Design of Offshore Structures
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Module - 06
Lecture - 02
Design againts Accidental Loads 2

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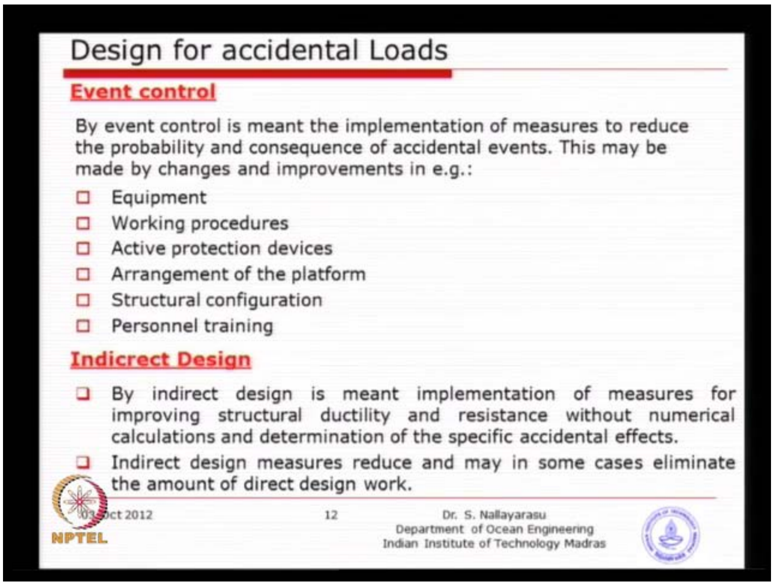

So, today we will continue with the even control, I think yesterday we were looking at. So, the indirect design means by provision of additional system implementation. Basically like, for example, typically ductile of the material to make the structure fail by ductile instead of brittle failure. So, that is idea behind, though it is not the direct design, you have not actually provided additional strength or additional messes, but by selecting suitable material, we have made the structure to the failing by ductile nature. The other method is providing redundancy for example, you take a photo frame and if one of the column fails, the system fails.

So, instead if you provide a ((Refer time: 1:01)) with the photo frame, probably you have a additional braising, which make even if one of the braise fails, the other braise will take over and provide stability for certain amount of loading. So, that is exactly, the indirect design means provision of system where, those facilities will cause the structure to fail, either slightly later that means additional load can be taken or fail by ductile nature, that means immediately it will not collapse. That is the idea behind the indirect design, these are some of the provisions actually if you read many of the codes, whether its highest score for a concrete designs, steel designs or other codes. You have several provisions by means of this kind of ideas, making the structure to have ductile behavior, during taking the load as well as to the ultimate capacity.

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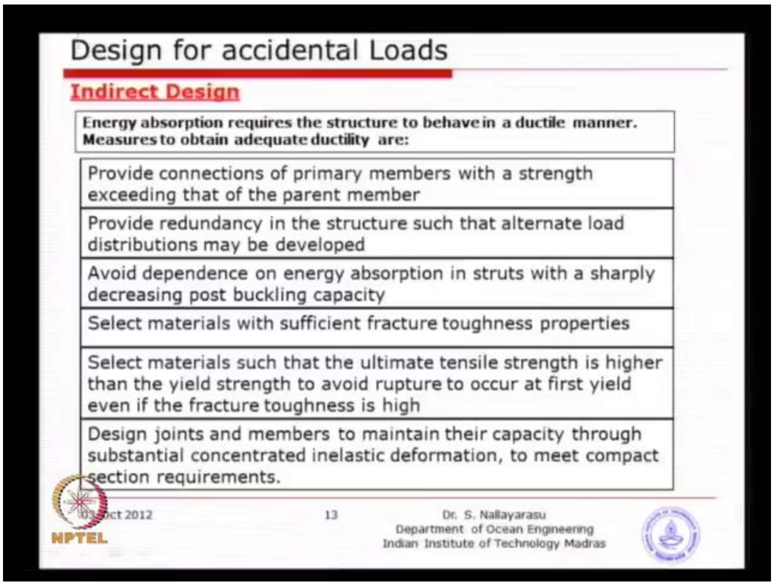

Provide connections of primary members, which I think I emphasis to do during our design of tubular connections always have the crust, the joint design having extra strength or extra margin compared to members. You can have one member fail, the system does not collapse, but if one joint fails, you look at the joint that we have had look at for jacket structures, one joint carries 7, 8 member, if one of the joint goes almost the system becomes unstable. So, that is why provide connection of primary members with a strength exceeding that of the parent member, wherever the members are. Provide redundancy in the structure, which typical example will be over x braise, two legs with an x braise of this kind, if one of the braise fails, the other braise will take the load by redistribution.

