Offshore structures under special loads including Fire resistance
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Module – 03
Fire Resistance
Lecture – 51
Types of Fire

Friends, in this lecture we are going to discuss about different types of fire which are common in offshore assets. In the last lecture, we discussed about fire resistant design as an overview and we understood that fire and explosion are inherent part of an exploration process of hydrocarbons, which cannot be completely mitigated but the consequences that arise from such accidents on offshore platforms can be minimized and the risk level can be kept to an acceptable level what we generally address as, as low as reasonably practical.

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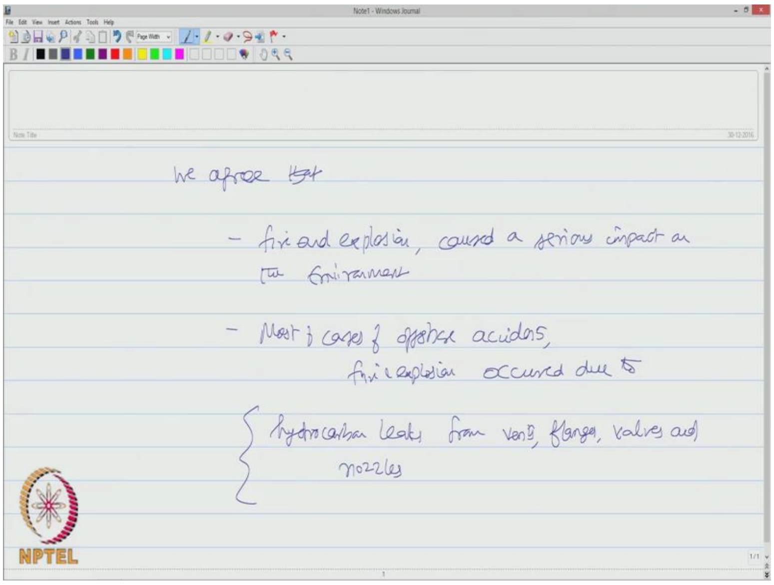

So, as understood by us, we agree that fire and explosion caused a serious impact on the environment and in most of the cases of offshore accidents, fire and explosion occurred due to hydrocarbon leaks that arise from vents, flanges, valves and nozzles.

So, there are no external ignition sources which are otherwise present by the layout of design of offshore platforms, but they generally originate as a part of the process itself essentially from the upper 10 answers. So, fire resistant design of these upper 10 answers is anyway not the part of the course content as we discussed now. We are focusing only on fire resistance design to the structural members and of course, a layout as a part of field.

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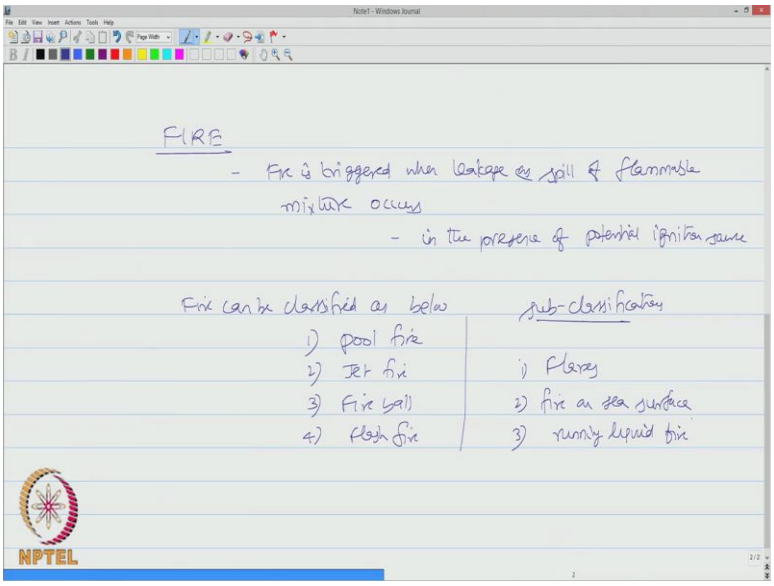

So, to understand this they already said what do we mean by fire? Generally fire is triggered when leakage or spill of a flammable liquid occurs, this will happen only in the presence of potential ignition source. So, fire can be classified as below pool fire, jet fire, fire ball and flash fire; in addition there are sub classifications which are flares, fire on sea surface and running liquid fire.

