Ocean Structures and Materials

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Module No. # 01

Lecture No. # 04

Compliant type offshore structures -II

Ladies and gentlemen, welcome to the fourth lecture on module 1 of offshore structures and materials.

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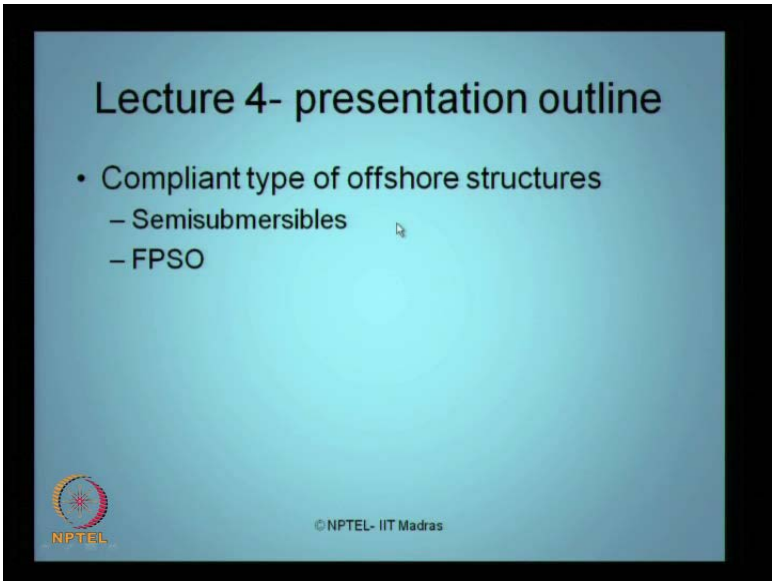

Let us quickly look at the outline of this lecture. We will discuss about compliant type of offshore structures as continuation of the previous lecture. In the present lecture, we will focus on studies related to semisubmersibles and FPSO.

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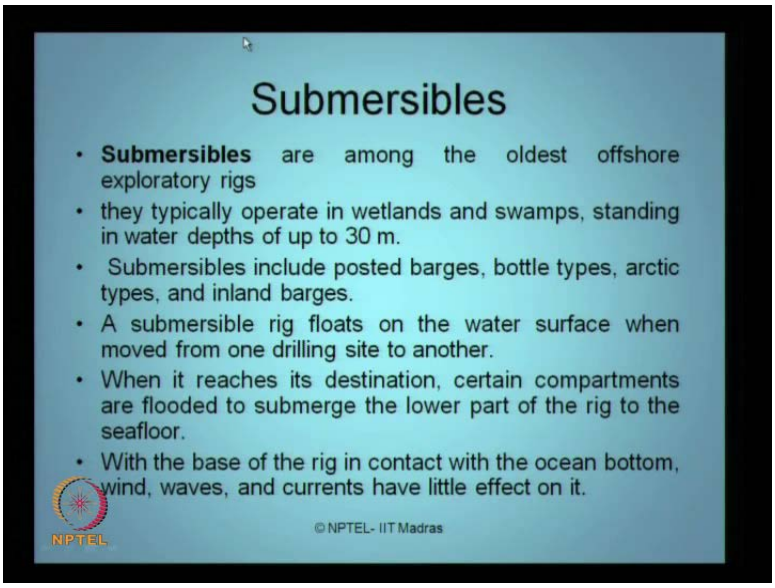

What are semisubmersibles? Semisubmersibles are also compliant type drilling structures which are one amongst the oldest offshore exploratory rigs used for oil exploration in deep sea. They typically operate in wetlands and swamps, standing in the water depths up to 30 meters. Submersibles include posted barges, bottle types, arctic types, and inland barges. A semisubmersible rig floats on the water surface when moved from one drilling site to another. It is similar to what we have seen in this last lecture about jackup rigs.

When it reaches the destination, certain compartments are flooded, which are what we call as ballasts to submerge the lower part of the rig to the seafloor. The lower part of the rig rests on the sea floor and therefore, a drilling operation can continue. With the base of the rig in contact with the ocean bottom, it has got a very good resistance for the lateral forces like wind, wave forces, and currents. They have a very little effect on the structural motion of semisubmersibles.

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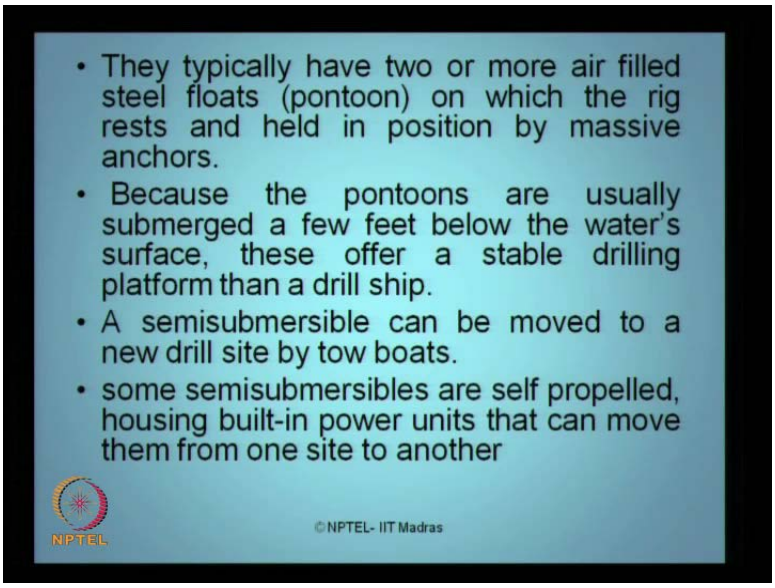

They typically have two or more air filled steel floats; we call them as pontoons. They are similar to what we have as pontoon member intention like platforms. There can be either one or two large sized air filled floats on which the rig rests and held in position by massive anchors to which these semisubmersibles will be anchored to the sea floor. Because the pontoons are usually submerged a few feet below the water surface, they have very high stability of operation during drilling and it is because of this reasons they are called as semisubmersibles.

They have a very good stability compared to the drilling ships, because drilling ship actually floats in water while drilling is carried over, whereas semisubmersibles rest on the sea floor when the drilling is carried out. The semisubmersibles can be easily towed or moved from one side another new one by tow boats. Some semisubmersibles are also equipped with what we called self propelled, housing inbuilt power units which can be used to propel them from one site to another site.

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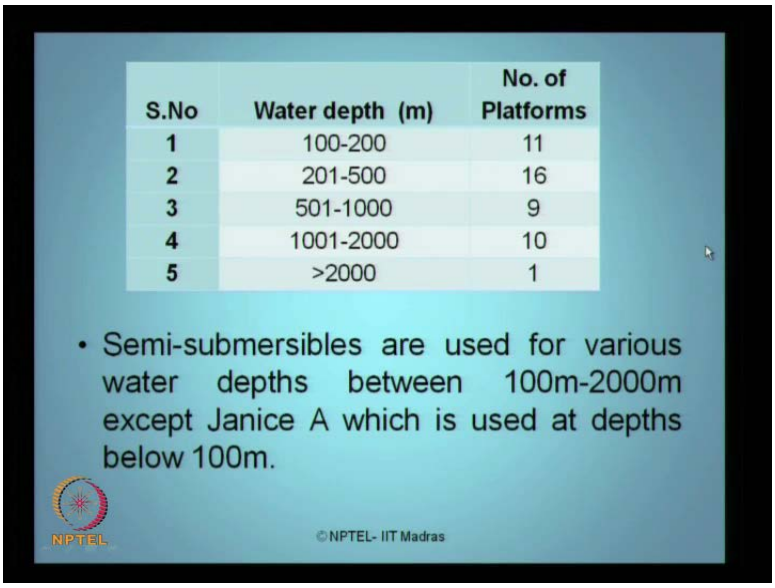

If you look at the table where you are talking about the number of semisubmersibles platform installed worldwide and the category is related to the water depths at which they are installed. Less than about 200 meter water depth, you have got 11 platforms installed; whereas from 200 to 500 you have got about 16, from 500 to 1000 you have got about 9, and more than about 2000 you have only 1 semisubmersibles so far being working. Semisubmersibles are actually used for various water depths varying in the range from 100 meters up to 200 meters. There can be only one exception which is Janice A; whereas this platform was used less than about 100 meter depth.