So, that is exactly the idea that though it is not a direct design method, but these are some of the recommendations, you will read actually if you go through API, these are the recommendations given in there indirectly. So, when you satisfy this automatically the structure has the sufficient strength for ductile nature of failure, avoid dependence on energy absorption in struts with a sharply decreasing post buckling capacity. In a basically for example, you have one member which later on we will design it, which is going to be designed for a energy absorbent for I say ship impact. But the support members are so small, if one of that member fails for example, the hole system fails. So, do not depend on such kind of design, what you need to have is additional members to support that same energy absorption capacity.

Select material with sufficient fracture toughness, this is what we were looking at in fact during our phatic design, phatic is directly proportional to the toughness of the material or the characteristics of material against fracture, which use your idea that there is no direct relations to strength. So, toughness makes so much importance because initiation of crack depends on the material, the crystal structure to open and propagate. So, basically that you normally selects sufficient toughness, especially for a materials serving, low temperature service. For example, in substructures, always going to be temperature less than 20 degrees, some areas can be less than 0 degrees, like if you go to North Sea.

Select materials such that the ultimate tensile strength is higher than the yield strength, for sure you might have learn your, you know the tensile test always you will be strength and then you have the ultimate tensile strength. Now, if you see the difference between the yield strength and the tensile strength larger is a good material, isn't it? Because, even after yielding you have larger redistribution to happen or else, if you have yield strength and just a horizontal curve.

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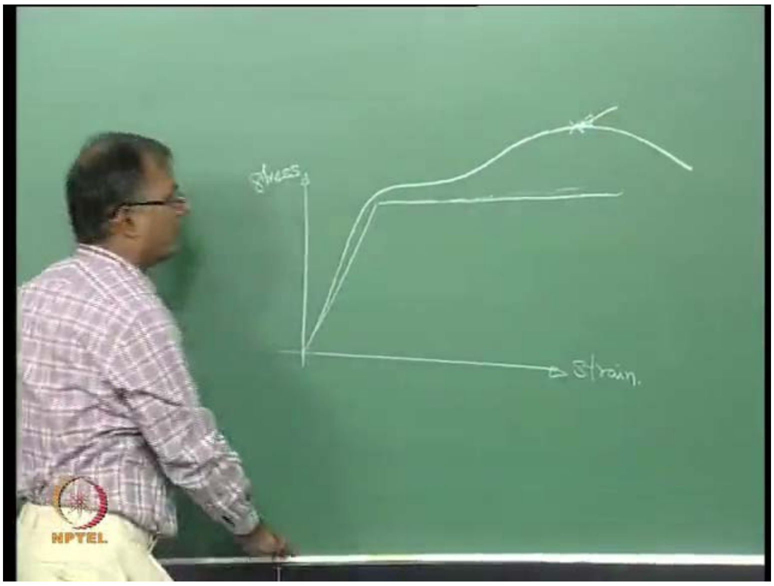

For example, a typical elastic perfectly plastic material. So, this is your strain, this, your stress you might have seen this stress strain curve for typical steel material, if you have something like this, elastic but perfectly plastic not very good. You have something, you will see most of the steel that is your ultimate failure point isn't it? If you see something like this, the larger the different between the ultimate point are the so called the tensile strength, breaking load strength to a yield strength. That means even after yielding, you see particular location in the connection or in the member yielding starts, but still does not fail because, you still have the sufficient strength before it breaks away and that is where.

So, you need see that ultimate strength is larger value, design of joints in members through inelastic deformation to meet the compact ((Refer time: 5:53)) that means, it should fail by you know basically yielding, rather than buckling. So, indirect design means you have provisions in the design procedure, which automatically satisfy most of them are actually if you read the codes. You really do not have to make any effort in designing, these are the guide lines you must follow, most of the boats are mandatory.

