Offshore structures under special loads including Fire resistance
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Module – 3
Fire Resistance
Lecture – 41
Explosion and Fire Protection

Friends, in this Lecture 41 we will discuss more on Explosion Modelling and steps towards Fire Protection as advised by international codes and other general safety practices which are commonly followed in offshore industry.

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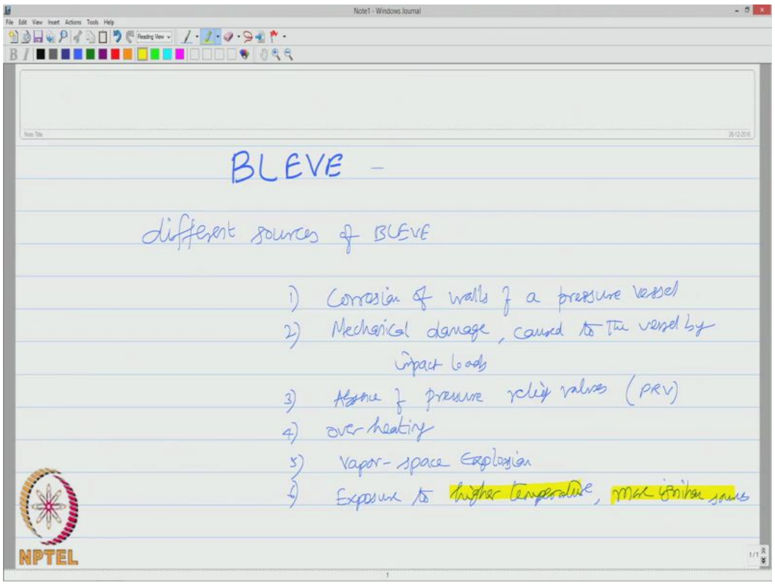

We already said that BLEVE is one of the important sources of explosion. There are different sources of BLEVE, let us see them as listed below. One, it could be a result of corrosion of walls of a pressure vessel, which could also arise because of mechanical damage caused to the vessel by impact loads, can also be due to the absence of pressure relief valves, it can also arise as we said in the last lecture, over heating can also be due to vapour space explosion.

The primary reason for occurrence of BLEVE could be exposure to higher temperature and exposure to more ignition sources. You can look at these two points; very interestingly these two are inhabitability present in offshore platforms being process or production. Or even storage platforms these two could be very highly present because of the complexities involved in oil and gas production process itself.

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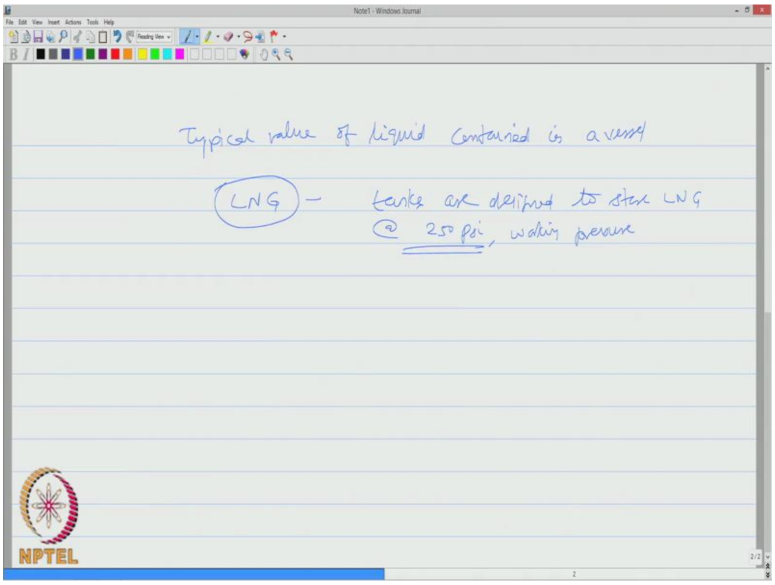

Let us look at the typical value; a typical value of liquid contained in a vessel for our understanding we need to look at this example value let us take liquefied natural gas LNG. Generally, the tanks or the tankers are designed to store LNG at a pressure of 250 psi which is the working pressure. Here, we are talking about pressure vessels which deal with highly flavour will liquids at a very high pressure.