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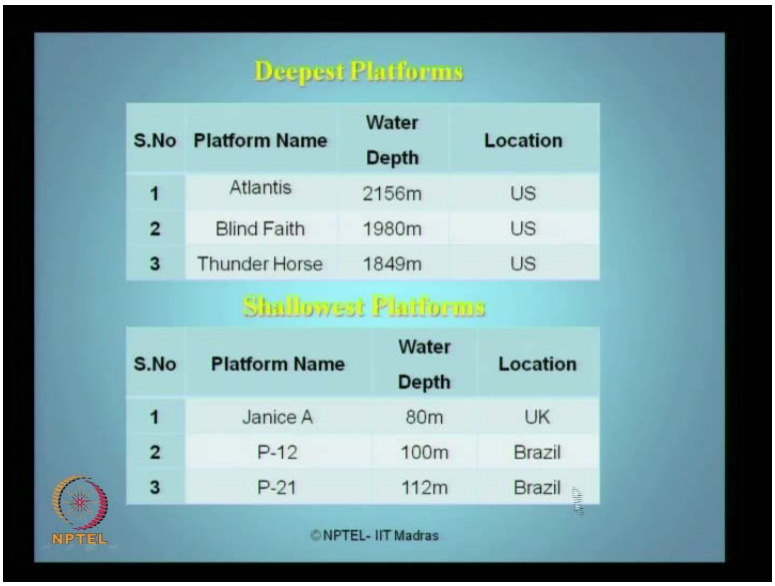

Look at the deepest and shallow platform semisubmersibles as on now; Atlantis, Blind Faith, and Thunder Horse are different kinds of deepest platforms which are all located in the inner states, whereas the shallowest platforms mainly located in Brazil.

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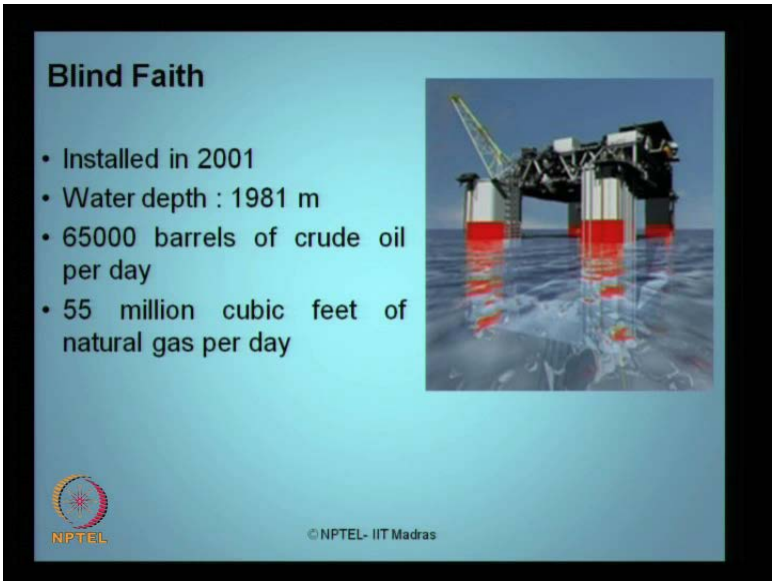

Look at the photograph of blind faith which is one of the deepest semisubmersibles installed in waters of Unites States, installed in the year 2001 at a water depth of about 1981 meters; 65000 barrels of crude oil per day is the capacity of production of this platform; 55 million cubic feet of natural gas per day is what it is producing.

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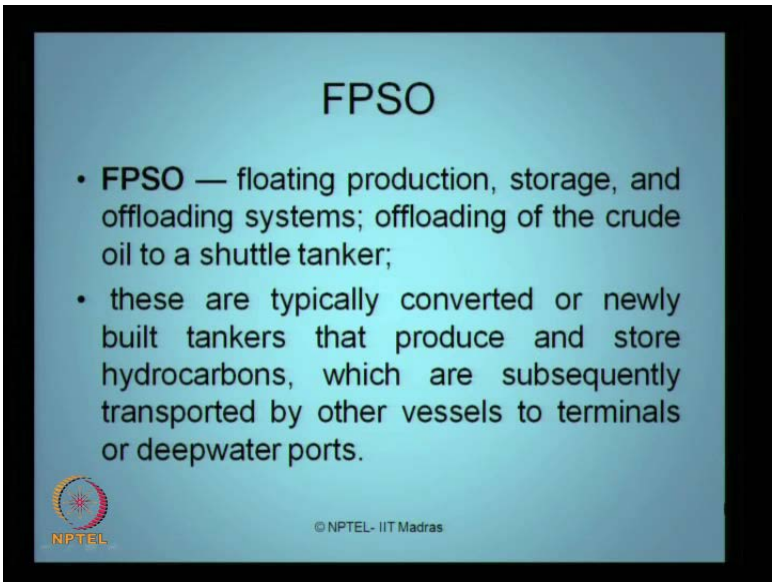

The other type of offshore combined platform is what we called as FPSO. FPSO abbreviates for floating, production, storage, and offloading systems. Essentially the offloading on to shuttle tanker which is actually the crude oil excluded from the sea floor. FPSOs are actually typically converted or newly built tankers. They produce and store hydrocarbon which are subsequently transported by other vessels to the terminals or deepwater ports.

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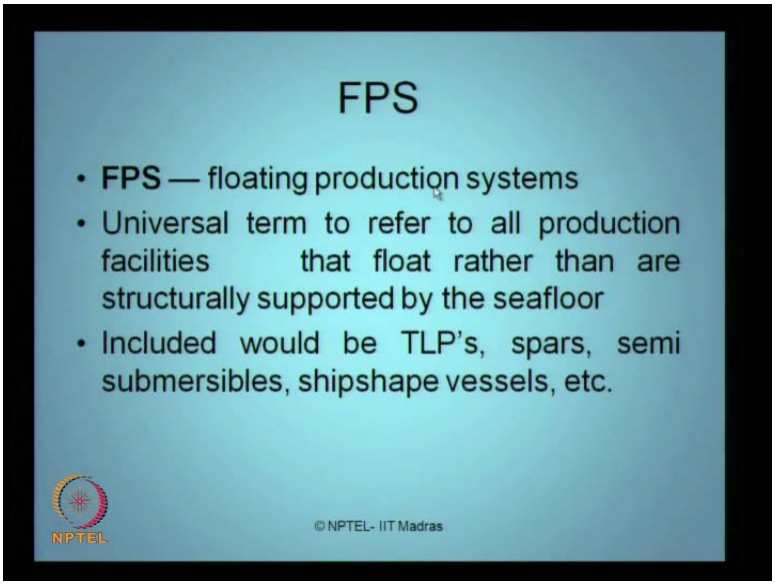

You have also something called FPS where there is no offloading system available in this; they are what we called floating production systems. The universal term FPS refers to all production facilities that float rather than are structurally supported by seafloor. Ladies and gentlemen, in the previous lectures you have seen there are offshore structures which are bottom supported. For example, steel jackup platforms which are anchored to the seafloor through piles.

You have also seen bottom supported structures which are resting on its self pile; for example, gravity based structures or GVS. We have also seen compliant structures like Tension Leg Platforms which are anchored down the seabed using tethers or cables. In general, floating production system refers to all those production facilities which actually float; rather than they are supported by the seafloor. This of course includes TLP, spars, semisubmersibles, shipshape vessels, etc. All of them come under the common bracket what we called as floating production systems.

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The term is also frequently used to describe the general category of floating production facilities that do not have onsite storage. The term is also used by American Bureau of Shipping to describe a classification of floating production facilities that do not have a storage capability in general.