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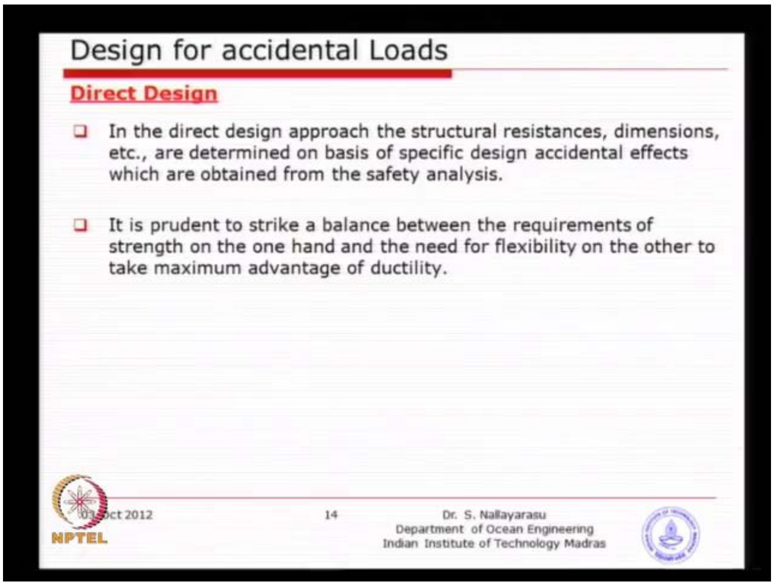

Direct design is very simple, this where we were we were going to spend some time. Basically, look at the fire as a design load or a scenario that creates additional load to the structure and then evaluate the strength, go back to the original design principal of design versus capacity. In this particular case what is going to happen is, when the fire occurs in the particular location in a structure, the structure gets heated up and the structure is part of a bigger frame, where it is trying to expand. Because, you know very well the steel thermal expansion co efficient so, it is going to expand, as long as long as you allow the expansive into happen, there may not be much problem actually. But the main issue here is, it is connected to another part of the structure, you may not actually permit expansion, when the expansion is restricted what will happen?

The induced stresses and forces will be so enormous that, the supporter members will fail, that is the idea behind, it is just trying to expand and the supported members will deform excessively, either by bending or by shear or whichever the weakest means. So, that is way this direct design approach is to evaluate the resistance of the members, against the thermal induced process and that means we need to find out what is the temperature and what is the duration. Because, steel is not going to just one minute you have a 1000 degrees and then just come to 0, it is not going to expand so fast. So, basically we need to see how long the persistence of the fire is happening.

So, this characteristics of the fire is as important as the characteristic of material so that, you can actually superimpose both of them and find out how the behavior, we are going to see that. Of course, absolute means of direct design is also not so good because, you may actually spend a lot of money on that. So, we need to find out how much direct design you would like to make and how much indirect means of enhancing the structural capability against fire, then you just provide.

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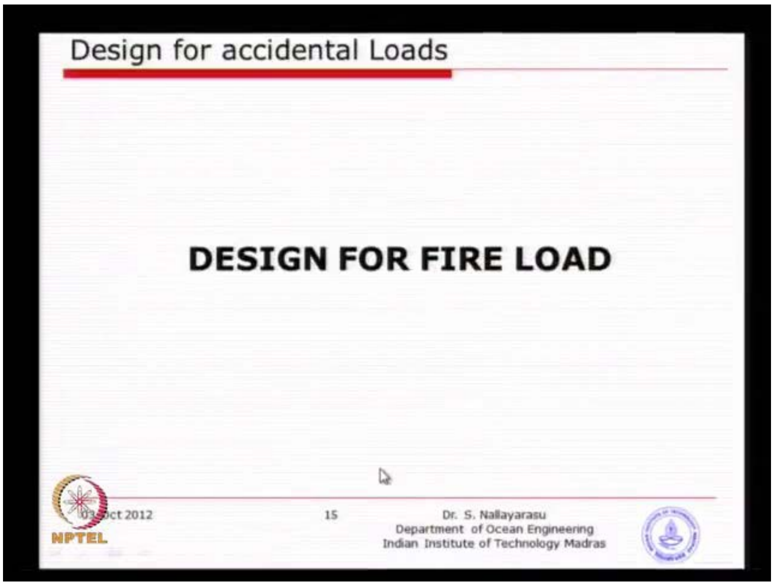

So, design for fire as a loading condition is to be evaluated quickly.