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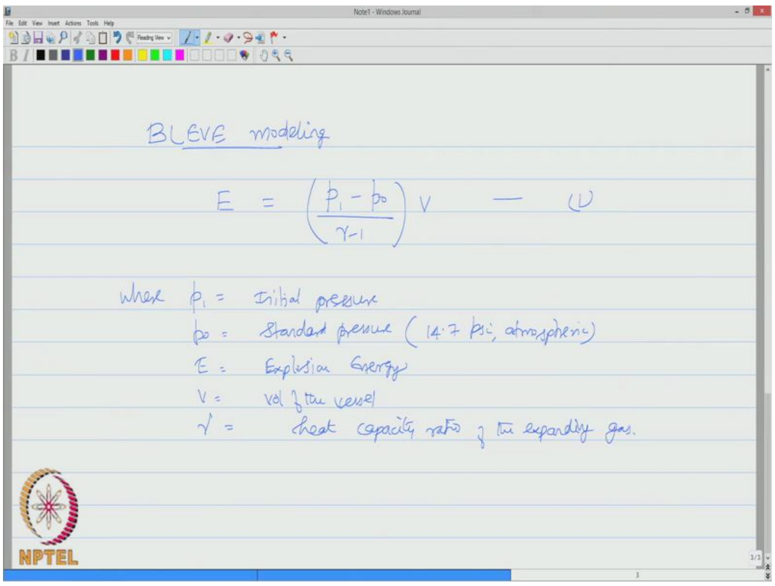

Let us look at BLEVE modelling E is given by p 1 minus p 0 by nu minus 1 the whole multiplied by v. Where, p 1 is the initial pressure, p 0 is the standard pressure usually it is 14.7 psi atmospheric, E is the explosion energy, v is the volume of the vessel and nu is actually heat capacity ratio of the expanding gas.

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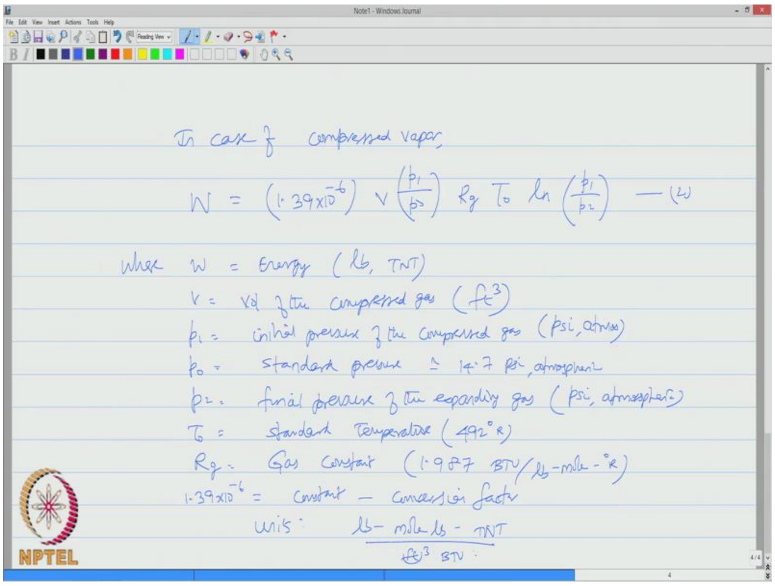

In case of a compressed vapour it is given by the following equation which is an empirical equation, where w is the energy in lb in terms of TNT equivalence. V is the volume of the compressed gas in cubic feet, p 1 as we said is initial pressure of the compressed gas which is in psi atmospheric, p o is the standard pressure which is actually approximate the equal to 14.7 psi atmospheric, p 2 is a final pressure of the expanding gas is again measured psi atmospheric, T 0 is the standard temperature which is 492 degrees R; where Rg is the gas constant which is 1.987 BTV units for lb more degree R.

This1.39 10 power minus 6 is actually a constant which takes care of the units to get w in energy terms which is actually a conversion factor. The unit of this conversion factor is in lb mole pounds TNT divided by feet cube BTV.

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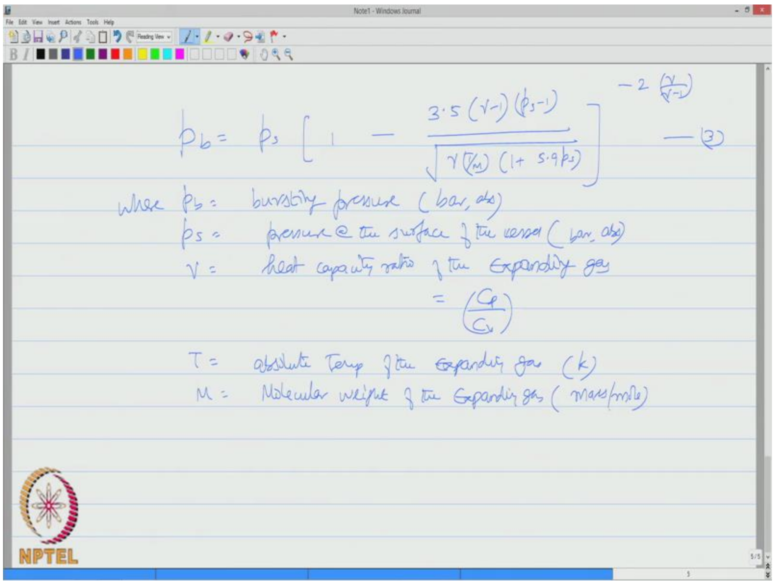