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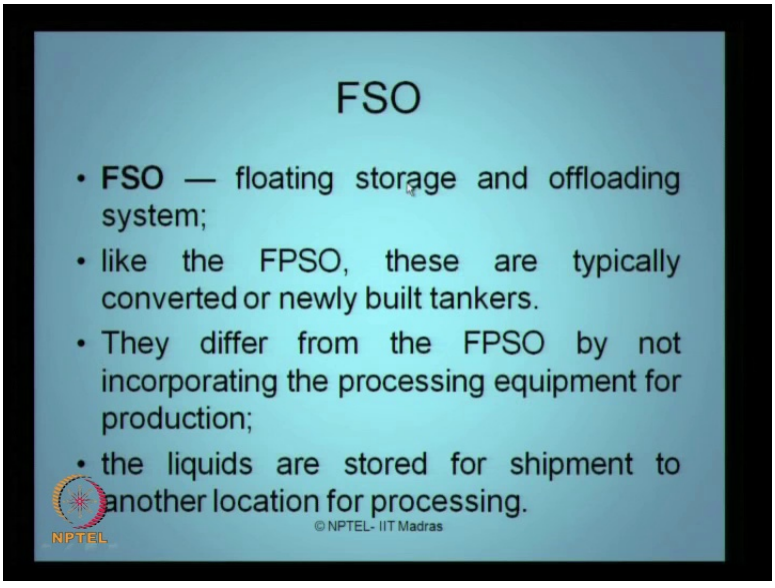

When we talk about FSO in the literature, they are otherwise called floating storage and offloading system. Ladies and gentlemen understand here, that there is no production unit attached to this kind of floating systems. Like the FPSOs, they are actually typically

converted or newly built tankers which are essentially used as storage on offloading systems. They differ from the FPSO because do not many processing equipment which is essentially required for production. The liquids are stored for shipment another location for processing. Essentially they are floating storage units; they can be also used as offloading systems.

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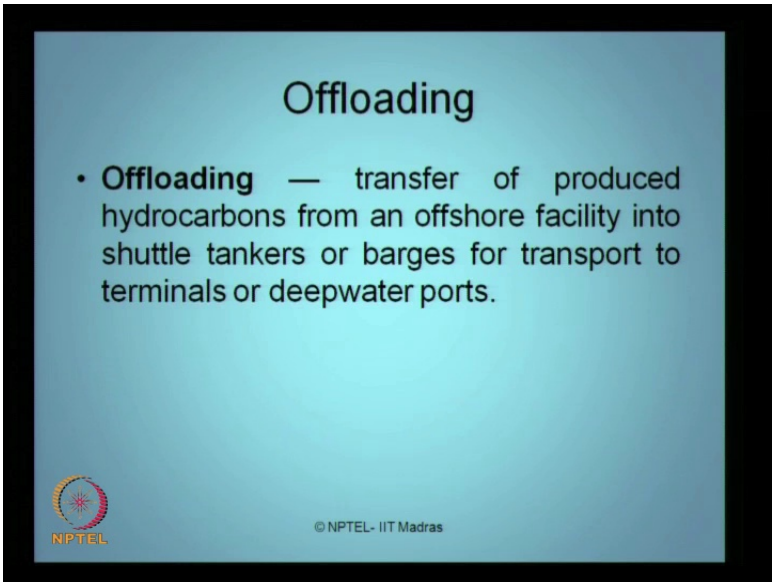

Now the question comes, what do we understand by offloading? Offloading is a term related to transfer of produced hydrocarbon from an offshore facility into a shuttle tankers or barges for transporting it further deepwater ports.

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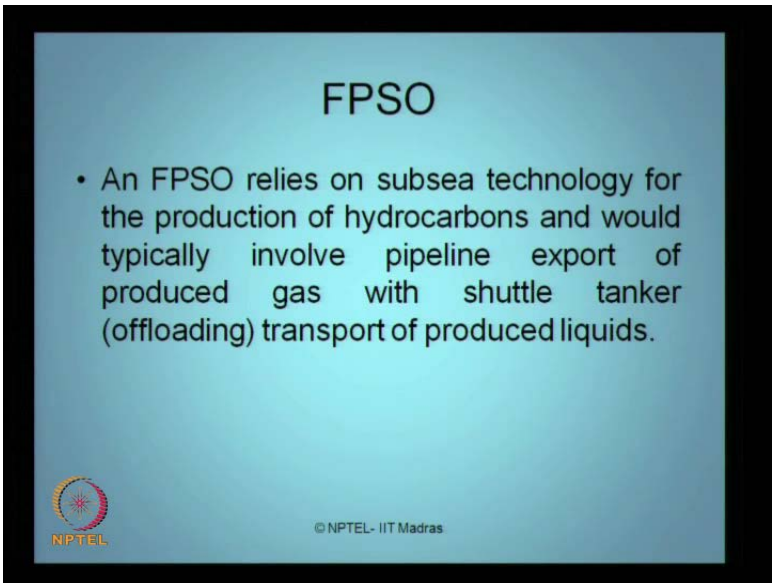

An FPSO actually relies on subsea technology for production of hydrocarbons and this would involve typically pipeline export of produced gas with shuttle tanker that transports the explode hydrocarbons from offshore site to onshore, what we called as offloading systems.

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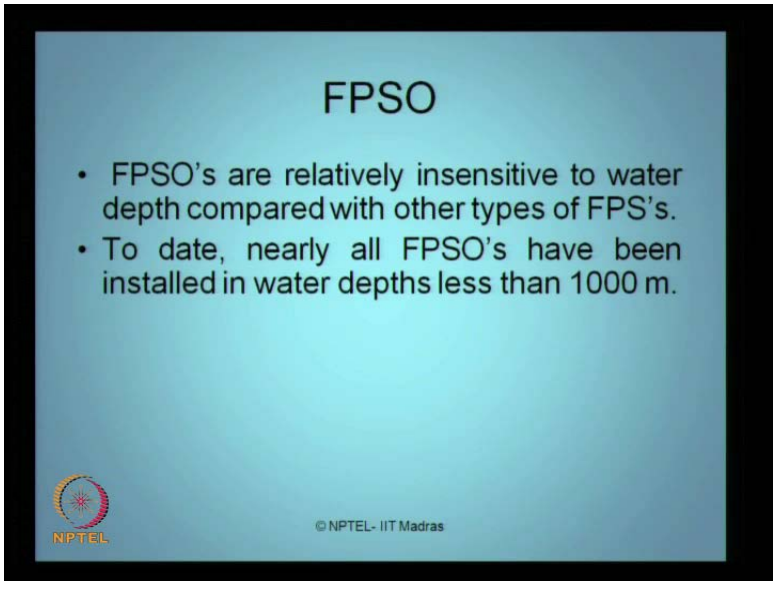

FPSO's essentially are relatively insensitive to water depth, because essentially they are floating system; as we understand for example, like TLP any floating system which is not resting on the seafloor do attract less forces, when they are installed in deep waters.

Today nearly all FPSO's have been installed at a depth which is greater than above 1000 meters; that is a greater advantage. Therefore, FPSO's are generally used for deepwater oil exploration, some units are meant for production, some of them are meant for only storage and offloading. So, it can be either FPSO or FSO.

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Ladies and gentlemen, here is the photograph of an FPSO which is Greater Plutonio. Then look at the complicated top site facility which has been seen in the the figure here. It houses all kinds of equipments that are required for production unit like a drilling derrick, like living quarters, helipad, ballast tank, complicated machineries used for power generation, used for processing, etcetera. We can easily recognize from this picture that FPSO is nothing but a conventional barge or a tanker converted for floating, production, design.

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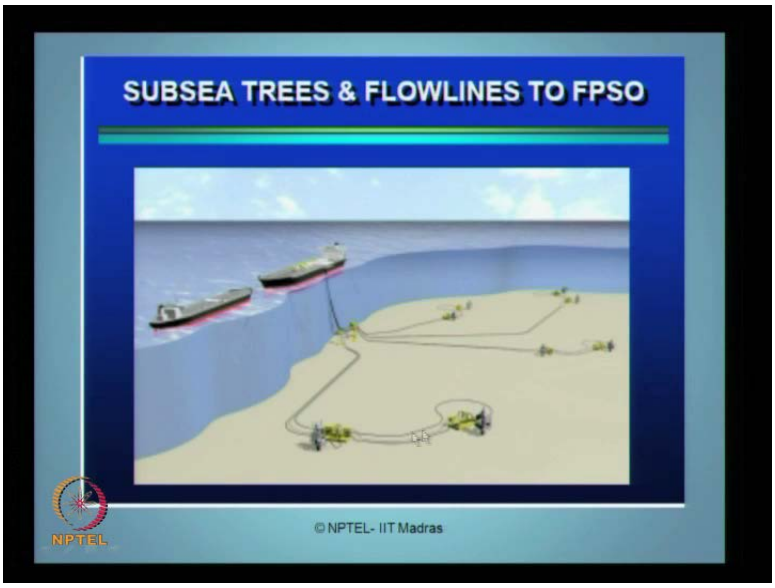

This picture shows the different layout of subsea trees and flow lines which are attached to FPSO. These are two FPSO's; one can be an offloading tanker, one can be again a storage vessel, can be an FSO or a production facility which is having FPSO can have different drilling units, different drilling locations sites, which are all connected to an FPSO as seen here. This is what we call as subsea layout of subsea trees.