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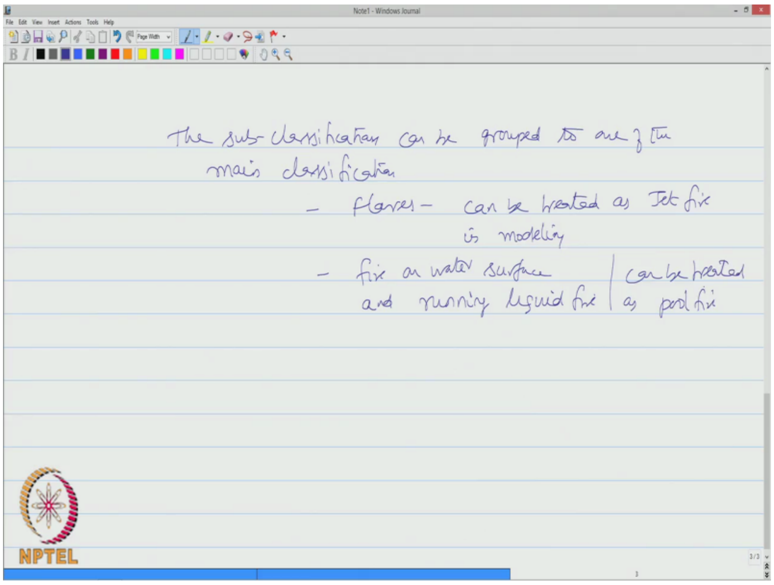

However the sub classifications can be grouped to one of the main classifications; for example, flares can be treated as jet fire in modeling. Similarly fire on water surface and running liquid fire can be treated as pool fire. So, let us talk about details of types of fire which we already said in the previous lectures but still for understanding, let us elaborate this more in detail.

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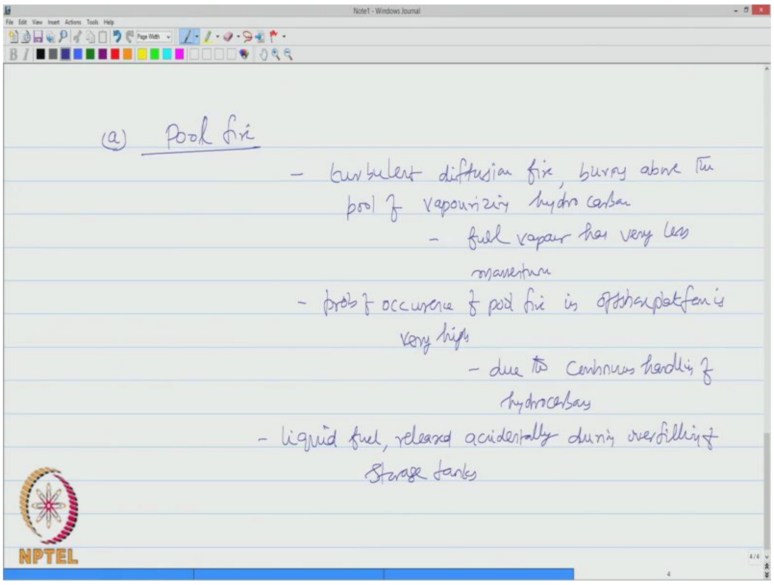

Let us talk about pool fire; pool fire actually is a turbulent diffusion; diffusion fire which generally burns above the pool of vapourizing hydrocarbon. So, in this case the fuel vapour has a very less momentum so it cannot travel. The probability of occurrence of this fire in offshore platform is very high due to continuous handling of hydrocarbons, there is a continuous supply of hydrocarbon which is being explored, processed, stored, or explorated or produced.

This continuous handling chain of hydrocarbon will sustain the occurrence of pool fire in the given platform. So, pool fire generally occurs when the liquid fuel released accidentally during overfilling of storage tanks.