Further, p b is given by p s 1 minus 3.5 v minus 1 p s minus 1 by route of gamma T by m 1 plus 5.9 p s rise to the power minus 2 nu by nu minus 1. Where, p b is called the bursting pressure which can be in bar absolute, p s is called the pressure at the surface of the vessel is again in bar absolute, nu is heat capacity ratio of the expanding gas is actually equal to C p by C v, and T is absolute temperature of the expanding gas in Kelvin, and m is the molecular weight of the expanding gas in mass per mole.

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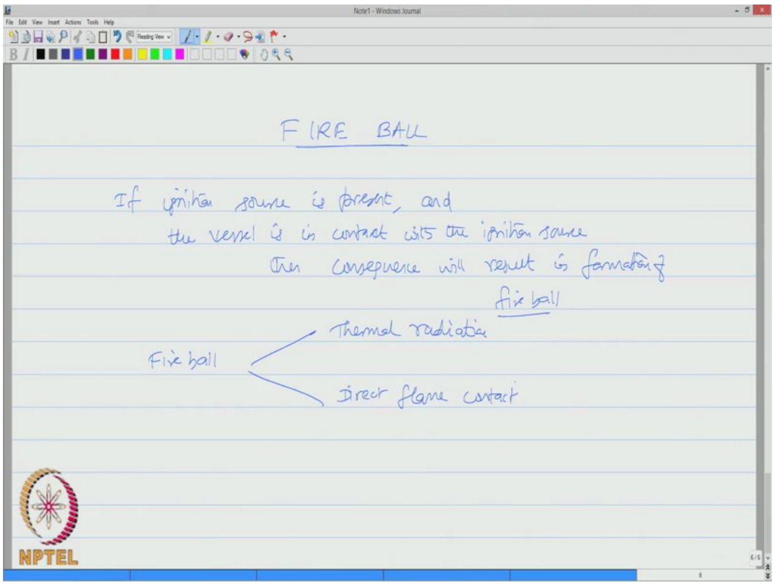

The next consequence of fire in oil and gas industry could be fire ball. Friends, if ignition source is present which is very much true in an oiling gas production platforms and the vessel is in contact with the ignition source then the consequences more catastrophic, it will result in formation of fire ball. Fire ball can result in two outcomes: one, it can cause thermal radiation, two it can also result in direct flame contact.

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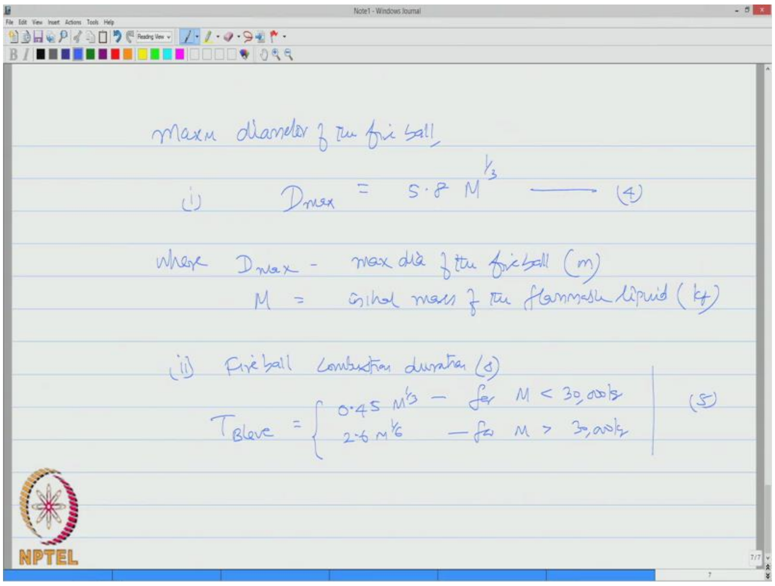

Maximum diameter of the fire ball is given by Dmax which is equal to 5.81 by 3. Where D is the maximum diameter of the fire ball in meters and m is the initial mass of the flammable liquid in kg. So, that is the first parameter we are interested in.

The second parameter about fire ball is that the fire ball combustion duration T Bleve will be 0.45 m one third can also be equal to 2.6 m one sixth for m less than 30000 kg for m greater than 30000 kg; call equation number 5.

