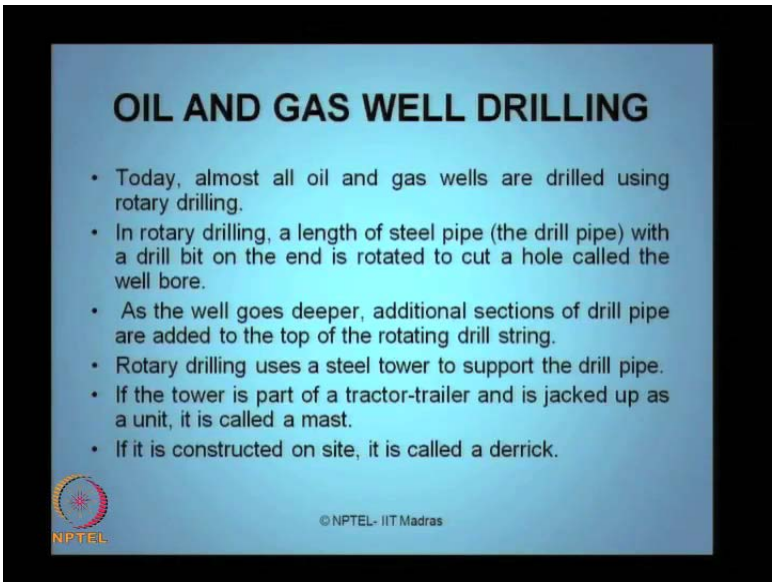
(Refer Slide Time: 31:07)



We do what we called well logging. Well logging actually refers to performing tests during or after the drilling process. It is done to allow the geologists and drill operators to monitor the progress of the well drilling, how deep are driving, how wider we are drilling

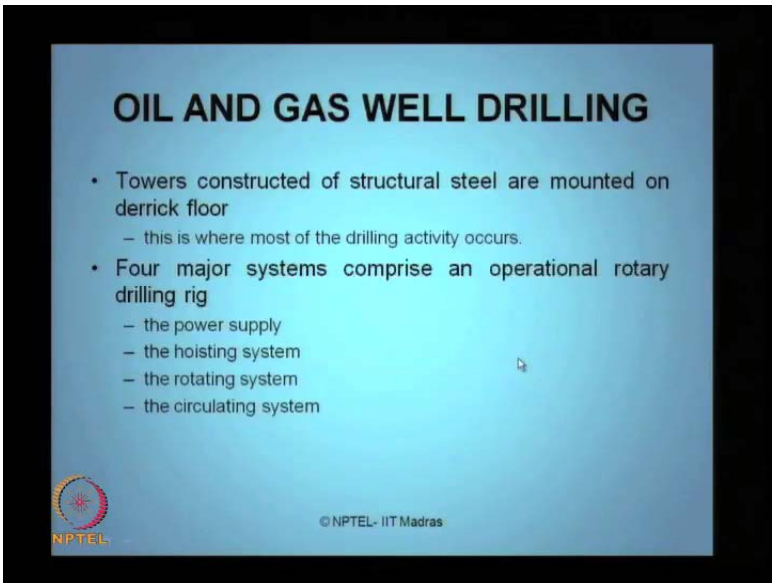
and how far towards the boundary we are drilling. So if, you want to know them we got to do what is called well logging. To gain a clear picture of subsurface formations, well logging is very highly useful. Well logging is also use to identify specific rock layers in particular those represent target zones for further exploration.

