Offshore structures under special loads including Fire resistance

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Module – 03
Fire Resistance
Lecture – 50
Fire Resistant Design Over View

Friends, we will continue to discuss more concepts related to fire resistant design as applicable to offshore platforms. We have understood in the last set of lectures, characteristics of fire, different types of fire, we will also deal with varieties of types of fire in this module, in the next lecture as well. We have also understood various mechanical properties and characteristics of material at elevated temperature. We have realized that understanding the yield strength and Yang's modulus is important at different strain rate, which should be compactable with the rate of loading as far as the blast resistant and explosions are concerned.

We have understood that fire resistant design in general should be based upon deformation control and not essentially on strength control. We will talk about the design procedures as well as we continue ahead with the set of lectures. In this lecture now, we will discuss about the fire resistant design, will have an overview of the whole process.

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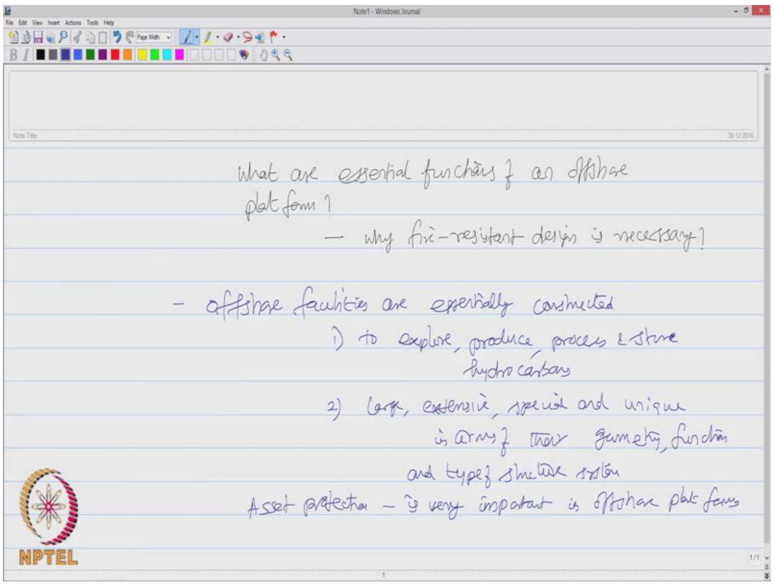

Friends, let us try to ask a question what are essential functions of an offshore platform and therefore why a fire resistant design is necessary, let us ask this question. We already know that offshore facilities are essentially constructed to explore, produce, process and store hydrocarbons. Offshore facilities are large, extensive, special and unique in terms of their geometry, function and even type of structural system

So, asset protection is very important in offshore platforms, so my design procedures should enable absolute safety of the asset so that in case of any untoward incidents even accidentally the asset protection place a very important role in the whole design philosophy because offshore structures and offshore platforms are commission at a very high price and they are in evitable and very crucial for nationals, economical growth. Therefore, we cannot take a chance of cap sizing or losing the offshore asset just because accidentally a fire or explosion occurs in the platform because of risk involved in the process of production of hydrocarbons.

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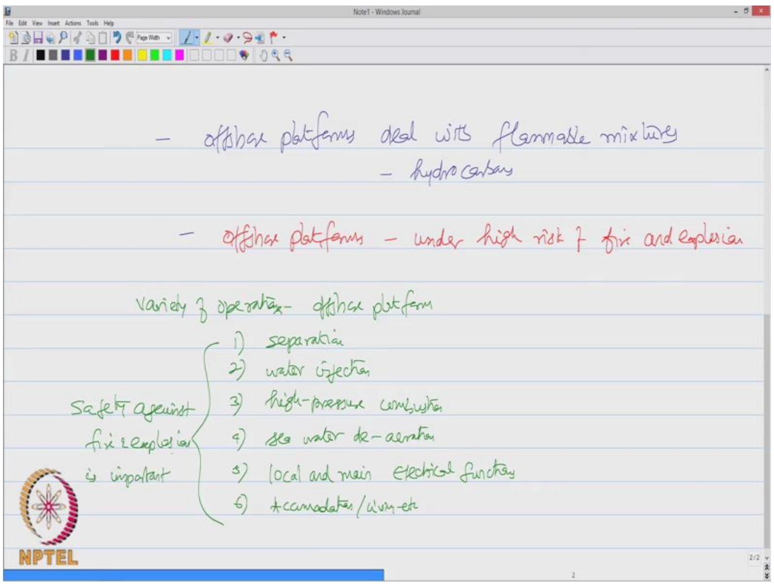

So therefore we have realized that offshore platforms deal with flammable materials, let us say hydrocarbons therefore, one can say that offshore platforms or generally under high risk of fire and explosion. Let us look into a variety of operation which takes place in offshore platform, so this will give a hint for us to realize the degree of risk involved in terms of fire in explosion in offshore facilities. Separation, water injection, high pressure combustion, sea water de-aeration, local and main electrical functions and accommodation; let say living etcetera. Though all of them do not originate or do not promote fire and explosion, but safety in terms of asset management and human resource in all segments of the plan operation becomes very vital. Therefore safety against fire and explosion is important.