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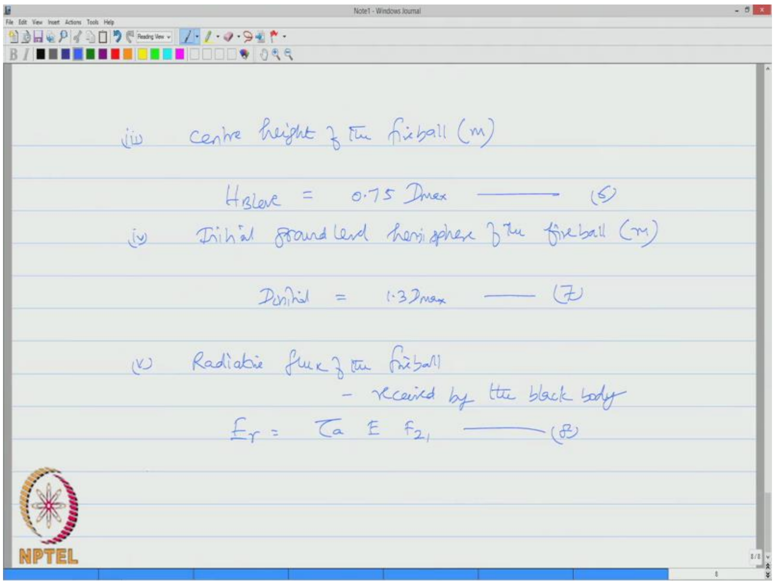

The next parameter could be centre height of the fire ball, again in meters. Height of the fire ball is given by 0.75 of the maximum diameter of the fire ball. The fourth parameter could be initial ground level hemisphere of the fire ball, because fire ball will form the hemispherical manner so that initial diameter is given by 1.3 times of Dmax.

Radiative flux of the fire ball this is another important issue to estimate risk assessment arise from fire balls. This is the one which is received by the black body. So, that is given by Er is where E F 21.

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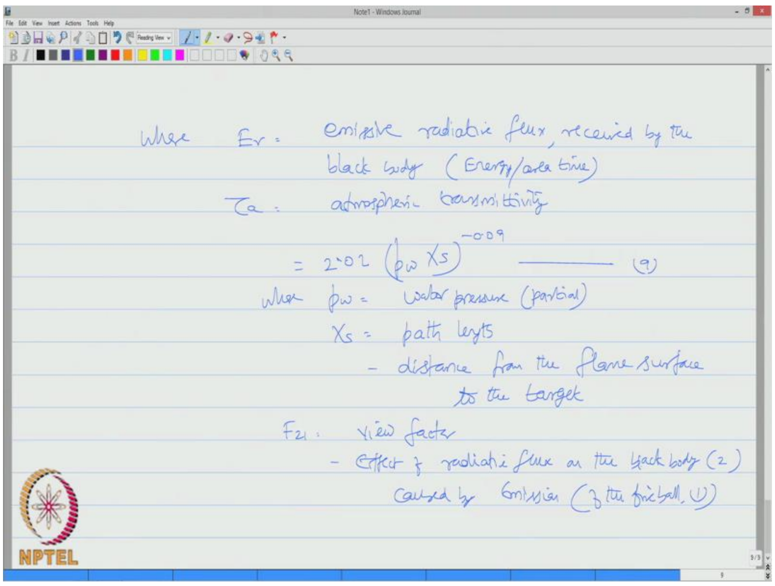

Where Er is emissive radiative flux received by the black body which could be the units of energy per area time, tau a is atmospheric transmitivity which is given by 2.02 p w into s rise to the power minus 0.09; where p w is the partial water pressure, x s is the path length which essentially the distance from the flame surface to the target, F 21 is called the view factor that is effect of radiative flux on the black body let us say that is 2 caused by emission of the fire ball which is 1; so that is F 21.

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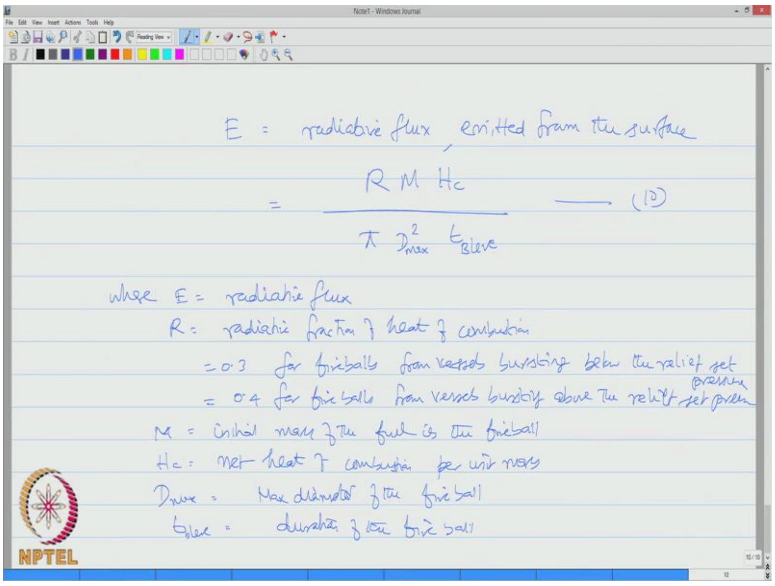