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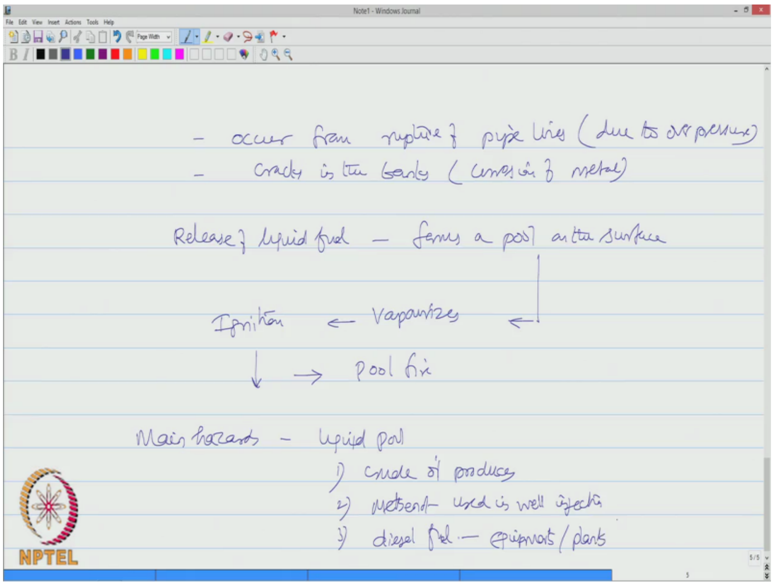

This can also occur from rupture of pipelines due to over pressure, it can also occur because of cracks in the tanks which can be due to corrosion of metal etcetera. So when the liquid releases, it forms a pool on the surface and this pool formation vaporizes and results in ignition and that causes what we call as pool fire. Main hazards occurred due to liquid pool or may be the crude oil produced; it is methanol being used in well injection that can be another reason. Third could be the diesel fuel being used for the equipments and plants.

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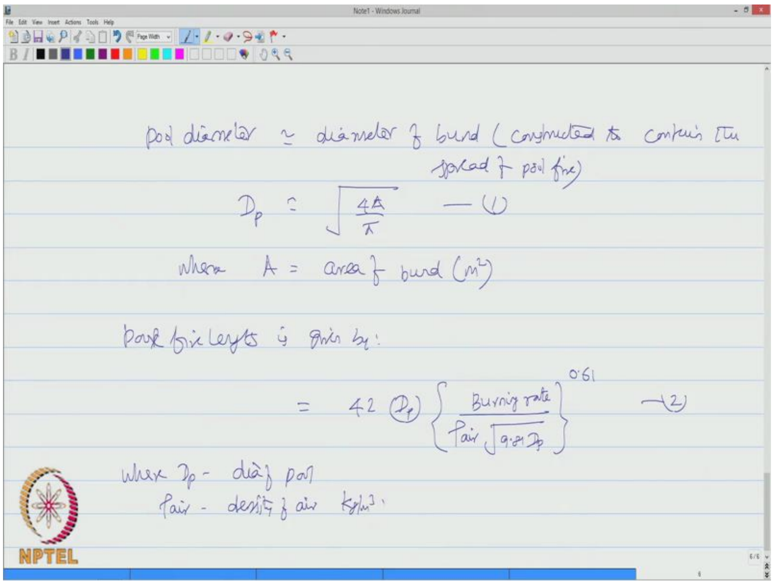

The pool diameter will be approximately equal to the diameter of the bund which is generally constructed to contain the spread of fire. So, this is nothing but root of 4 A by pi; where A is going to be the area of the bund in square meters.

Pool fire length is given by 42; is the diameter of the pool D p, burning rate by density of air into square root of 9.81 D p raise to the power 0.61 where D p is the dia of the pool; rho air is the density of air in kg per cubic meter.

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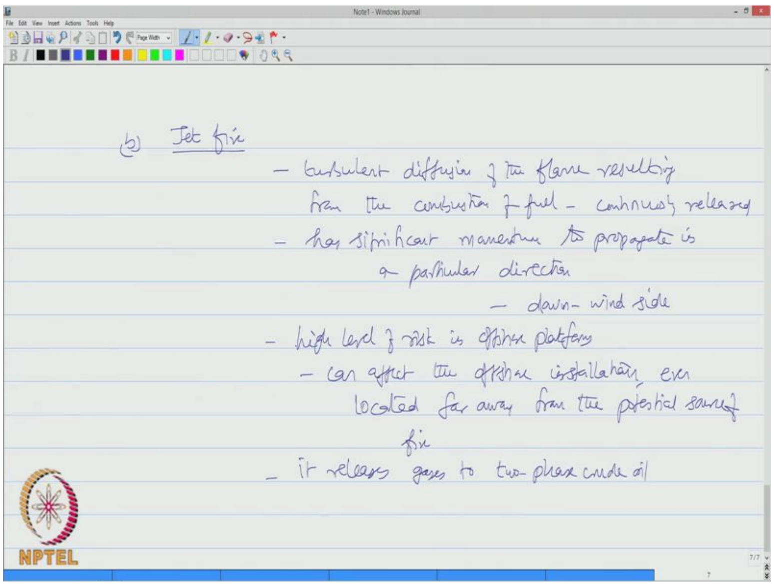