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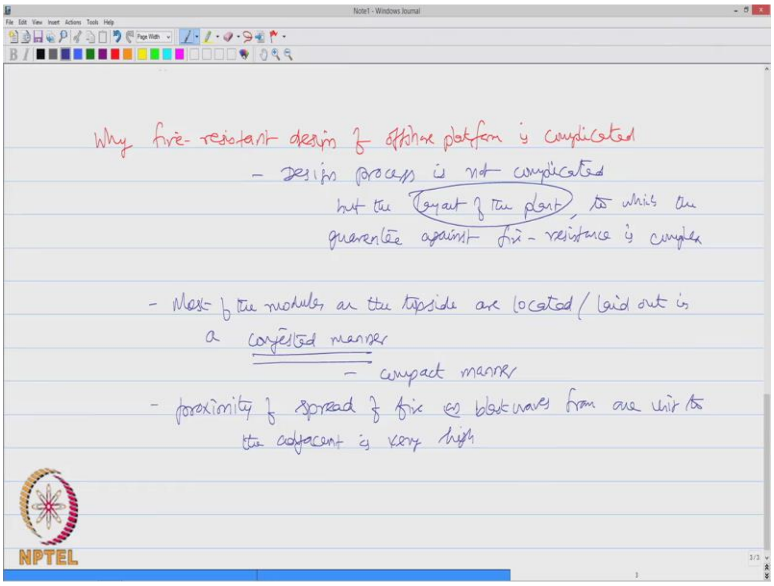

Now the question comes why fire resistant design is complicated. The answer is very simple; the design process is not complicated but the layout of the plant to which the guarantee against fire resistance is complex. So, it is actually the layout because most of the modules on the top side are located in a congested manner. Let us say to make it more decent, we say it is laid out in a compact manner. For me as a structural engineer, I would say that compactness in terms of geometric layout is a structural congestion. Therefore, proximity of spread of fire or blast waves from one unit to the adjacent is very high.

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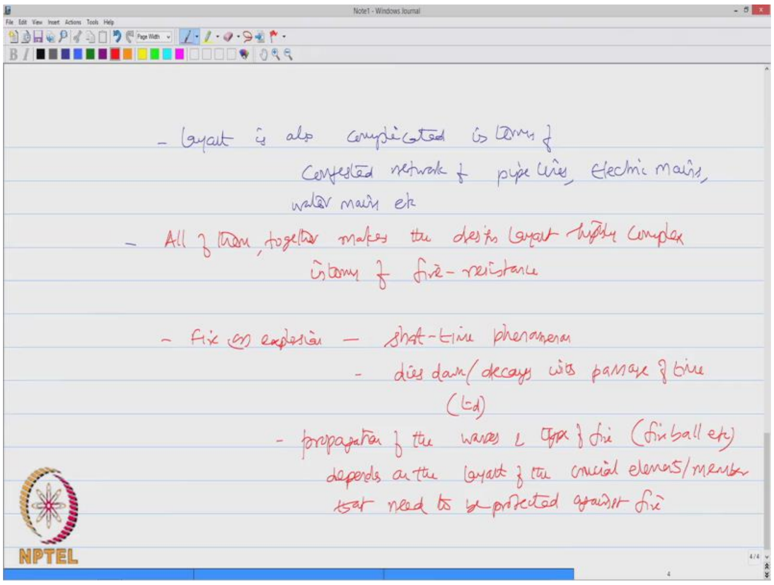

Further the layout is also complicated in terms of congested network of pipe lines, electric mains, water mains etcetera. All of them together makes the design layout highly complex in terms of fire resistance because as we understand fire or explosion is a short time phenomena which dies down or decays with passage of time, what we call as t d.

Propagation of the waves and type of fire like for example, fire ball etcetera all depends on the layout of the crucial elements or the members that need to be protected against fire. For example, if we are able to layout the mechanical equipments and the leaving quarters for away from the hotspots which are probable to have fire explosion then the asset damage can be as minimum as possible, but unfortunately in a given layout of an offshore topside we do not have this liberty of spreading these facilities for away because all of them need to be assembled and commission at the most compacts phase available on the top side.