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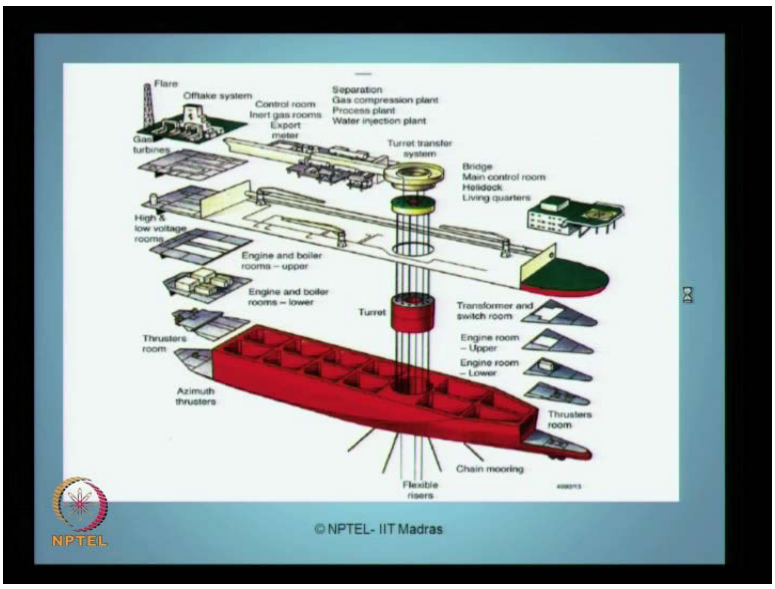

It is a typical figure which shows different components of an FPSO. For example, we look at the flare stack here. It is having gas turbine; it is an off take system which is

having an offloading facility. There is a central moon pool which is having specification and standards that can house actually the risers through which the flexible risers can enter for production systems. It contains bridge main control room and Helideck and living quarters on the top deck.

In the middle deck, it contains lot of machinery rooms which we call them high and low voltage rooms, engine and boiler rooms on the upper hull, and the engine and boiler room on the lower hull; of course transformers and switch rooms are located at the lower as well as upper hull, The bottom most hull will have thrusters rooms, azimuth thrusters and thrusters rooms on either side of the FPSO, where as the chain mooring system will be attached to the lowest hull of this.

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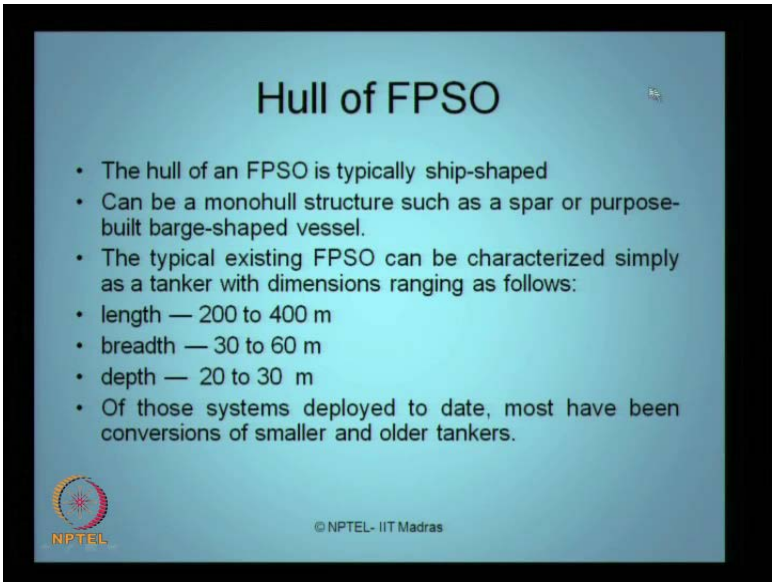

If we look at the hull configuration of FPSO, the hull of an FPSO is typically ship-shaped; of course recent research has been done in IIT Madras to study semisubmersibles and FPSO's which are non-ship-shaped. I will discuss this very briefly at end of my presentation later. So, hull of an FPSO can be a monohull structure that is having a single hull such as spar or purposefully built barge-shaped vessels. The typical FPSO can be characterized simply as a tanker the dimensions as follows.

The length can vary anywhere from 200 meters to 400 meters, where as the breath can vary from 30 to 60 meters, and the depth or the height can vary from 20 to 30 meters. Of those systems deployed to date, most of them have conversions of smaller and older

tankers. Ladies and gentlemen, generally FPSO's are very rarely newly built. They are actually converted modules of old tankers which have been used for production storage and offloading facilities in the sea.

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One of the major advantages of converting the existing vessel to an FPSO is saving of time; you can use that rapidly for the first production. For example, if you have a newly purpose-built FPSO, it will take few years to commission it. instead of that people generally go for conversion of existing floating barges to FPSO's.

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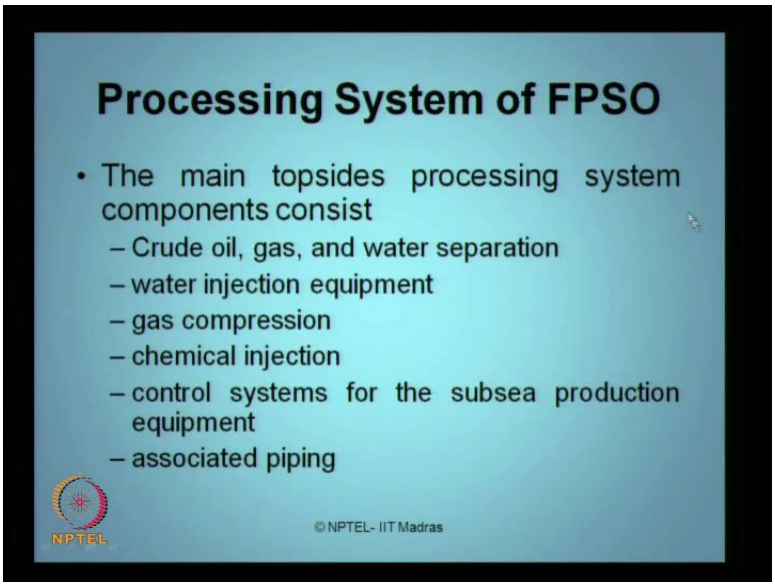

If we look at the processing system which is deployed on FPSO, the main topside processing system consist various components which can be used for processing and production of crude oil, gas, and water separation units. There can be requirement of water injection equipments. There can be gas compression units. There can be chemical injection units and equipments. It will also house control systems for the subsea production equipments, associated piping will also form a part of the processing systems of an FPSO.

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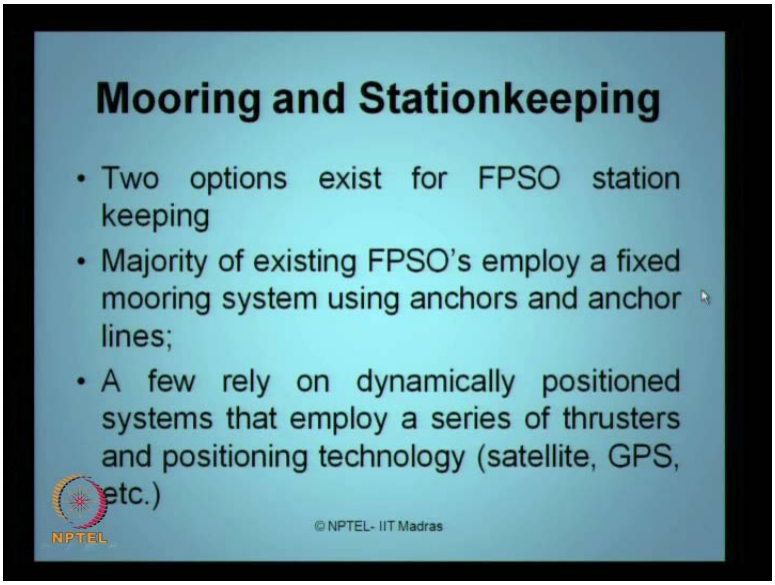

Let us quickly look at the mooring and station keeping of an FPSO. There are two options for station keeping of an FPSO. Majority of existing FPSO employ a fixed mooring system which uses anchors and anchor lines hold it in position. FPSO's can also use dynamically positioned systems what we call as DPS, that employ a series of thrusters and positioning technology which depends on the satellite and GPS receivers, etc.