E is radiative flux emitted from the surface which is given by R m by pi Dmax square T Bleve. Where E is radiative flux, R is radiative fraction of heat of combustion usually taken as 0.3 for fire balls from vessels bursting below the relief set pressure, it is taken as 0.4 for fire balls from vessels bursting above the relief set pressure; m is the initial mass of the fuel in the fire ball, Hc is the net heat of combustion per unit mass, Dmax is the maximum diameter of the fire ball which we already gave the expression, and T Bleve is duration of the fire ball for which also be have the expression.

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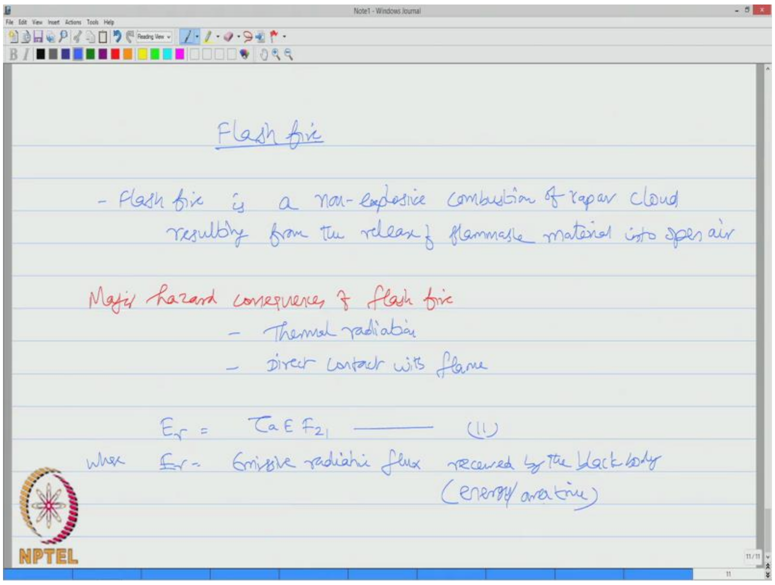

The next consequence which is interesting is flash fire. Flash fire is non explosive combustion of vapour cloud resulting from the release of flammable material in open air. Let us ask a question: what are the major hazard consequences of flash fire. The major hazard consequences are: one thermal radiation, two direct contact with flame. The energy release is given by this equation Er which is tau a E F 21 similar to that of the earlier module where, Er is emissive radiative flux received by the black body measured in terms of energy per area time.

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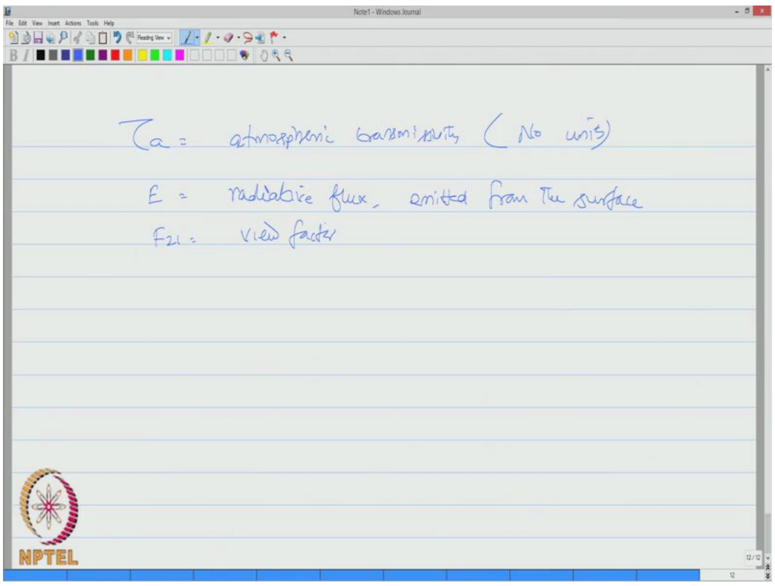

Tau a is atmospheric transmissivity either is no units E is the radiative flux emitted from the surface, F 21 as explained earlier is called view factor.