The next could be jet fire, is a turbulent diffusion of the flame resulting from the combustion of fuel being continuously released. This has a significant momentum to propagate in a particular direction; usually it is on the downwind side. Jet fire has a very high level of risk in offshore platforms because it can affect the offshore installations even located far away from the potential source of fire.

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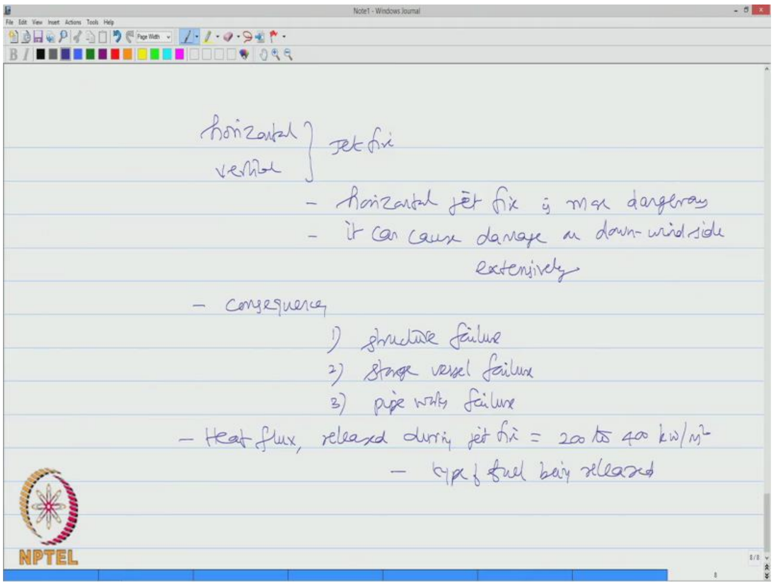

It releases the gases to two phase crude oil; there are two types of fire horizontal jet fire and vertical jet fire; out of which the horizontal jet fire is more catastrophic because it can cause damage on the downwind side extensively. So this can lead to following consequences, it can cause a structural failure, it can cause the storage vessel failure, it can also cause pipe works failure. The heat flux released during jet fire is very high is above 200 to 400 kilo watt per square meter, it depends on the type of fuel being released. Essentially the most, high potential source of jet fire risk is the pressurized gas lines.

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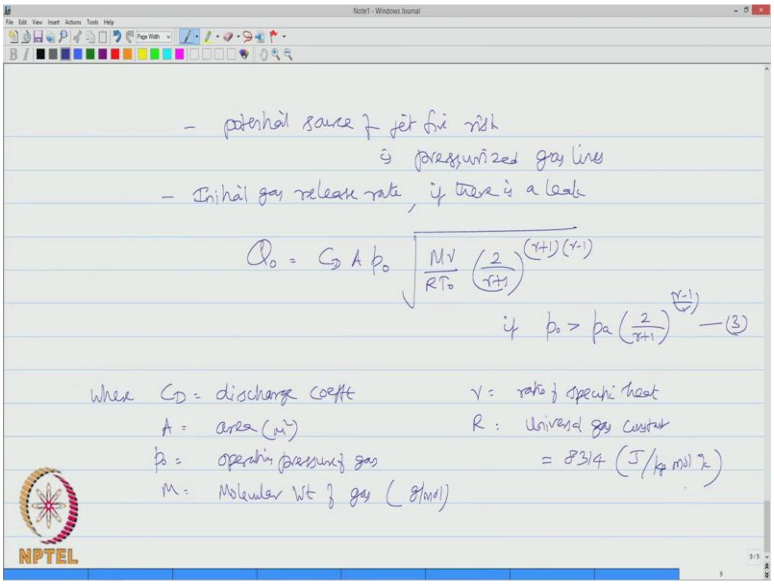

So one calculate the initial gas release rate, if there is a leak and is given by Q 0, which is C D; A; p 0 root of M nu by R T 0; 2 by nu plus 1; nu plus 1 nu minus 1, if pressure is greater than atmospheric value of 2 by nu plus 1; raise to the power nu minus 1 by nu; equation number 3. Where C D is called discharge coefficient, A is the area in square meters, P 0 is the operating pressure of gas atmospheric, M is the molecular weight of gas gram per mol, nu is ratio of specific heat of the gas and R is universal gas constant which is taken as 8314 joules per kg mol per degree Kelvin.