(Refer Slide Time: 31:51)



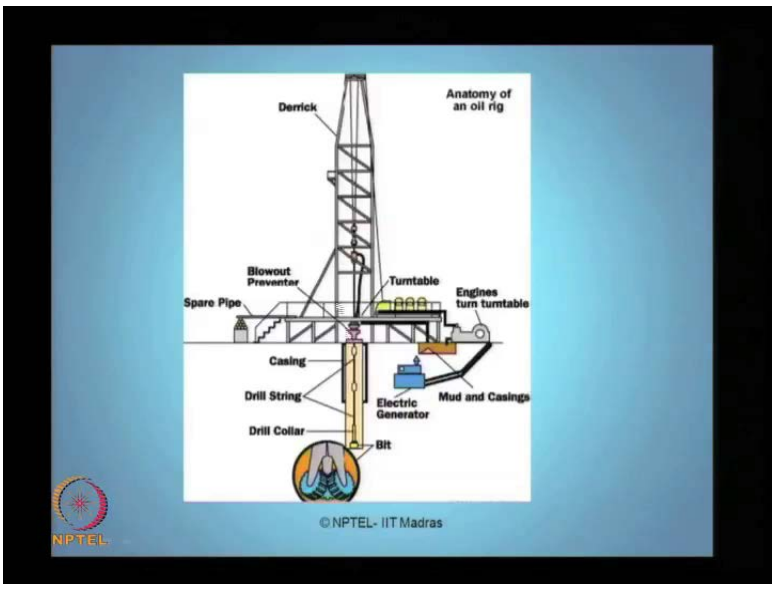
If we look at the oil and gas welding, drilling together, today almost all oil and gas wells are drilled using what we called rotary drilling. There are different kinds of drilling operations. Rotary drilling is very common method by which drilling is done throughout the well. In rotary drilling, a length of steel pipe what we called drill pipe with a drill bit on the end, it is rotated. As the drill bit is rotated, it keeps on a cutting hole which we called as well bore. As the well goes deeper and deeper, additional sections of drill pipe are added to the top of the rotating drill string. The rotary drilling uses a steel tower to support the drill pipe is what we called as drilling mast. If the tower is part of a tractor-trailer and jacked up we called them as mast. If it is constructed on site, we called as derrick. So, is the different between the drilling mast and derrick. If its tractor-trailer and jack up keep on proceeding drilling we called them as drilling mast; if it is constructed on site as a total is called as a derrick.

(Refer Slide Time: 33:15)



Towers constructed of structural steel are mounted on derrick floor. This is where most of the drilling activity occurs. Four major systems comprise an operational rotary drilling rig. Let see what they are. The power supply system, the hoisting systems, the rotating systems, and the circulating systems are four vital compliment of what we called as rotary drilling.

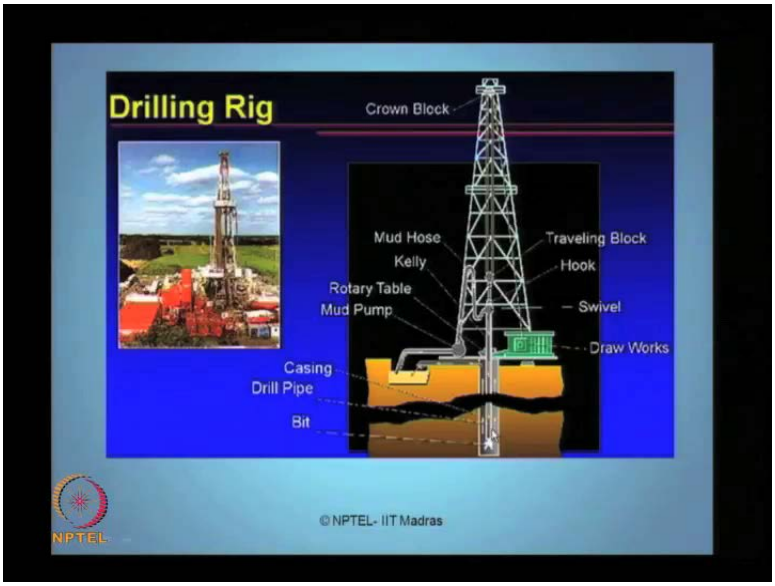
(Refer Slide Time: 33:40)



So, this is an anatomy of the oil rig. You are see derrick which is nothing but a mast. This is where I am going to do draw moon pool and this where I am going to do drilling.