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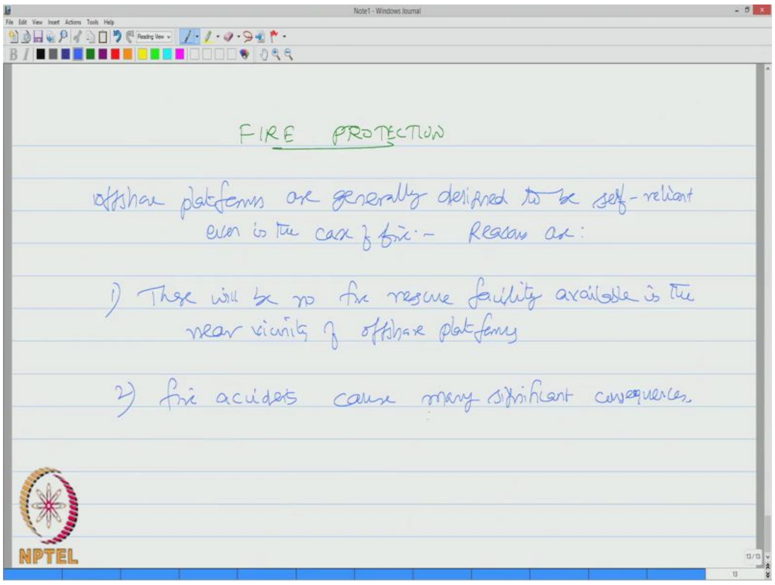

Friends having said this let us talk about different methods of fire protection. There are different methods by which fire protection can be ensured. Offshore platforms are generally designed to be self reliant even in the case of fire. There are reasons for this, the reasons are: there will be no fire resistive facility available in the near vicinity area of offshore platforms, the second good reason could be fire accidents cause many significant consequences. So, we need to avoid them completely.

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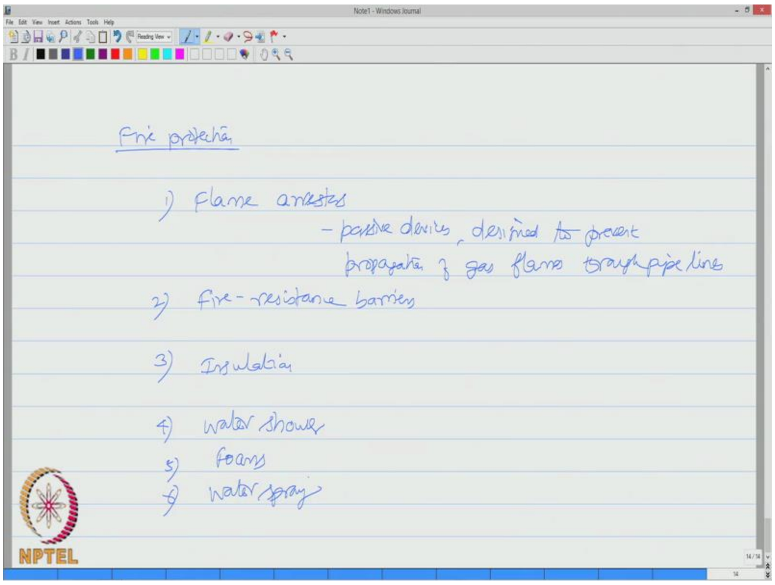

Fire protection can be achieved by using flame arrestors. These are actually passive devices that are designed to prevent propagation of gas flames through pipe lines. The second method what people generally follow is construction of fire resistance barriers. Third could be fire insulation. Fourth method could be by designing a proper water shower. Fifth could be by controlling fire using foams. And next could be by controlling fire with water spray.

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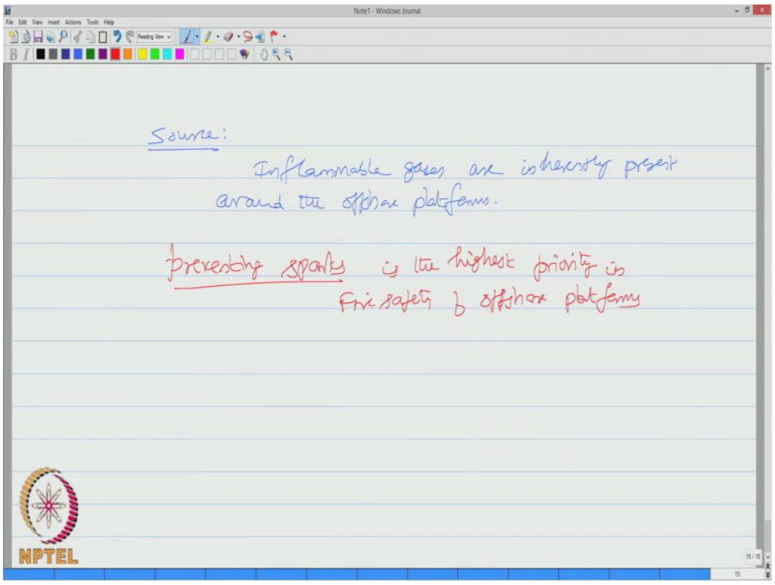

To understand fire protection let us try to understand what are the source from which the fire can be originated. You know inflammable gases are inherently present in offshore platforms; therefore preventing sparks is the highest priority in fire safety of offshore platforms.