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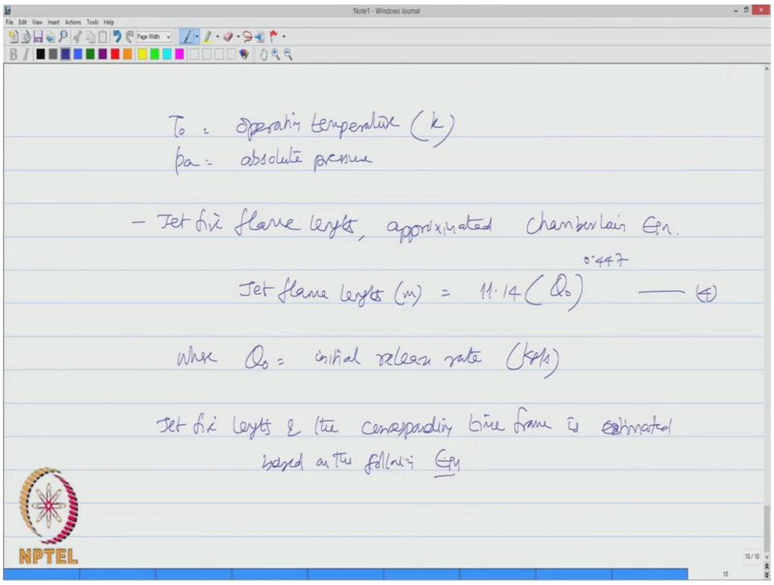

T 0 is the operating temperature in Kelvin's and pa is the absolute pressure. One can also find the jet fire flame length, which is approximated using chamber lain equation. So, the jet flame length in meters is given by 11.14, q 0.447; where Q 0 is initial rate in kg per seconds. Jet fire length at different time frame will have a release, can be estimated jet fire length and the corresponding time frame is estimated based on the following equation.

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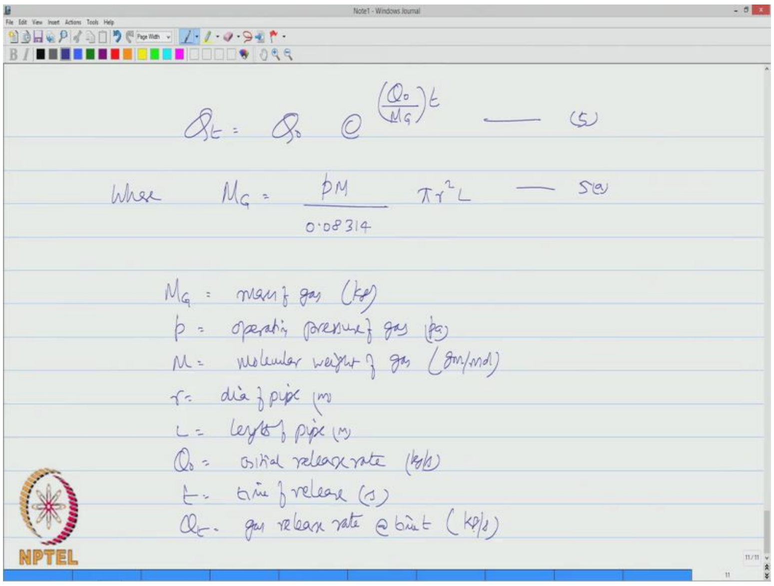

Q t is Q 0; e to the power Q 0 by MG of t; equation number 5, where MG is given by P M 0.08314 pi r square L.

MG is mass of gas in kg, p this is operating pressure of gas; M is the molecular weight of gas in grams per mol, r is the diameter of the pipe and L is the length of the pipe, Q 0 is the initial release rate in kg per second and t is the time of release in seconds, these are all in meters, this is Pascal pressure and Qt is the gas release rate at time t in kg per second.