This is my drilling casings, which is seeing black color here. This is drilling string, the end of the drilling string is what we called drilling collar. The drilling collar will terminate with the end piece or out piece, which is called as drill bit, which is look like rotary drill bit like this. For doing drilling - enable drilling, you need lot of power. So in a electric generated which is supplies power for these kind of drilling. So, to prevent any accident while drilling happening we fixed what we called as a blowout preventer at the top. As we all understand, drilling needs lot of rotational forces I must have facilities to move and align the drilling rig is required. So, I need what we called turntable on the top. Of course, I need turbo engines, which are powered electric generated to perform drilling operations.

(Refer Slide Time: 34:51)

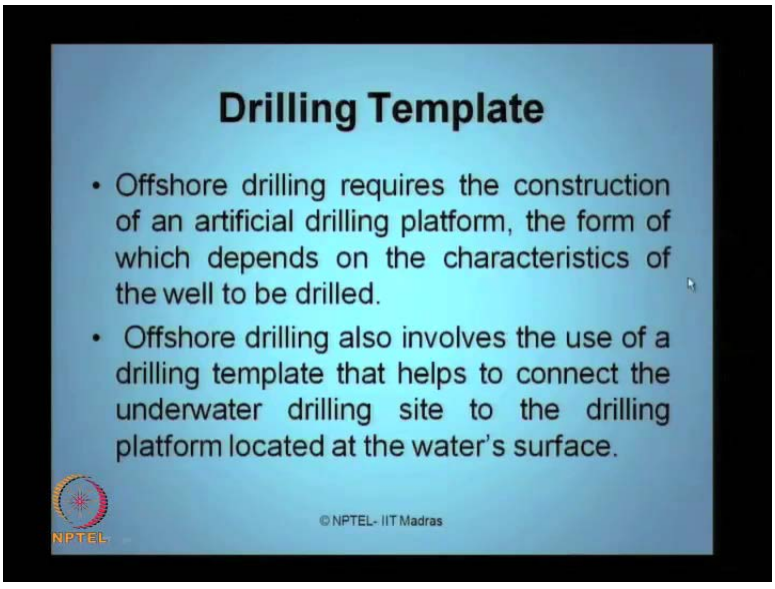


Here is the photograph and schematic view of the drilling rig. This photograph shows the drilling rig in position. In this you cansee the drilling rig mast, of course, the drilling mast top is what we called as crown block. The crown block is connected the drilling rig and the crown block is what is going to connected to the drilling pipe of the drilling casing. The out site of the drilling pipe is what we called as drilling casing or hole is what we call drilling casing. Draw works will keep on supplying the necessary liquid or any injected pressure to perform drilling. Of course, you need mud hose, Kelly to control the drilling operations as I said you also need what we called turn table or rotary table. Mud pump required to keep on circulating member while drilling and operations.

(Refer Slide Time: 35:50)

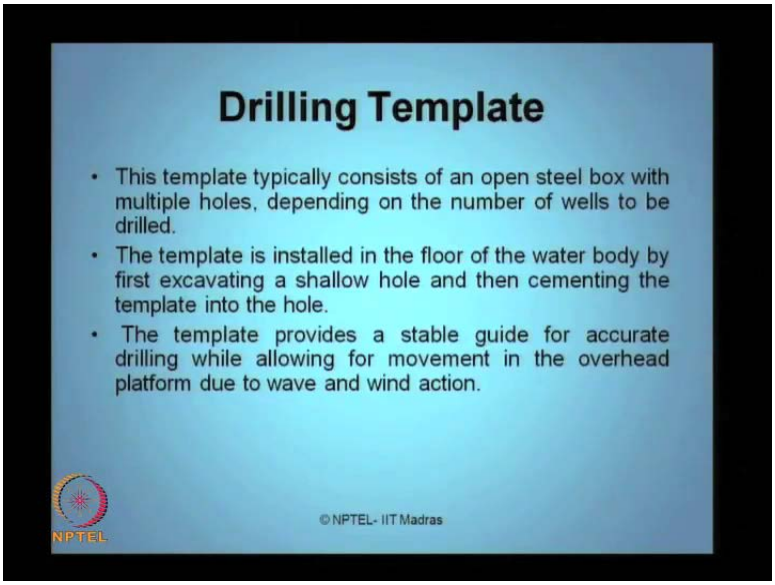
What is the major difference between an onshore drilling and offshore drilling. The major difference between these two is that the nature of the drilling platform itself. In addition, in offshore drilling the drill pipe must pass through the water column before entering the seafloor, whereas in onshore drilling there is no problem of water column at all. So, the drilling casing or the drilling pipe will subjected to lot of lateral forces exerted by wave, wind and current actions whereas in onshore drilling no such problems are encounter by the drill pipes. Offshore wells are generally drilled in water as deep as about 3 kilometer.