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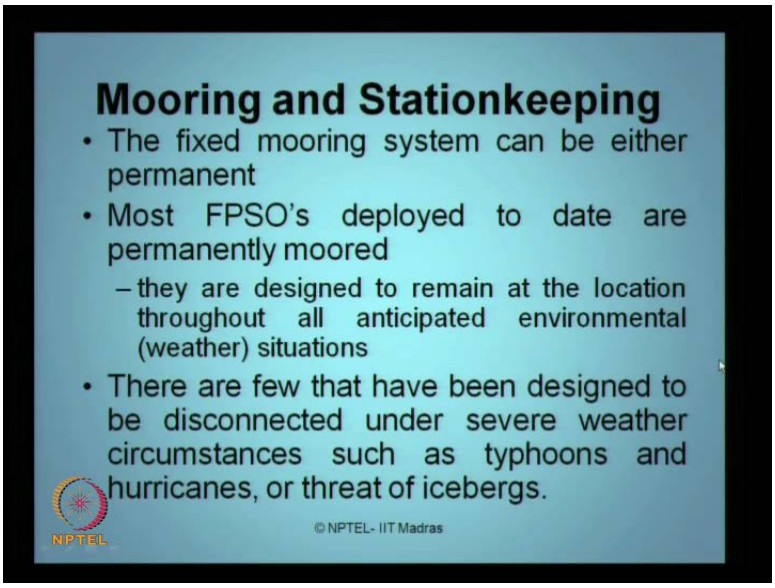

The fixed mooring system can either be permanent or temporary. Most FPSO's deploy permanently moored system. Actually they are designed to remain at the location throughout all the anticipated environmental situations. They are not decommissioned even though the weather can become rough. There are very few cases where they have been designed to be disconnected under severe conditions such as typhoons and hurricanes or icebergs.

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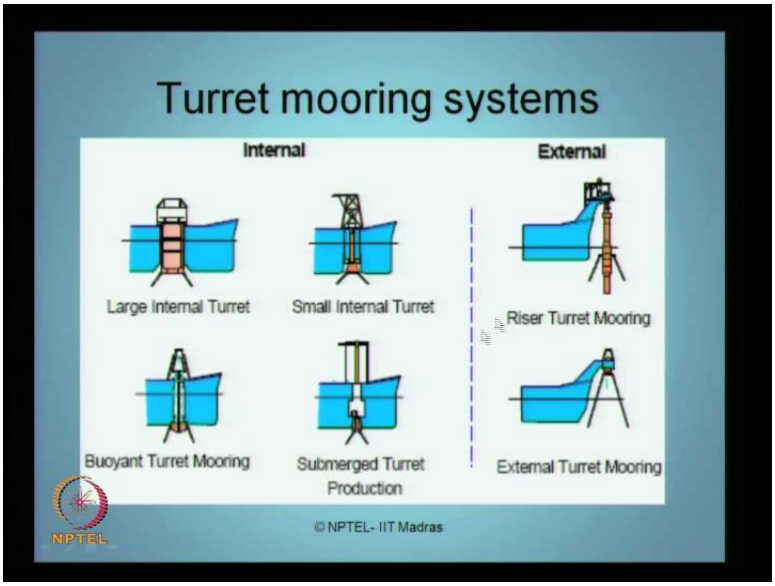

If we look at the mooring systems which are generally equipped for an FPSO, we have got two classified mooring systems which are turret mooring system. One is an internal, other is external. In internal mooring systems, we have got large internal turret mooring system, small internal turret mooring system, buoyant turret mooring system, and submerged turret production system. As we can see very clearly here, the diameter internal mooring system for large compared to that of small is very different.

Whereas for a submerged turret production system, the turret mooring system is submerged in the FPSO vessel itself; whereas in all other three cases, they are housed on the top hull. If you look at the external mooring system, you can see that the productions risers are cantilevered away from the FPSO's; where as in internal mooring systems, there is moon pool which passes through the semisubmersibles or the FPSO through which drilling takes place. So, that is why, these kinds of mooring are called internal, whereas these kinds of mooring are called external because they cantilever out from the FPSO's holes.

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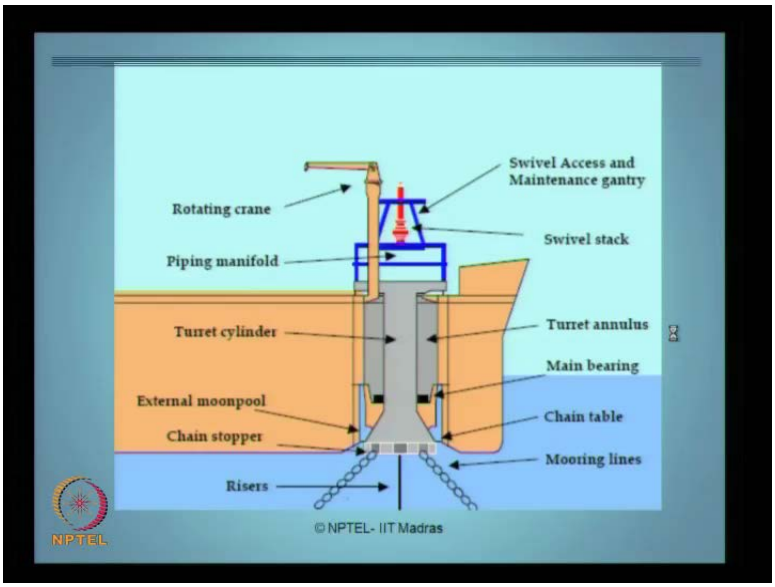

If we look at the detail anatomy of the turret mooring systems, you see you have got actually a swivel stack at the top, the swivel access and maintenance gantry is house on the top hull; where as it is attached to a rotating crane which is used to lay rises or the mooring lines, which comes in rolls is a pipe manifold through which the risers are passed through.

The turret cylinder is equipped in the moonpool and the turret annulus is a component with an angular covering of the turret mooring which is housed and resting on the main barring; whereas the external moonpool is what you see here which is cut in an FPSO and it is the chain stopper which prevents the backflow of chains or the mooring lines in to the turret system. This is what you see is the riser which passes through the moonpool which is essentially used for production relay.

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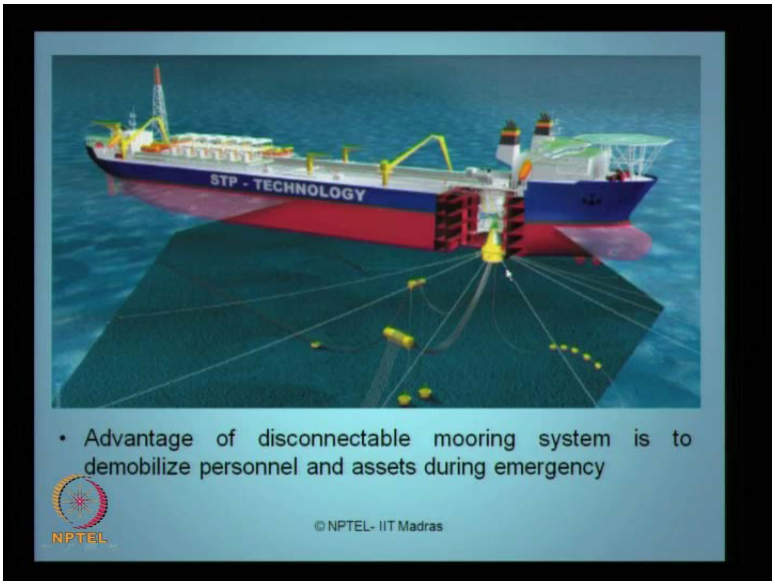

It is a very typical photograph of an FPSO which is being used for catering to different lines on subsea trees. We can see here, these are the mooring lines. These are all the productions risers. These are the mooring lines and production risers being spread. In different segments, all of them are connected to the mooring system here which is being used for production storage as well as offloading in this case. The advantage of a disconnectable mooring system as you see here is, you can demobilize the personnel and assets during emergency.