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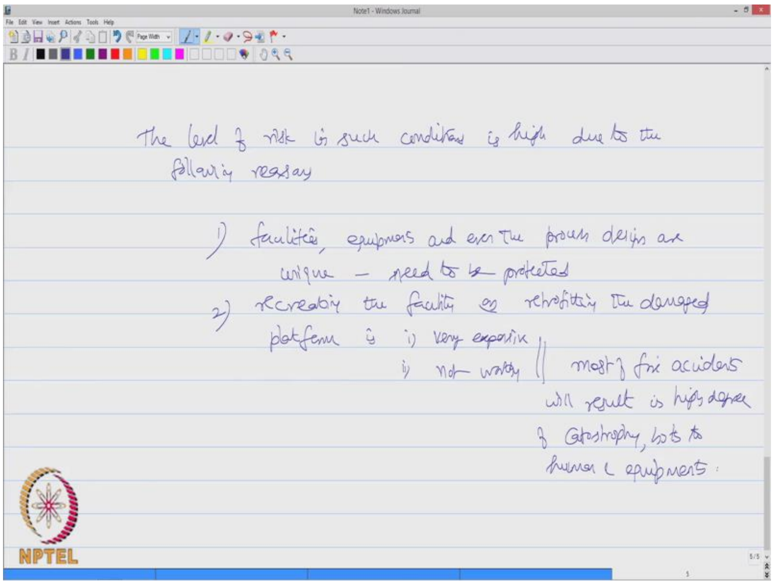

Therefore the level of risk in such conditions is high due to the following reasons – one, facilities, equipments and even the process design are unique therefore, they need to be protected; two, recreating the facility or retrofitting the damaged platform is one very expensive and practically not worthy because most of the fire accidents will result in high degree of catastrophe both to human and equipments.

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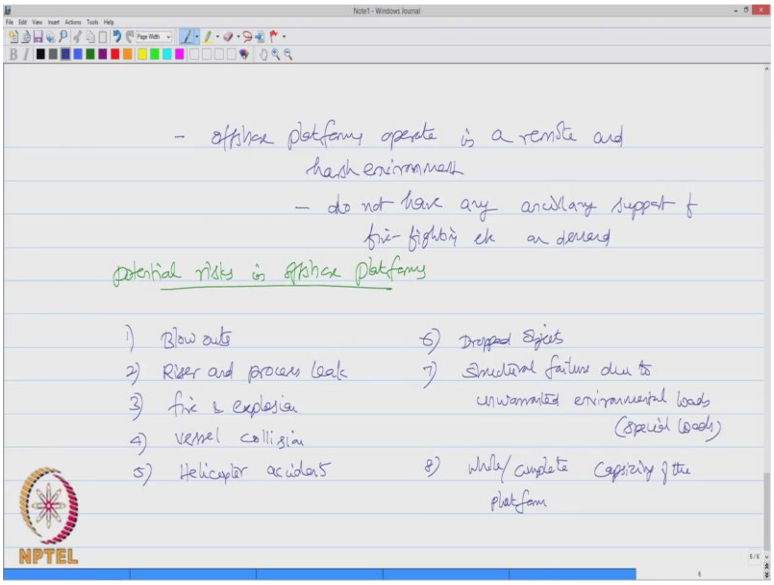

The third point could be we all do agree that offshore platforms operate in remote and harsh environments, which do not have any ancillary support of fire fighting etcetera on demand. Hence the risk involved in offshore platforms especially related to fire and explosion is on a very high scale.

Now, let us try to list the potential risks in offshore platforms, the potential risks include blow outs, riser and process leak, of course, fire and explosion, vessel collision causing series impact, helicopter accidents, impact cost because of dropped objects from the crane, structural failure of members due to unwarranted environmental loads which we have been seen through and through in this course as special loads and of course, a whole or complete capsizing of the platform. So interestingly there are large levels and variations in the risks involved in offshore platforms, but one can see here that there are wide variety of potential risks in offshore platform as listed on the screen just now.

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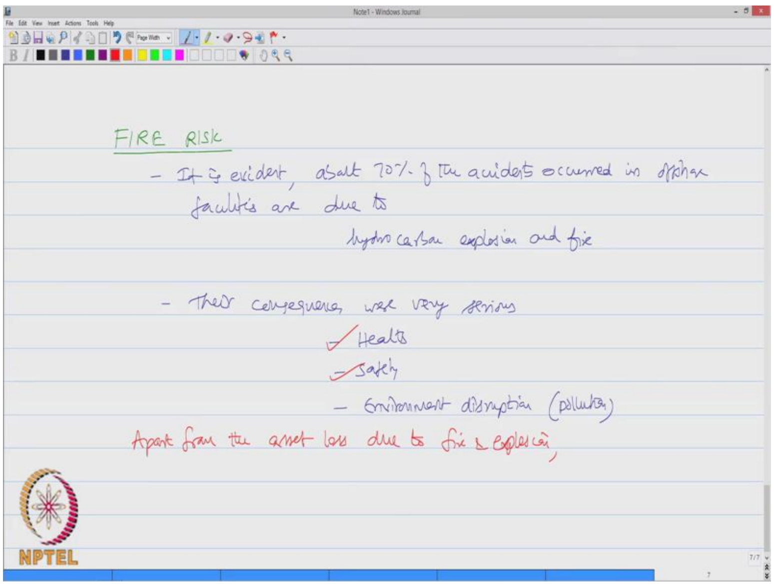

Out of which let us pick up; fire risk, it is evident from the literature that about 70 percent of the accidents occurred in offshore facilities are due to hydrocarbon explosion and fire. It is also seen that their consequences where very serious; it affected health, safety and also resulted in environmental disruption or let us say environmental pollution. So apart from the asset loss due to fire and explosion, you also end up in pain penalty towards loss of personal health, challenging safety of the whole operation which can invoke legal complications on the existence of the facility and of course, you have to also pay on the societal obligation towards the environmental loss cost because of the accidents.