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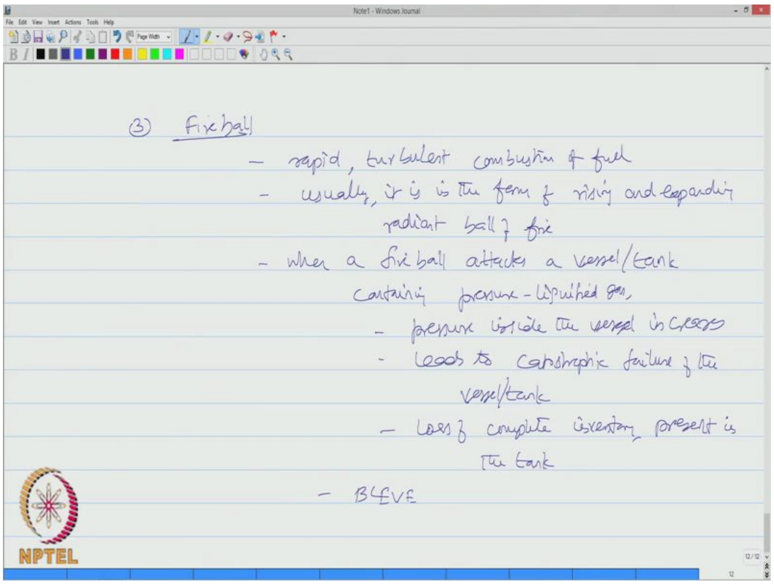

The third case is the fire ball is actually a rapid, turbulent combustion of fuel. Usually it is in the form of rising and expanding radiant ball of fire; that is why it is called as fire ball. When a fire ball attacks a vessel or a tank containing pressurized, liquefied gas; pressure inside the vessel increases and this leads to catastrophic failure of the vessel or a tank.

So this may lead to loss of the complete inventory present in the tank, this phenomena is what we call as Boiling Liquid Expansion Vapour Explosion.

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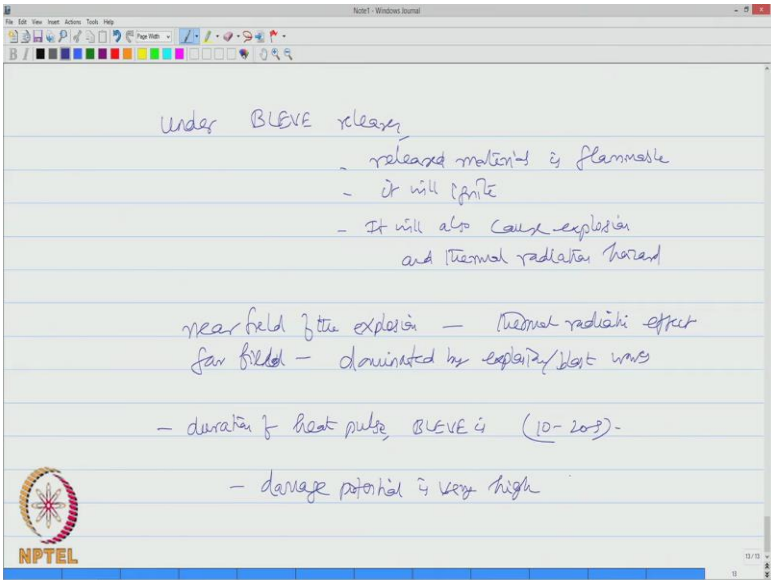

Under BLEVE release, the release material is highly flammable; it will ignite, it will also cause explosion and thermal radiation hazard. So the near field of the explosion will be dominated by thermal radiation effect and the far field will be dominated by explosion or blast waves. Generally, the duration of heat pulse which arise; from BLEVE is about 10 to 20 seconds but the damage potential is very high.

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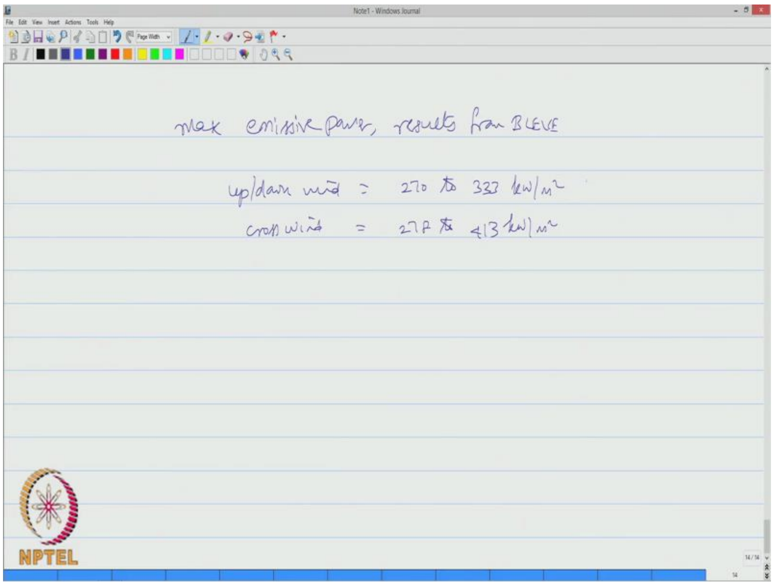