As we understand very interestingly, when you connect the mooring systems or a riser to an FPSO or any floating system, there will be always a coupled action imposed on the floating system, by the dynamic sway action of the riser or the mooring cables. In such situation in case of any emergency, you want to really safeguard the personnel or assets; you can disconnect the mooring system from the FPSO, so that the FPSO or the floating

system can be saved, because of the coupling action imposed on by the risers on to the floating systems.

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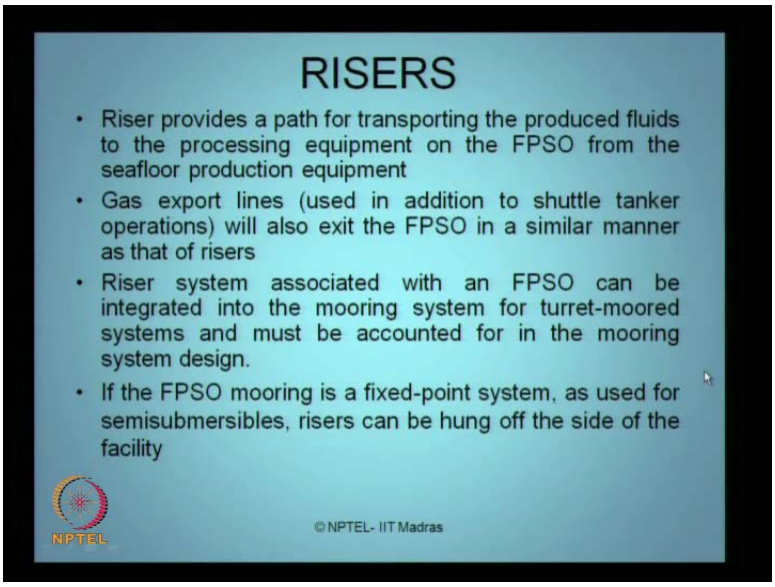

Let us quickly talk about the risers which are deployed in FPSO's for oil production. Risers actually provide path for transporting the produced fluid to the processing equipment which are housed on the top hull of an FPSO. Gas export lines which are used in addition to the shuttle tanker operation will also exit from the FPSO in a similar manner as that of the risers. Riser system associated with an FPSO can be integrated to the mooring system for turret-moored systems as we just now saw in the previous slide; however, when you connect integrally the riser system with the turret mooring systems, you must design it for the coupled analysis as I mentioned in the previous slide. In an FPSO mooring systems, you can always have a fixed-point system which is generally used in the case of semisubmersibles. In that case, riser can be hung off the side of the facility as we see in the case of the external turret mooring system.

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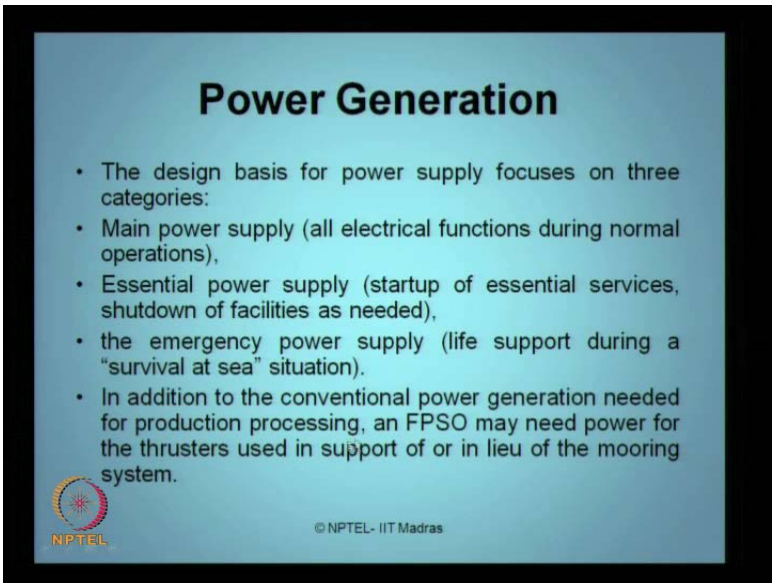

If you look at the power generation units which they generally put on semisubmersible and FPSO's, the design basis for power supply focus on three categories. One is a main power supply which is required for all electrical functions during normal operation. Other is an essential power supply which requires for startup of operations or shutdown of facilities as required. The third one is a vital which is an emergency power supply which is required when you want to have a "survival at sea situation" arises. In addition to the conventional power generation needed, the FPSO also require power for thrusters used in support for the mooring system.

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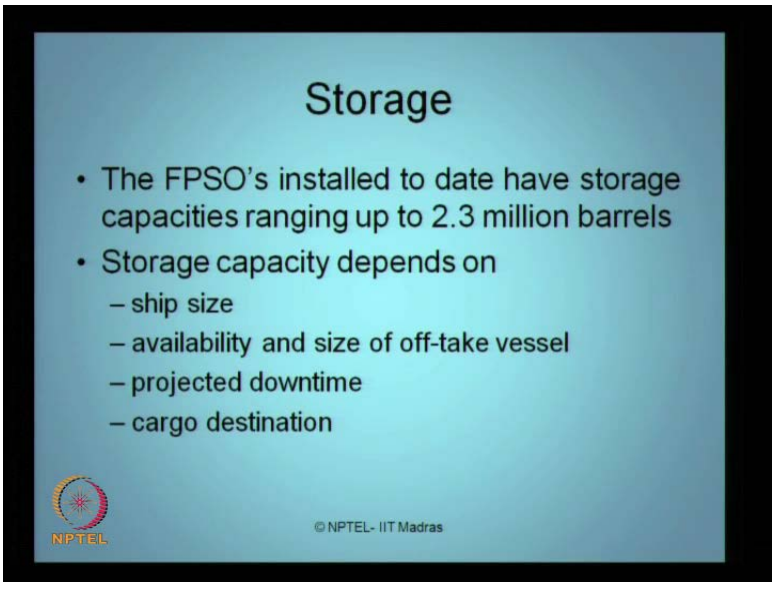

If you look at the storage of an FPSO, the FPSO's installed to date have storage capacities ranging up to 2.3 million barrels. The storage capacity of an any FPSO actually depends on many parameters; for examples depends on the ship size, the availability and size of the offtake vessel through which the stored oil can be transported to other production or processing facility from the FPSO, the projected down time; basically it is the time of operation at which the FPSO will remain in the sea for production and of course, the cargo destination; how far is the site of operation from the shore.

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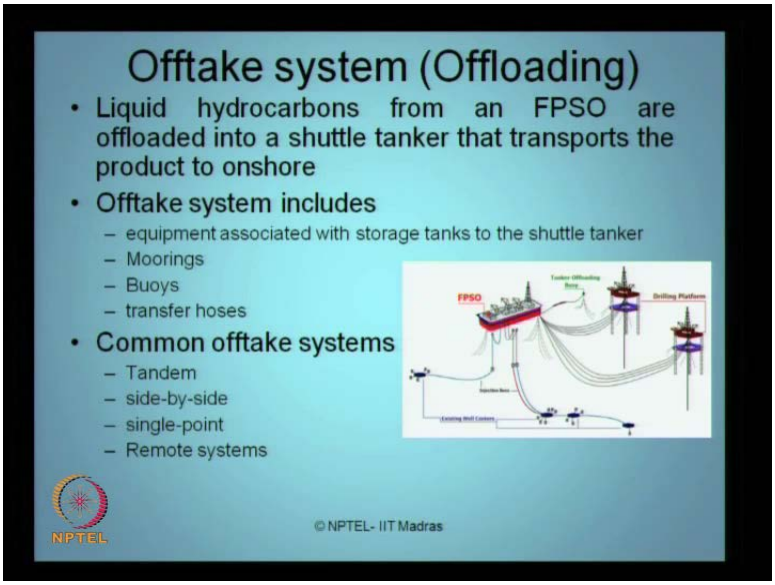

Now let us look very briefly about the offtake systems which are used in FPSO's. Offtake essentially means offloading. Offloading is a term related to transferring the produced oil hydrocarbon from the barge or the floating system to another location. If we look at the figure here, this is an FPSO which is connecting different wells from which drilling is taking place. You also have drilling platforms from which the hydrocarbon is transported to an FPSO.