So it is very vital and important that platforms must be design to encounter the risks which are arised from fire and explosion.

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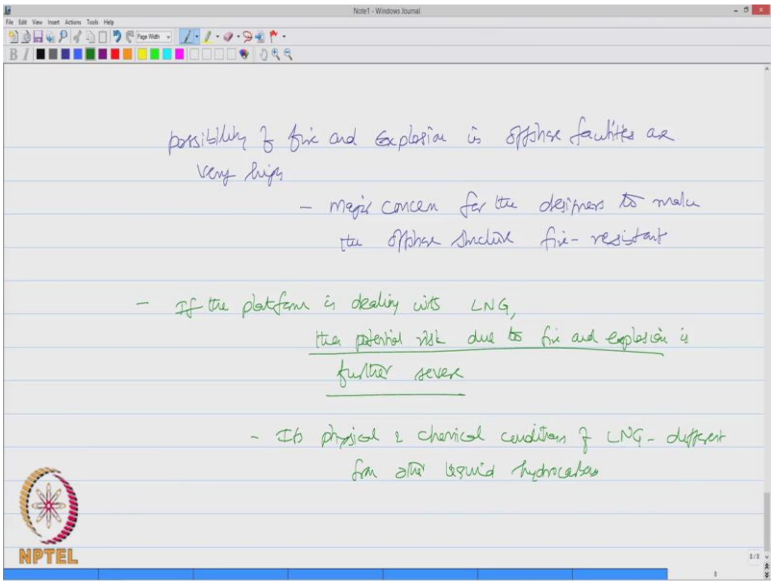

Therefore one can say that possibility of fire and explosion in offshore facilities are very high therefore, it is one of the major concerned for the designers to make the offshore system or offshore structure fire resistant. Adding to this, if the platform is dealing with liquefied natural gas then the potential risk due to fire and explosion is further severe, that is a very important point. It is due to its physical and chemical conditions of LNG which is different from other liquid hydrocarbons.

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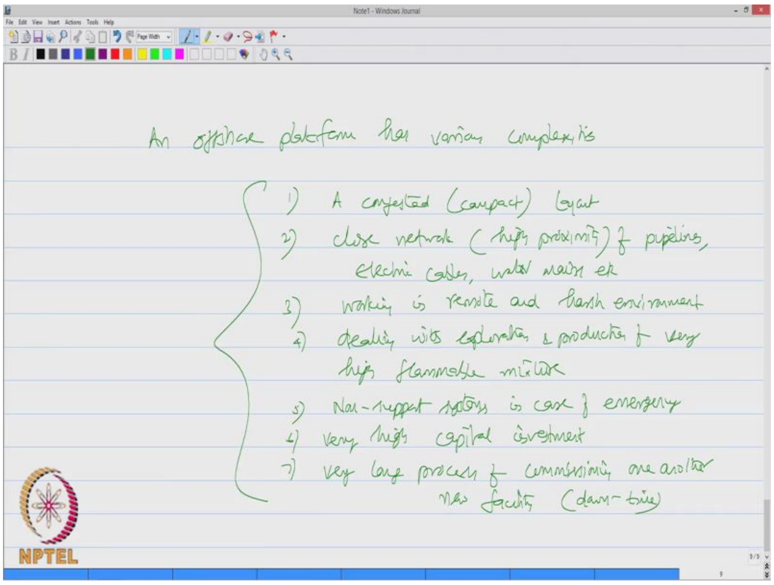

But let us take a statement here, under the given embracement of the complexities involved in layout; in offshore platform has various complexities. Let us see what are they; a congested layout I can even say to be very decent a compact layout, close network; close in sense high proximity of pipe lines, electric cables, water mains etcetera which is again a complexity. Third; working in remote and harsh environment, four dealing with exploration and production of very high flammable mixture, non support systems in case of emergency, very high capital investment and very long process of commissioning one another new facility; what we call as the down time.