So, the maximum emissive power which results from BLEVE are as follows; in the up and down wind it is about 270 to 333 kilo watt per square meter, in the cross wind direction it is about 278 to 413 kilo watt per square meter.

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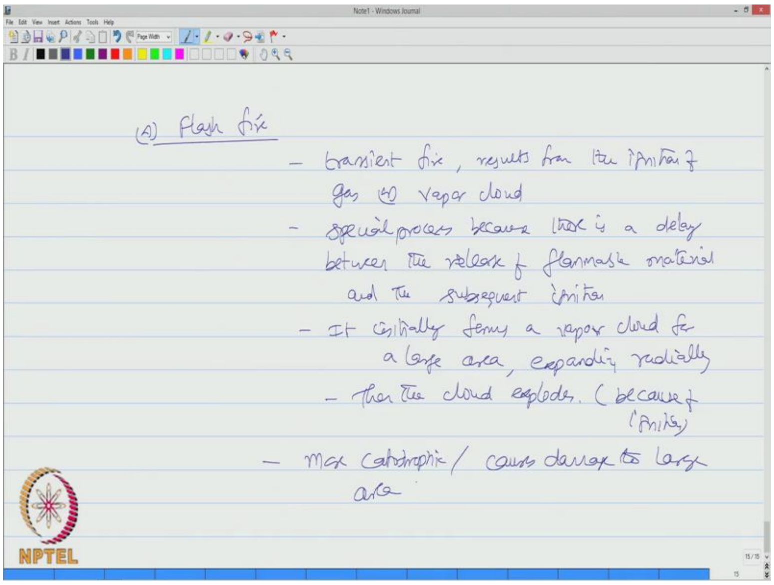

The next could be flash fire; flash fire actually is a transient fire which results from the ignition of gas or vapour cloud. This is a very special process because there is a delay between the release of flammable material and the subsequent ignition. It does not happen instantaneously, it actually forms a cloud; it initially forms a vapour cloud for a large area expanding radially then the cloud explodes because of ignition, so it is more catastrophic and causes damage to a large area.

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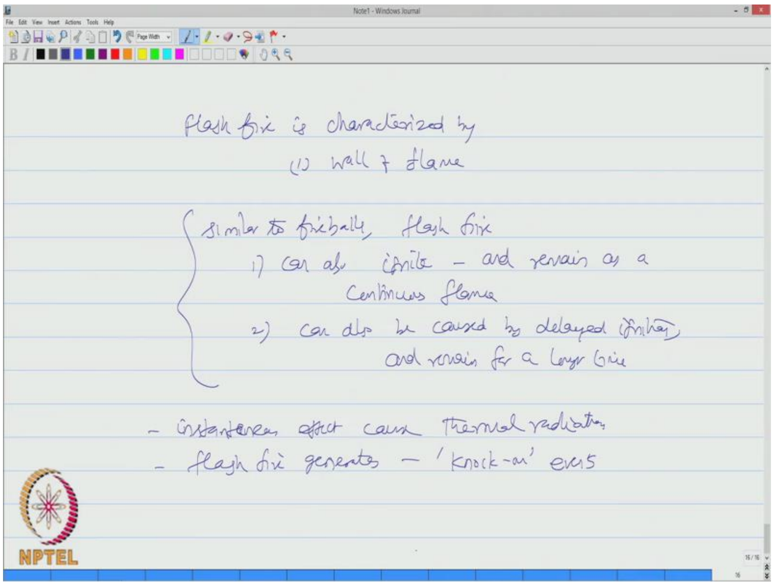

A flash fire is usually characterized by wall of flame, similar to fire balls; flash fire can also ignite and remain as a continuous flame. It can also be caused by delayed ignition and remain for a longer time, so it has got both immediate and subsequent effects on the assets. The instantaneous effect will cause thermal radiation; however, flash fire generates something called knock on events.