You may wonder why the explored hydrocarbon from a drilling platform should be transported to an FPSO. As we recollect, these floating production systems may not have larger capacity to store the exploded hydrocarbons. FPSO has s standing for storage, so there can be the large volume of hydrocarbon can be stored; therefore, the produced hydrocarbon is actually transported to FPSO as you see here. Further from the FPSO,

they have been transferred to offloading system from a boil. So, the liquid hydrocarbons from an FPSO are offloaded into a shuttle tanker which further transports it to onshore.

Offtake systems actually include equipments associated with storage tanks to the shuttle tanker, the mooring lines, the buoys, and transfer hoses. So as a total for example, the equipment associated with the storage tanks, the mooring lines which are used for holding down the offloading system, the buoys which are used for transferring the crude oil from FPSO to offloading system and of course, the transfer hoses put together is what we call as an offtake system or offloading system. Common offtake systems can be tandem, side-by-side offtake system, single-point offtake systems or remote systems.

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I will show you some pictures of side-by-side and tandem. This is an FPSO equipped with tandem offloading system. You can see this is my FPSO, whereas along with this tandem, I have an offloading system which is towed along with this together. This is what they call tandem offloading system associated with FPSO; whereas in this case, an FPSO which is used for production is also equipped with a side-by-side offloading system.

So, this is actually a barge or a tanker which has large capacity to store the produced hydrocarbons. So, it is actually a twin ship which sails together; whereas this is anchor and the production takes place from here. This is anchor to the FPSO here and the produced hydrocarbon from this location is offloaded to this barge. So, this is what we

call side-by-side offloading system, whereas in this case I call them as at tandem offloading systems.

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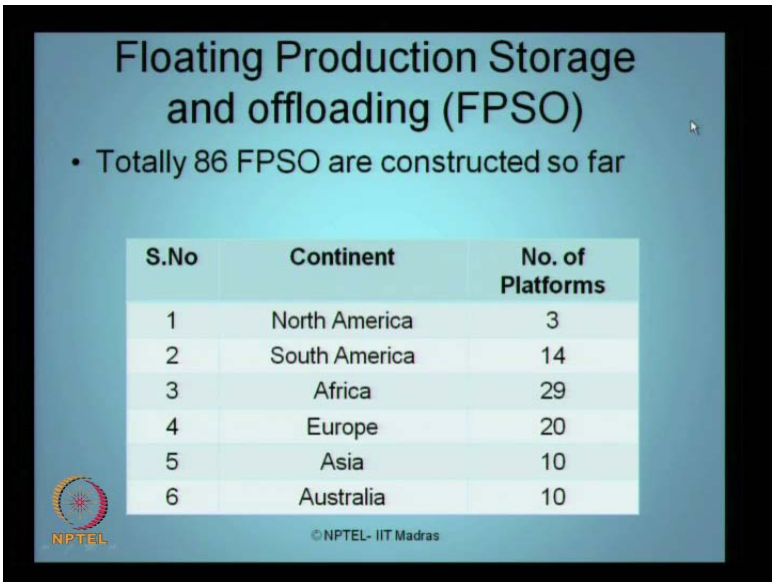

If you looked at the FPSO's and offloading system which are constructed as on today, we have got 3 numbers constructed in North America and 14 in south America. Large of them are in Africa and Europe and of course, few of them in Australia and Asia. Totally there are around 86 FPSO's constructed so far.

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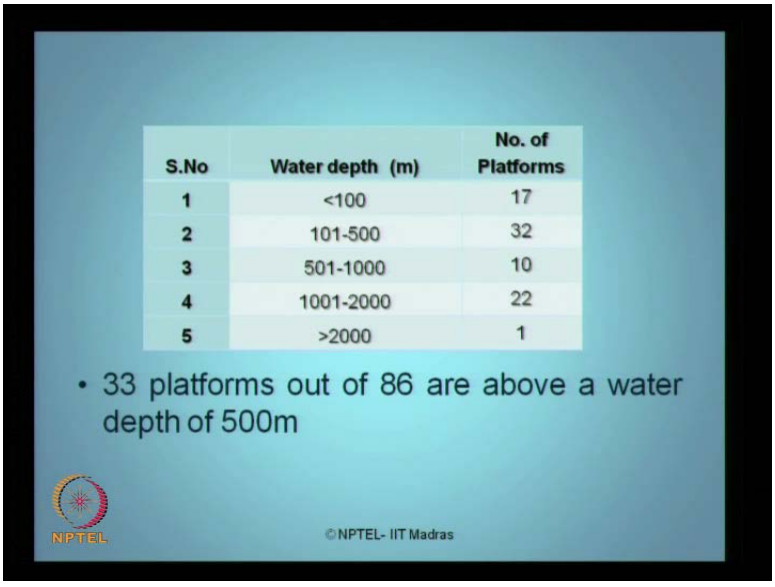

If you look at the water depth where they have been deployed, less than 100 meters you have got 17 numbers; where as from 1000 to 2000 meter you have got majority of 22 numbers. 33 platforms out of which 86 are on average operating at a depth of more than 500 meters. So, FPSO's are offshore production systems which are used for oil production, exploration in deepwater.

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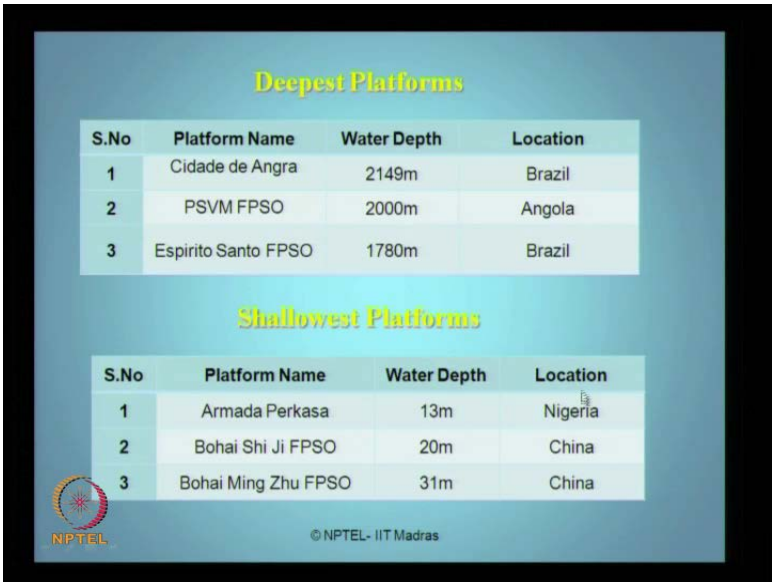

If you look at the location of an FPSO's, the deepest and shallowest; you will see the deepest operation is about the 2.15 kilometer deed located in Brazil, whereas the shallowest can be as close as 13 meter in Nigerian water.

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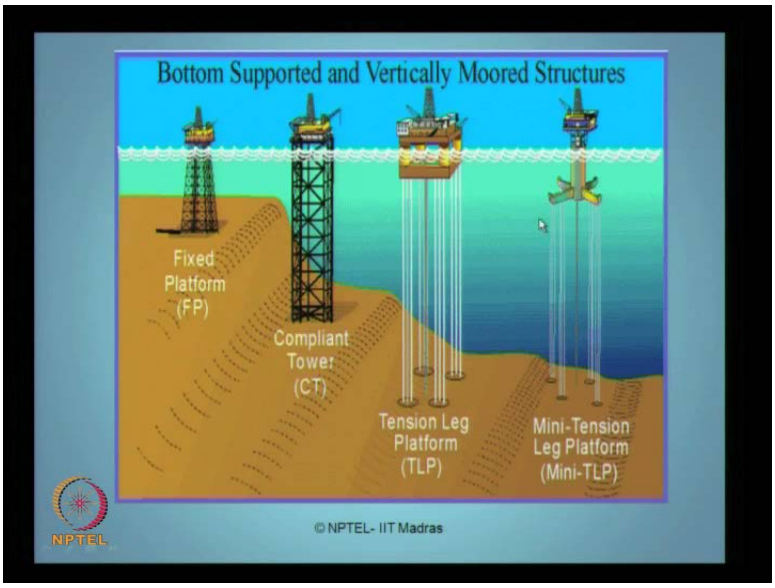

If you look at a brief overview of different bottom supported and vertically moored structure, we are seeing very detailed discussion on fixed platforms; we have also discussed as we go for deeper waters, compliant towers where we call articulated towers. Further you want to go for deep resolution, we have discussed about floating structures which is complaint in nature, where we called TLP is an unique hybrid platform which has got combination of two set of different natural periods of the structural system. You can also have a mini-TLP where you have got a separate anchoring system. Here the tendons or the tethers are through in this case, whereas you have got the projection systems from which the tendons or tethers are anchored to the seabed.