(Refer Slide Time: 36:44)



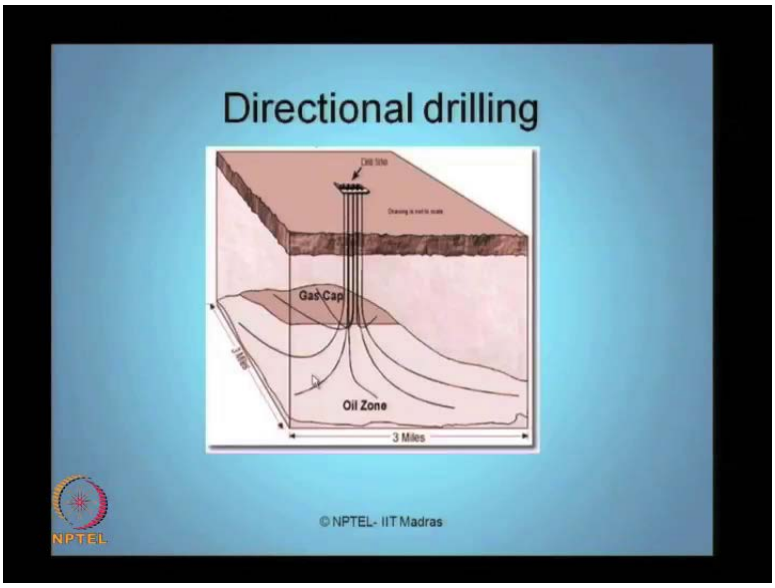
What is called drilling template? It is the very common terminology used in offshore drilling, that is talking about drilling template. Offshore drilling actually requires the construction of an artificial drilling platform, the form of which depends on the characteristics of the well to be drilled. Offshore drilling also involves the use of a drilling template that helps to connect the underwater drilling site to the drilling platform located at the water surface. So, the drilling template is nothing but the layout of the form of drilling area, which we are going do, which will be connecting drilling site to that of the drilling platform which is located at the top hull ships.

(Refer Slide Time: 37:26)