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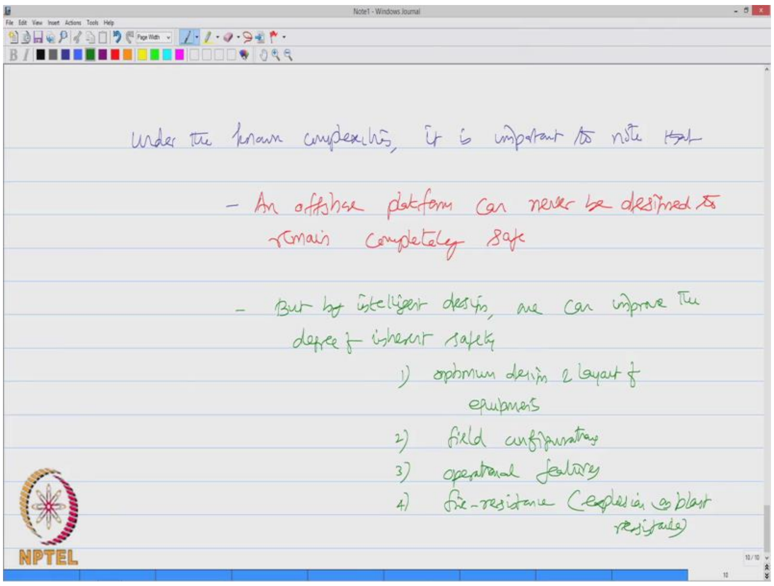

All these factors will make an offshore asset or a platform to remain very complex, therefore under the given list of complexities, it is important to note that an offshore facility or an offshore platform can never be designed to remain completely safe, then what do we do actually, but by intelligent design one can improve the degree of inherent safety.

So what are the steps involved in doing this; one optimum design and layout of equipments, field configurations, operational features and fire resistance impact including explosion or blast resistance because we do not include them as separate, blast and explosion resistance are inherent part of fire resistance.

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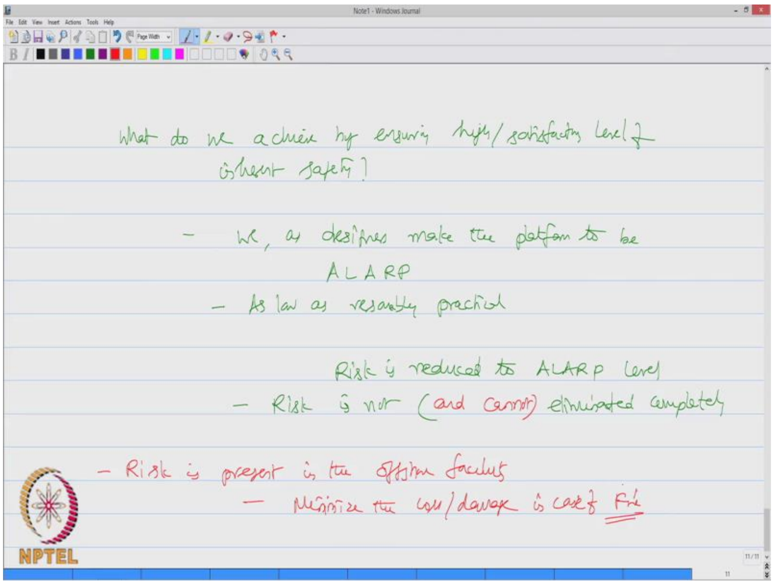

So what do we achieve by ensuring this, that is a very interesting question, what do we achieve by ensuring high or at least satisfactory level of inherent safety. We as designers make the platform to be as low as reasonably practical, so the risk is reduced to ALARP level plus please understand risk is not and in fact cannot eliminated completely.

So, offshore platforms are generally designed with presents of risk, so what do we do as a designer, we only minimize the loss or damage in case of fire. So, we said that the important source which challenges the potential existence of a platform in case of production, exploration, storage and processing of hydrocarbon because hydrocarbons are highly flammable mixture.

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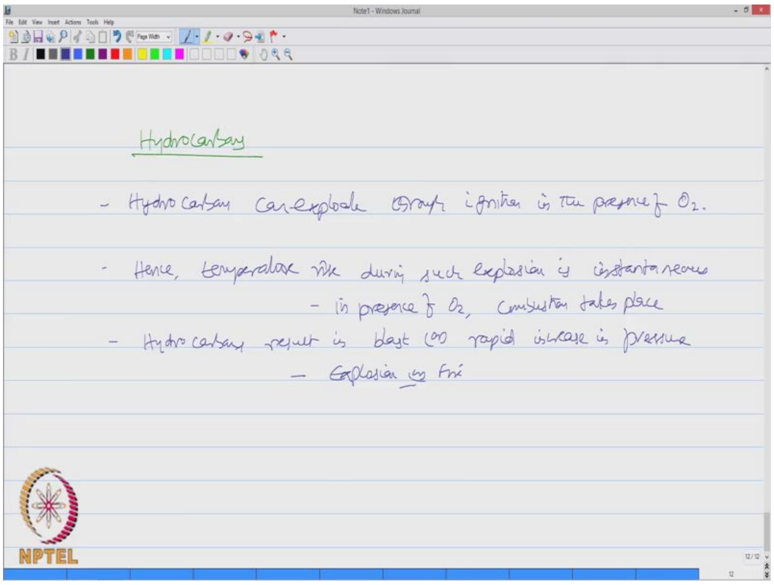

Now let us talk about the properties of hydrocarbon alone. Hydrocarbons can explode through ignition source when in or in the presence of oxygen, hence temperature rise during such explosion is almost instantaneous in the presence of oxygen, combustion takes place therefore, hydrocarbons result in blast or rapid increase in pressure that results two explosion or fire.