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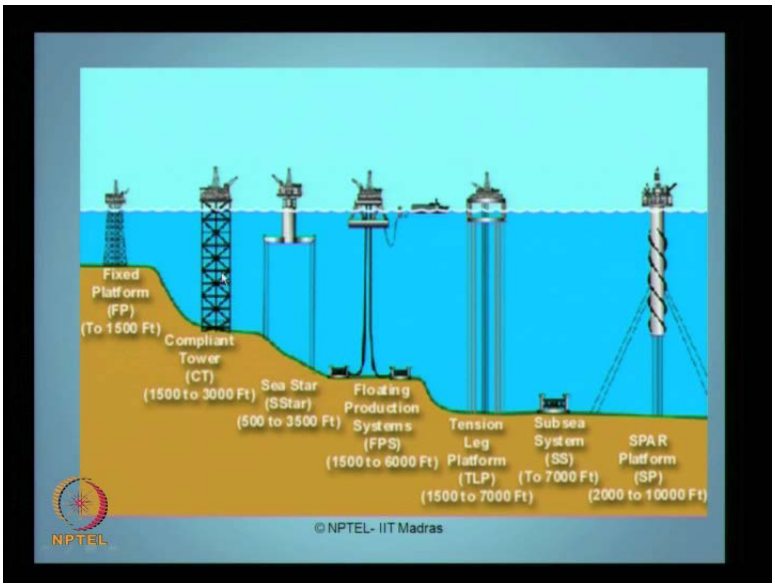

If you look at a comprehensive view of different kinds of platforms for different water depths, up to 1500 feet you can use fixed platforms; from 1500 to 3000 feet you can use compliant towers; you can use sea star from 500 to 3500 feet; you can use floating production systems FPS up to 6000 feet; you can use TLP's up to 7000 feet; you can use subsea systems up to 7000 feet; you can use SPAR from 2000 to 10000 feet. This gives very comprehensive overview of different kinds of offshore structural systems which can be deployed from shallow water, medium water to deep water to ultra deep water.

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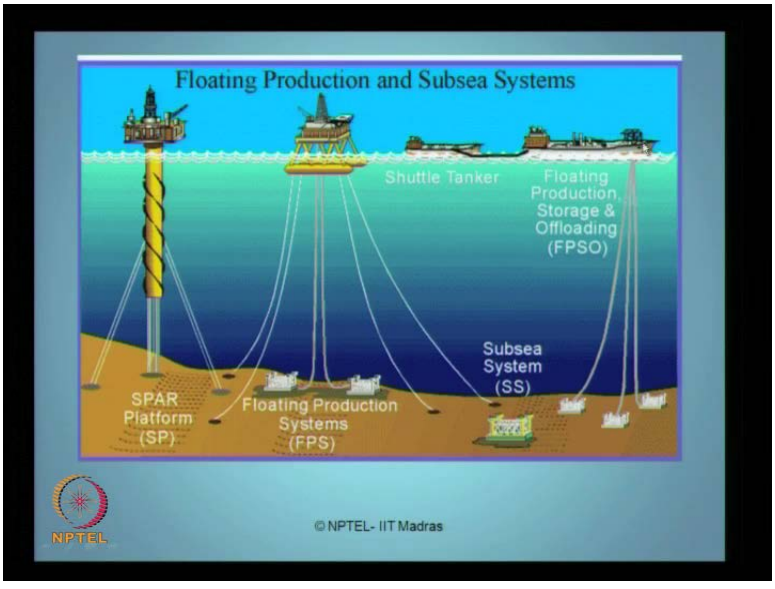

If you look at the floating production and subsea systems, you have combination of SPAR platforms, floating production systems, and floating production storage and offloading facility; we are going to shuttle tanker in tandem attached with the FPSO.

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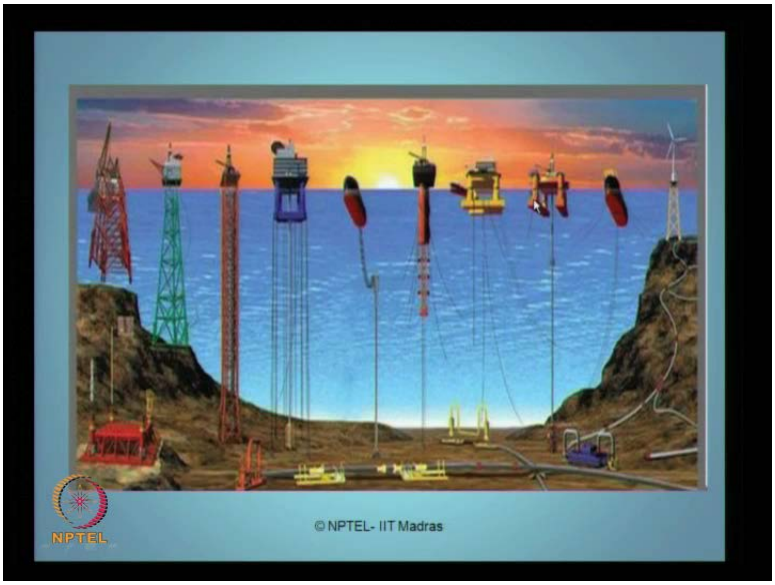

Here is the comprehensive view of different kinds of platforms which has been shown in this picture. Ladies and gentleman, I want you to name few of them. Let us try to name few of them here. Do you think this is an offshore platform? This is actually a platform house to locate a windmill on the top. This is a truss type platform which can be used. Can you name what is this kind of platform? It is a floating production system which is having the pontoon and the column members, so this is a typical tension leg platform, because you can see series of tethers anchored to the seafloor. This is may be drillship or a semisubmersible which is moored to the seafloor. This can be again a tension leg platform and semisubmersibles which can be used for exploration and production in deepwater.

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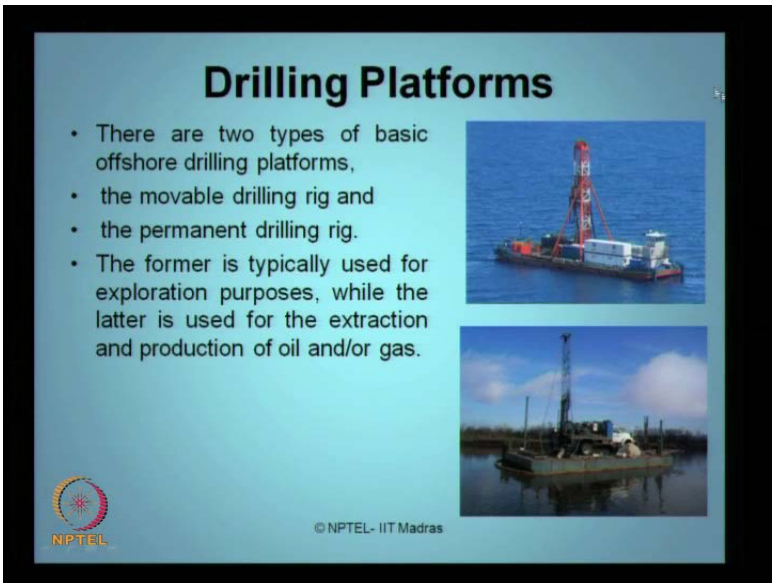

Let us quickly look at the drilling platforms in general which are used for offload drilling. There are basically two types of drilling platform; one is what we call as the movable drilling rig, other is the permanent drilling rig. The former is actually used for exploration purposes, while the latter is actually used for production purposes.

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I can give you some examples in this photograph. You can see this is the floating production platform. It is a typical example for semisubmersibles and drillship. I want you to name this particular type of structure; we have seen this in the previous lecture.

Yes, you able to recollect correctly, this is a jackup rig. Now when the rig is actually floating, the legs are all raised up; that is why it is called jackup rig. I hope you have understood some basics of drilling from this lecture. Thank you.