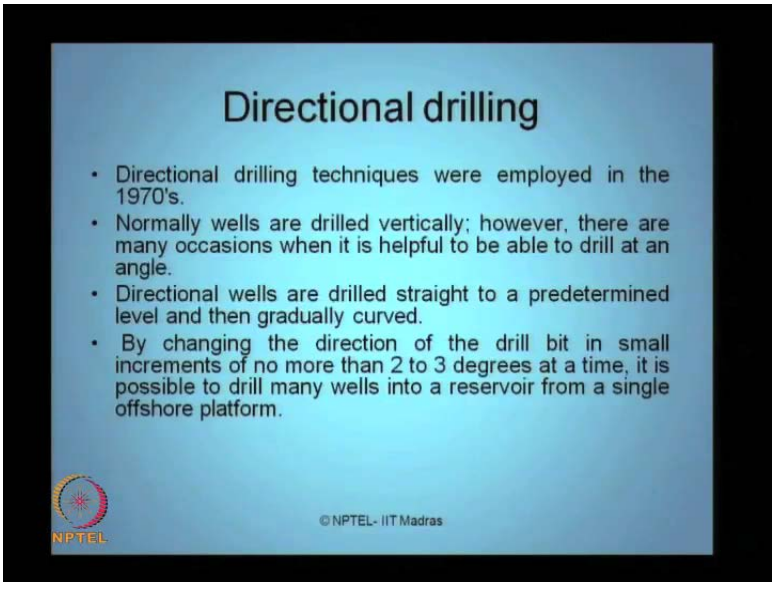
This template typically consists of an open steel box with multiple holes, depending on the number of wells to be drilled. Therefore, it is nothing but the layout of frame – steel frame, which having different kinds of holes. All the holes indicated probable location of the holes to be drilled in deep sea. So, now the drilling template which is establish the connectivity between that of the holes to be drilled with that of the drilling position will be carried out from the hull. The template is installed in the floor of the water body by first excavating a shallow hole and then cementing the template into the hole. The template provides a stable guide for accurate drilling while allowing for movement of the overhead platform during wave and wind action.

(Refer Slide Time: 38:15)



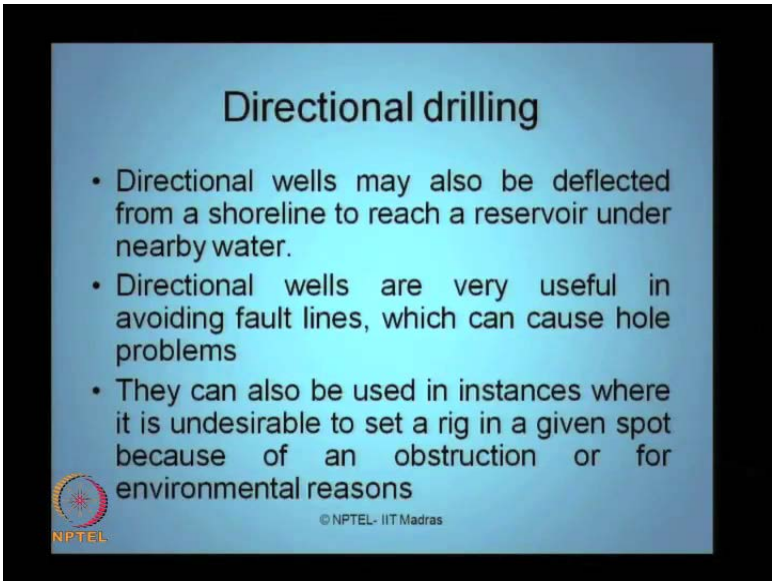
What you understand by directional drilling? Ladies and gentlemen, as you see here in this figure, if you want to do a drilling actually from the moon pool of a ship. I said the moon pool should located exactly above the drilling hole, I prefer to drilling vertically down, but sometimes we have to also extent the drilling not exactly vertical but also have possible lateral direction to touch as far as possible the boundary of the hydrocarbon traps.

(Refer Slide Time: 38:57)