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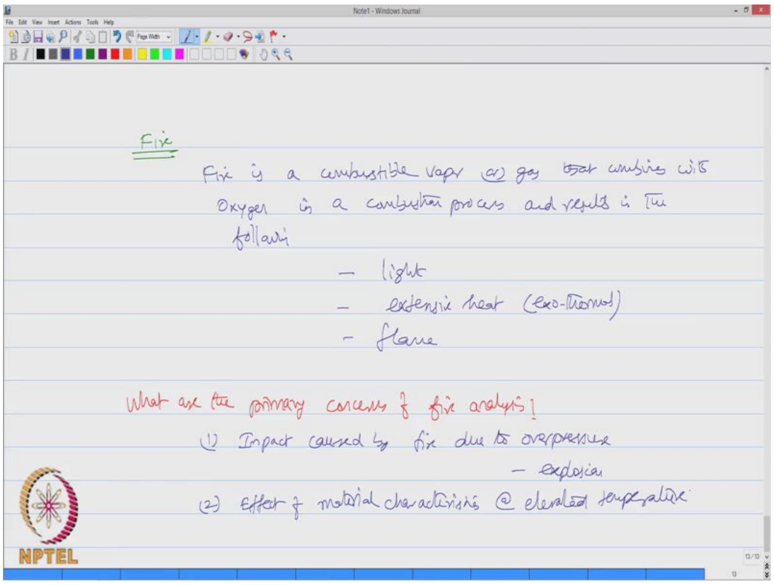

So, therefore let us now try to understand the characters of fire; fire is actually a combustible vapour or gas that combines with oxygen in the combustion process and results in the following, it results in light, results in extensive heat; mostly this exo-thermal and flame. Then let us ask a question what are the primary concerns of fire analysis, the primary concerns could be the impact caused by fire due to over pressure is results from explosion which we have been discussing in the earlier lectures. The second could be effect of material characteristics at elevated temperature, which we also discussed in the last set of lectures.

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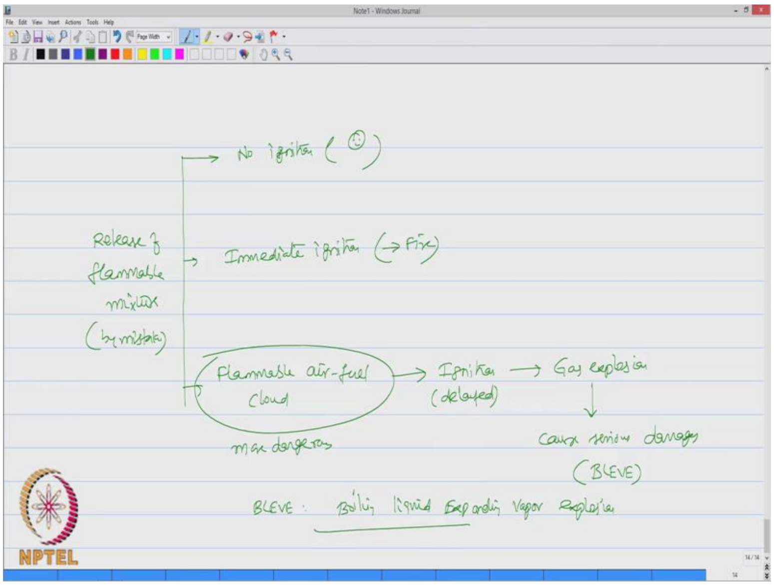

We can simply make a layout indicating the cause of fire, let us say release of a flammable mixture happens, let say by mistake is an accident. This can result in three ways, it can cause no ignition, so in that case we are very lucky; it can cause immediate ignition which is quite common; it will result in fire. It can again cause flammable air-fuel cloud, this is more dangerous because this will result in ignition, which is a delayed ignition and this can result in further gas explosion, which can cause serious damages. One such example could be BLEVE which is boiling liquid expanding vapour explosion.

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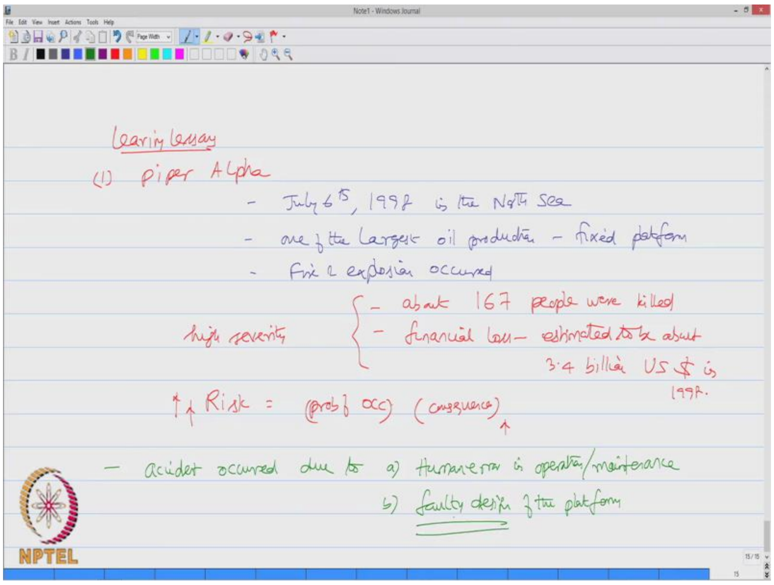