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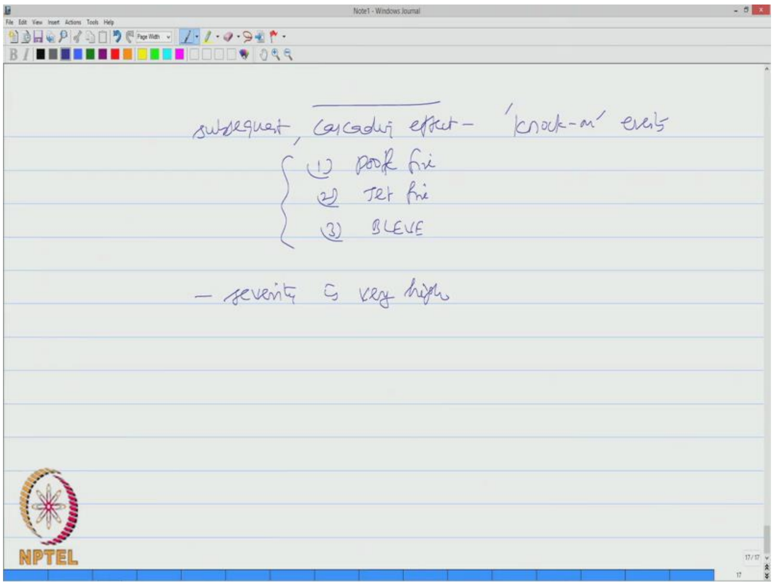

The knock on events can be subsequent effect; subsequent cascading effect, they are called as knock on events. These events can be a pool fire, a jet fire and a BLEVE, so flash fire has cascading effects as well and the severity caused by flash fire is very high.

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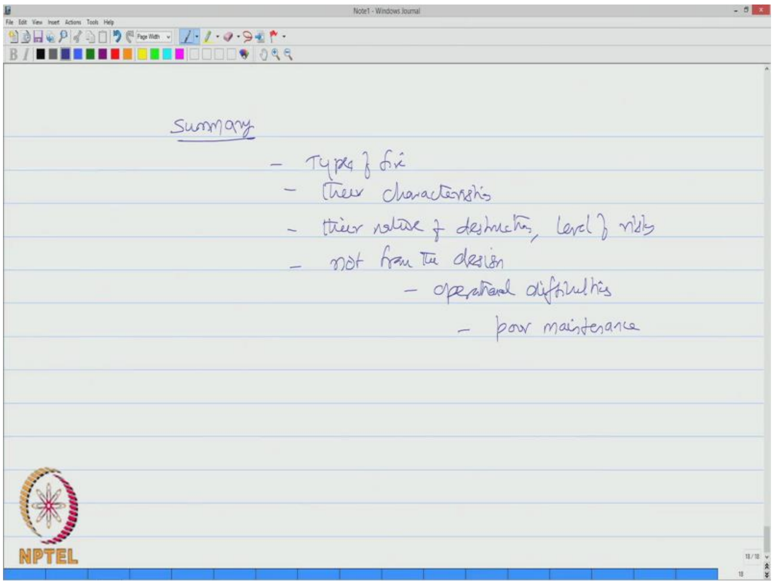

So, friends in this lecture we discussed about different types fire, their characteristics and their nature of destruction and level of risks involved. We do agree that fire and explosion accidents are inhabitable because they arise essentially because of the complexities present in the process systems. They cannot be completely mitigated, they can be avoided by intelligent design, but because of process complexity, they will be inherently present, the essential source is not from the design, but from operational difficulties. In fact, operational difficulties also include poor maintenance because valves and appurtenances are important source of leak of hydrocarbons, which can result in different forms of fire as we discussed.

So, fire resistant design not only applicable to the building modules and machineries which are present in the top side, but also careful selection and layout of material and plants and equipments on the top side including the risers, the water mines, the electrical cables and their layout etcetera.

So fire resistant design is a very interesting phenomena actually, which deals with lot of multi disciplinary activities including layout of structural systems, piping the electrical cables etcetera to make them the risk arising from the fire explosion as to an acceptable level which is referred as; as low as reasonably practical in offshore engineering terms.

Thank you very much.