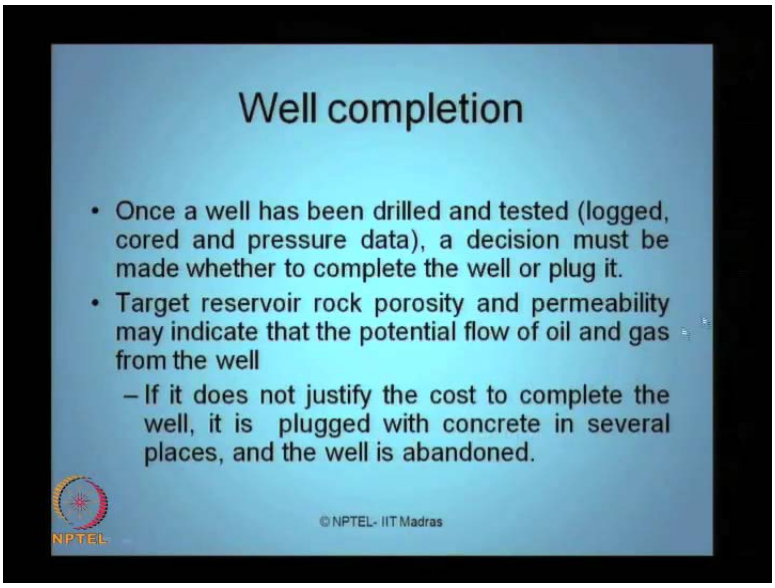
So, when you do drilling which is not purely vertical I called this mathematically as directional drilling. Directional drilling is not a new techniques, it has been deployed in offshore industries since late 70s. Normally wells are drilled vertically; however, in many locations they may have to drilled the well at specific angles other than 90 degrees. Directional wells are drilled straight to predetermined levels and then gradually curved. So, the angle of inclinations of turning of these wells are gradual. Now by changing the direction of the drill bit in small increments of not more than certainly 2 to 3 degree at a time, it is possible to drill many wells into a reservoir from a single offshore platform that is one of the greater advantages you have in case of directional drilling.

(Refer Slide Time: 39:43)



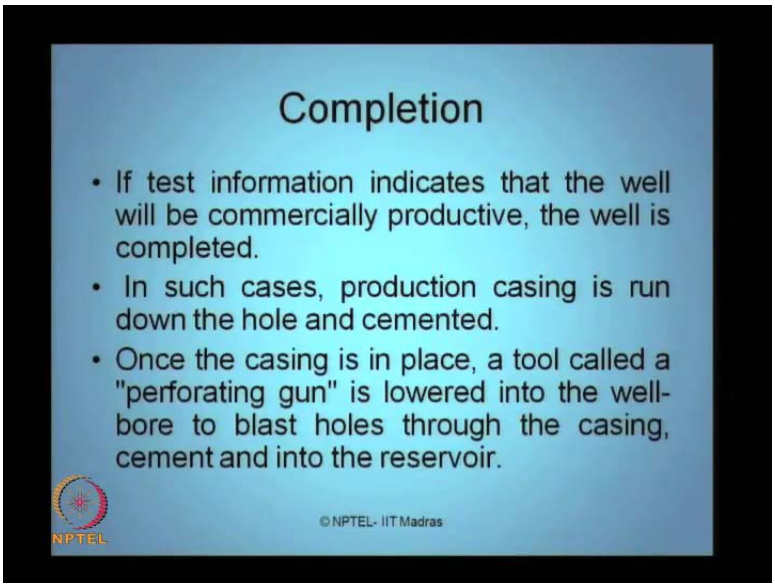
Directional wells may also be deflected from a shoreline to reach a reservoir under nearby water. Directional wells are very useful in avoiding fault lines which can cause hole problems severally during drilling operations. They can also be used in instance where it is undesirable to set a rig exactly on a given spot, exactly above the hole can locate the rig at a different location, whereas the drill hole is not located exactly vertically below the drilling locations. If you have any such situations because of the environmental reasons then one can do what we called directional drilling.

(Refer Slide Time: 40:22)