Let us try to ask a question learning lessons from accidents. Let us say focus only on fire accident, let me talk about fire accidents offshore assets; the for most lesson which is being communicated to all offshore engineers is a very classical example of piper alpha; piper alpha accident occurred in July 6th, 1998 in the North Sea. Piper alpha is one of the largest oil production systems; which is actually fixed platform. We already seen the types of offshore platforms earlier in initial lectures, fire and explosion occurred the consequences are about 167 people were killed. The financial loss was estimated to be close to 3.4 billion U S dollars then at that time in 1998.

Now, that it is different so people did post analysis of this accident, they did detail studies of the reasons why such accident occurred. So here before we look into that, we must understand that the consequences cost by this accident where of a very high severity risk is actually a product of probability of occurrence into consequence. Since the consequence of this very very high, one can say that even though the probability of occurrence of such accidents are very minimum; very rare but the risk is a very high order because we can see the consequences caused by these single accident is enormous, so the post after math investigations concluded that accident occurred due to human error in operation and let us say; I should say maintenance.

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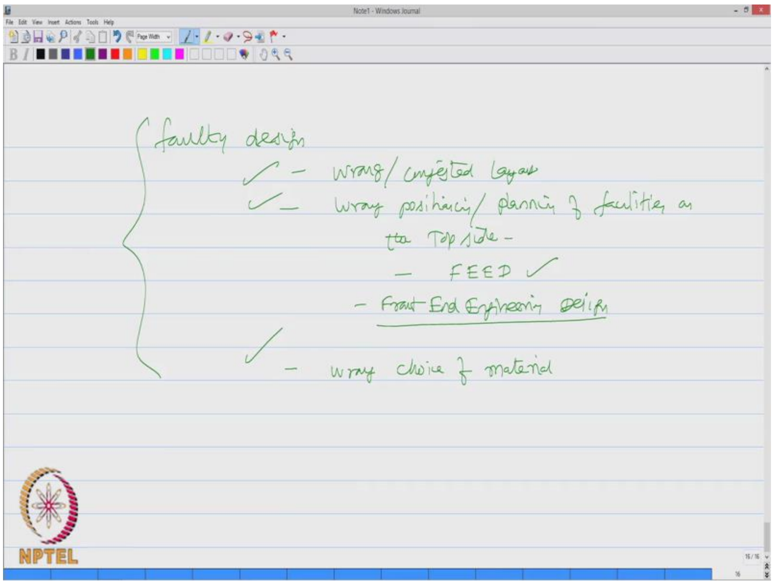

The second was faulty design of the platform, now the faulty design could be a wrong or highly congested layout, wrong positioning or planning of facilities on the top side. So, friends, it is very interesting the whole analogy of planning the top side facility is dealt in detail in braze called FEED, which expands for Front End Engineering Design say this is separate braze of team. In the FEED team which essentially looks into only and intelligent non-compromising, but compact layout of very facilities horizontally and vertically in a given platform top side alone. So, FEED was not effectively done, so 40 design could be due to this and of course, it can also be due to wrong choice of material because a material could not sustain its intended response behaviour at elevated temperatures, which resulted in a permanent deformation at a very high strain rate and that could have resulted in collapse or you could have added that the complication arose because of the fire accident.

So friends one can easily see that the consequences apart from being very severe, one could have avoided them in terms of at least minimize them if the factors of these can be taken care of properly which is actually the fire resistant design part.

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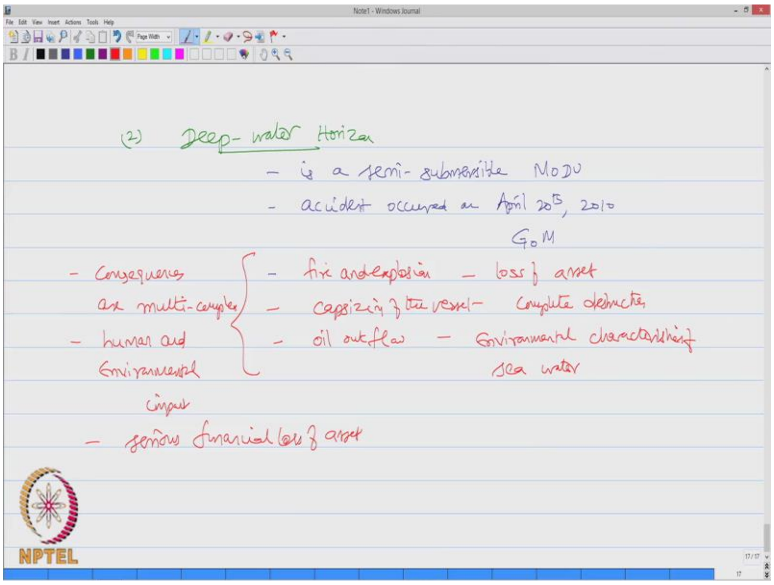