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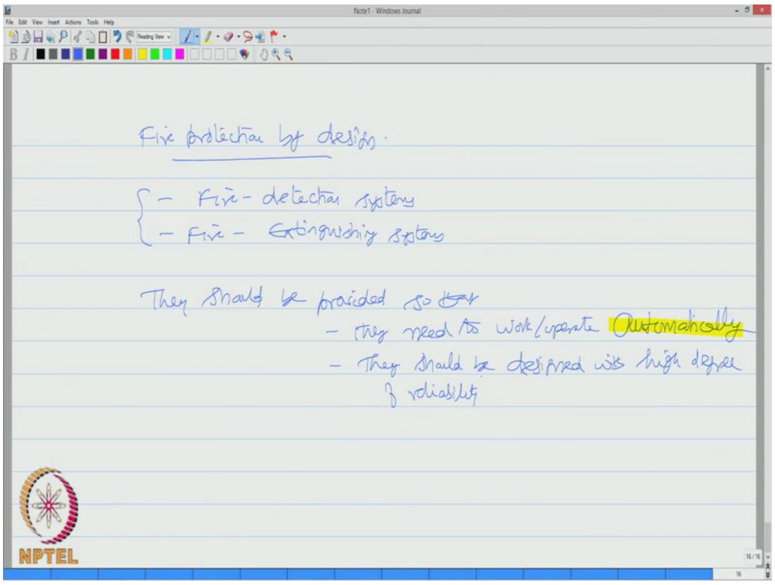

One can also do fire protection by design. You can have fire detection systems and also have fire extinguishing systems both of them should be provided so that they need to work or operate automatically. They should have or they should be designed with high degree of reliability.

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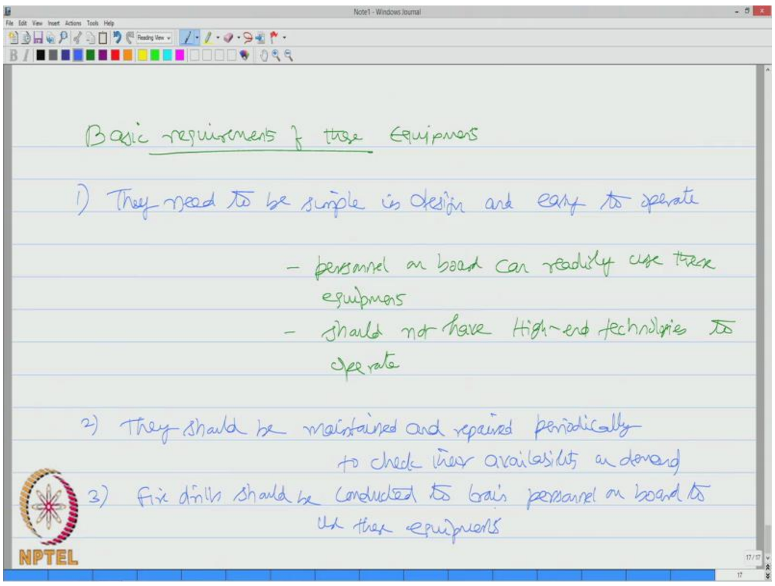

Let us ask a question what are the basic requirements of these equipments. One, they need to be simple in design and easy to operate. Why because, personnel on board can readily use this equipments. This equipment should have or let us say should not have high end technologies to operate. Second they should be maintained and repaired periodically to check their availability on demand. Thirdly fire drills should be conducted to train personnel on board to use these equipments.

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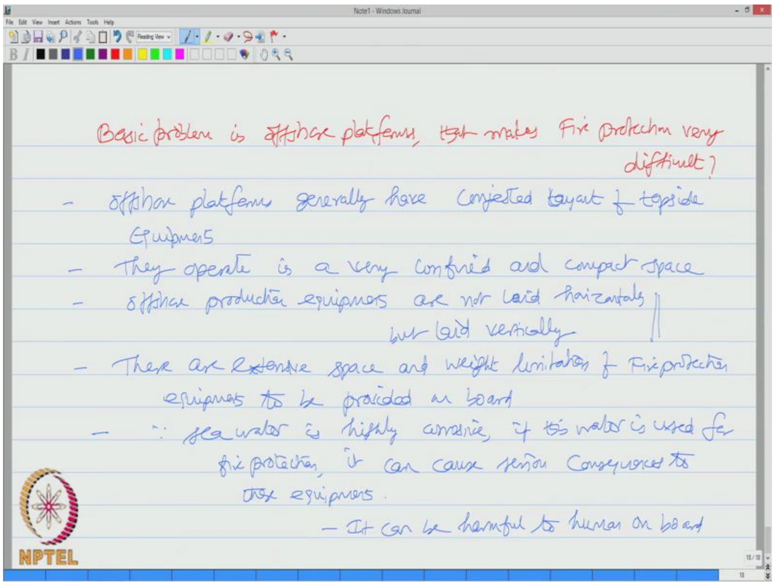

There is a very interesting question asked; what is the basic problem in offshore platforms that makes fire protection very difficult? Offshore platforms generally have congested layout of top side equipments. They operate in a very confined and compact space. Offshore production equipments are not generally laid horizontal, but laid vertically. So, we need to have fire protection along the height or depth but not along the lay out.