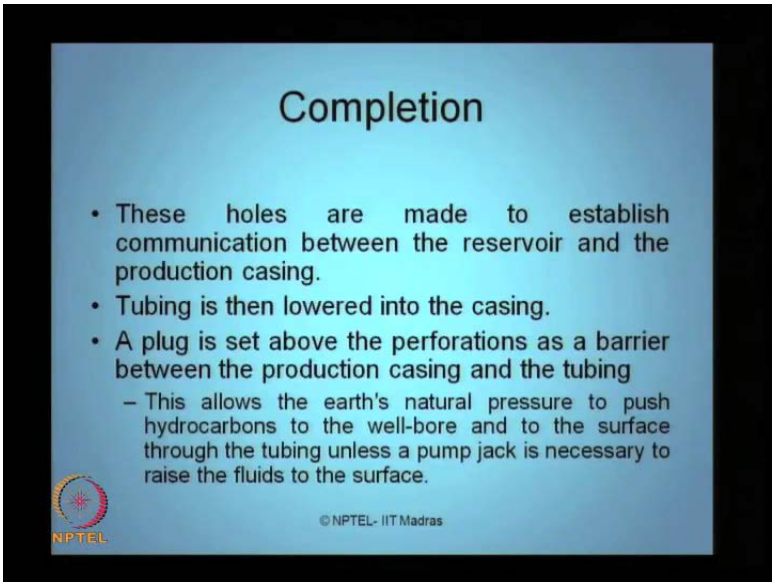
What do we understand by well completion? Once a well has been drilled and tested that is log core and pressure data obtained, now the decision will be taken whether to complete the well or plug it. So, what we understand by well completion? The target reservoir rock porosity and permeability will indicate, what is the possible potential flow of oil and gas present in the well? If it does not justify the cost to complete the well then it is plugged with concrete in several places and the well is what we called as abandoned. Suppose, you find after doing exploratory drilling based on the logged core well and pressure data, you desired that the well does not have in a potential of oil and gas reserve then the well can be completely abandoned by plugging it with concrete in several locations.

(Refer Slide Time: 41:20)



If the test information indicated that the well is commercially productive, then the well should be complete. So, what you understand by completion, then in such cases production casing is run down the hole and then cemented. Once the casing is in place, a tool called a perforating gun is lowered into the well bore to blast to blast holes through the casing cement and into the reservoir.

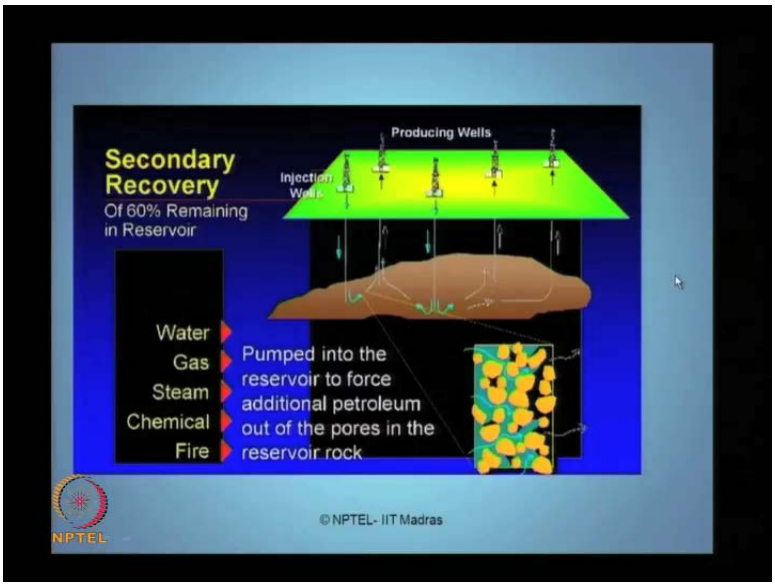
(Refer Slide Time: 41:49)



These holes are made to establish communication between the reservoir and the production casing. Tubing is then lowered into the casing. A plug is set above the

perforations as a barrier between the production casing and the tubing. This allows the natural pressure to push hydrocarbons towards the well bore and to the surface through the tubing unless a pump jack as required sometimes in some cases to rise the fluid to surface.

(Refer Slide Time: 42:16)



This photograph shows you the important of a secondary recovery in terms of the wells of 60 percent of the reservoir oil can always do a recovery by different methods of enhancing yield of the well, can do water injection, can do gas injection, can do stream, can do chemical or can do fire injection. Actually, these are all pump in to the reservoir to force addition petroleum out of the pores in the reservoir rock. What you see here may be production well or injection well. The block once what see here all are producing well whereas the blue once what we see here injection well. Injection well are actually used to enhance the oil recovery from the wells. I hope you understood some basics of drilling from these lecture.

Thank you.