The second example which can also be highly relevant in the present context could be the deep water horizon. Deep water horizon is a semi submersible MODU; Mobile Offshore Drilling Unit, the accident occurred on April 20th 2010 in Gulf of Mexico. It resulted in fire and explosion which led to loss of asset, it also resulted in capsizing of the vessel which is a complete destruction; it also resulted in oil outflow which affected the environmental characteristics of sea water which have also a pintable or punishable offence to the company.

So here also once again the consequences are multi complex, it has both human and environmental impact; it also resulted in a very serious financial loss of asset.

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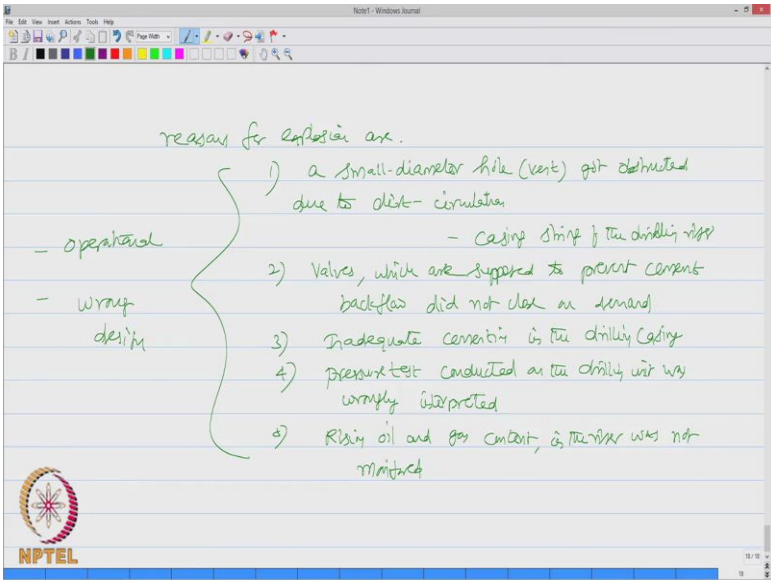

The diagnosis of this event show that reasons for explosion are a small diameter hole, which is vent got obstructed due to dirt circulation, this happened in the casing string of the drilling riser the second diagnosis was reported to be the valves which are supposed to prevent cement back flow did not close on demand, so miss functional operation, it also said there was an inadequate cementing in the drilling casing, it also was noticed that the pressure test conducted on the drilling unit was wrongly interpreted, it is also noticed that the rising oil and gas content in the riser was not monitored.

So, one can see here that most of the aftermath conclusion show that more or less they are operational difficulties but they are also coupled with the wrong design, so design plays a very important role in ensuring minimum loss to the asset even under such catastrophic accidents like fire and explosions.

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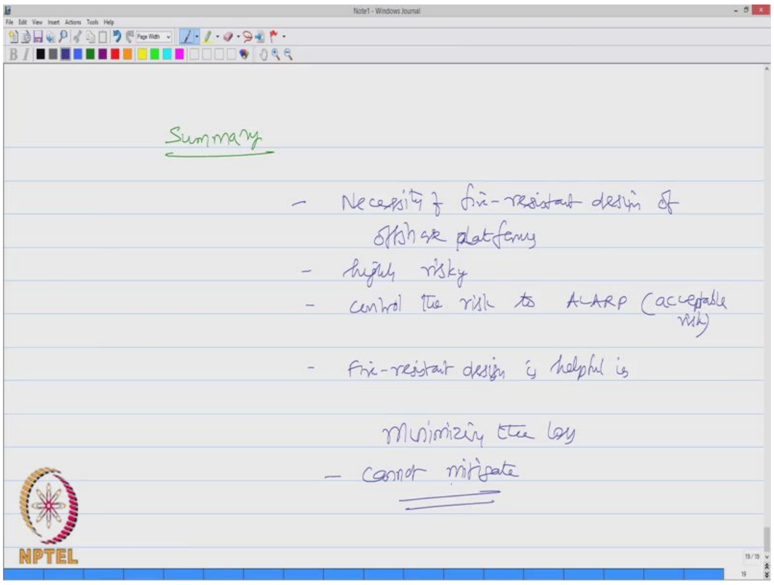

So friends in this lecture, we are trying to understand the necessity of fire resistant design of offshore platforms. We have also understood that offshore platforms deal with processes which are highly risky. We can only control the risk to an acceptable level like ALARP level, but we cannot attempt to mitigate the risk completely. So, fire resistant design will be helpful in minimizing the loss, it cannot mitigate the loss; please understand.

Thank you very much.