There are extensive space and weight limitations of fire protection equipments to be provided on board. Since, sea water is very corrosive if this water is used for fire protection it can cause very serious consequences to these equipments. Further, it is also harmful to human on board. Therefore, there is a high demand of pure water to be used for fire protection systems in offshore platforms.

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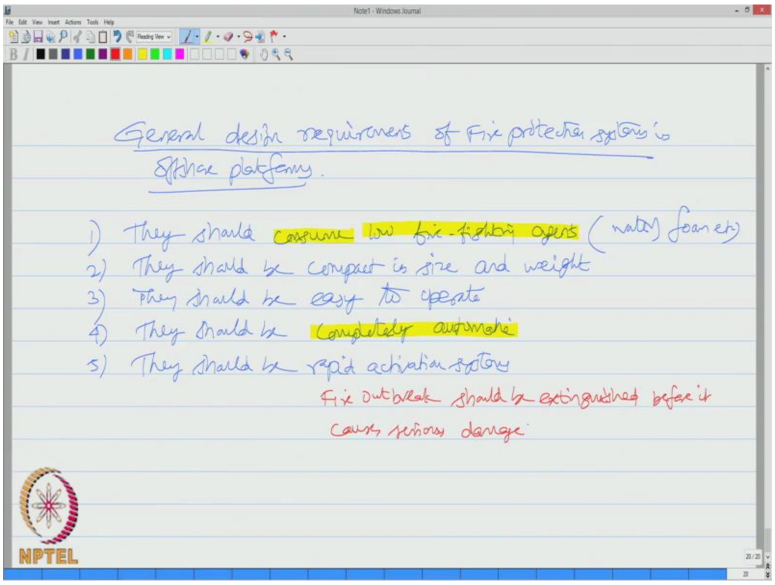

Let us ask a question what are the fundamental or this say general design requirements of fire protection systems in offshore platforms. One, they should be or they should consume low fire fighting agents, like water, foam, etcetera; they should have low fire fighting agents consumption. Secondly, they should be compact in size and weight. They should be easy to operate. They should be completely automatic; that is a very important issue. They should be rapid activation systems, because fire out break should be extinguished before it causes serious damage.

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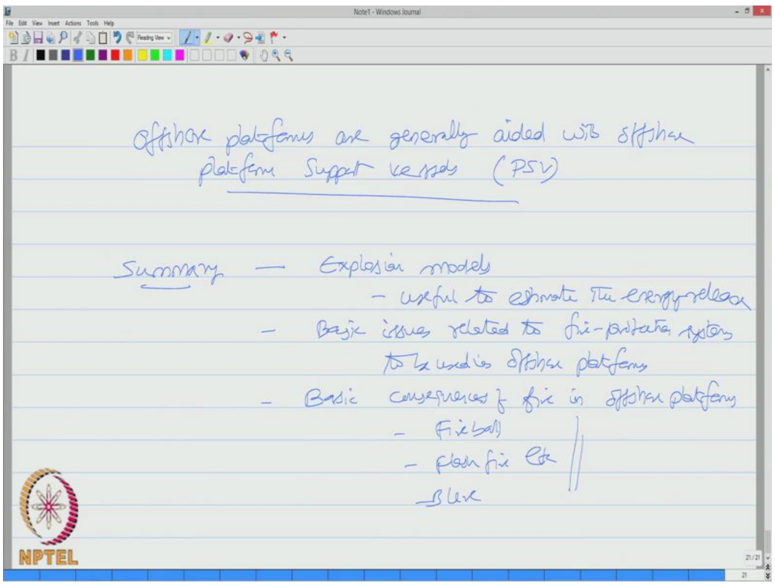

Offshore platforms are generally aided with offshore platform support vessels, what we call PSV is.

So friends, what would be the general fire protection requirements of such support vessels? We will discuss them in detail in the next lecture. In this lecture we understood explosion models which are useful to estimate the energy release. We understood some basic issues related to fire protection systems to be used in offshore platforms. Here what is understood, what are the basic consequences of fire in offshore platforms: like fire ball, flash fire, BLEVE, etcetera. In detail we will discuss about the fire protection systems on PSVs in the next lecture.

Thank you very much.