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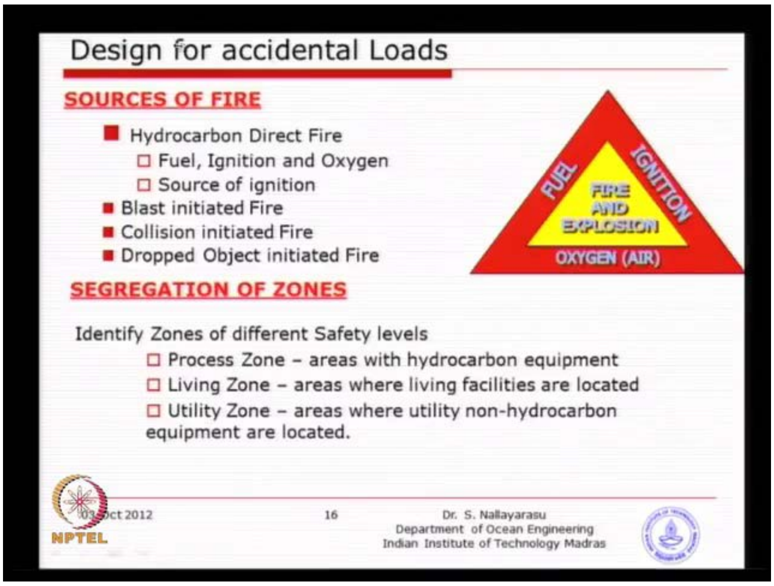

So, just look at the sources of fire, hydro carbon direct fire which is basically ignition by means of direct on to the hydro carbon or you could have blast initiated, collision initiated or drop object initiated, all are them are making spark and you have the fuel to burn. So, main idea is the fire to continue and to persist for a longer duration of time, you need supply of fuel for sure without which you will be, the temperature will come down and also the supply of oxygen, very important otherwise, you will not able to be burn any fuel. So, basically fuel and oxygen is very essential requirements for a fire to persist for a longer duration and of course, sources of ignition you could have purpose full ignition, which is normally not there in the such kind of facilities ((Refer time: 9:27)).

Whereas, you have indirect means of ignition like blast or kind of a collision or electrical faults can cause, you know basically ignition there. Dropped object, most of these three things are actually just a rubbing surfaces, in fact if you look at one of the fire happened in 2005. I did not know, I do not whether I have mention to you earlier, this fire caused by a simple boat, you know collision with the structure, which cause the rubbing surface and that surface is created spark and that spark together with the damage on a raiser land is the gas, got into fire and blast. So, basically you can see there is no ignition by somebody, there is no machine which is actually having fire just a cold gas, but which is the rubbing surfaces impact has come out and that spark created the fire and then explosion.

So, you could see that the ignition is not a very difficult thing to happen, as long has you have huge amount of fuel and the oxygen presence, fire is imminent, as long as any of such things like these three things happen, you will be having fire. So, that means the facilities having large inventory of hydro carbon fuel is potentially, high probability of fire occurrence, unless all the safety precautions are strictly followed. Now, you could see that is why we need to see the platform should be divided into, segregated into zones of different safety. It is not that basically unsafe or safe zone, notation basis we can call it all are safe zones, you know only thing is in terms of presence of higher, you know the hydro carbon because, the potential fire is more.

So, we should not actually call it safe zone or unsafe zone basically, process zone, living zone and utility zone basically, different amounts of safety levels. Of course, during the normal working condition all areas are safe, only thing is the practice will be different, when you, when you reach a process zone you need to have sufficient safety equipments. Whereas in the living zone for example, you live in inside a living facility you do not need any of the safety kits with you. For example, if you go into a process area some of the platforms handle sulphur, you know when you enter into that area you need a mask, otherwise a colorless gas can kill you instantaneously.

So, basically you need go there, you need have your safety kits, if you go into open area you need a helmet. So, the idea is to identify these zones to make sure that whenever you go there, you need to have such equipments with you. Living zone always will be very, made very safe because, you are going to live there, you cannot live with all, all the time the safety equipments, which is why you make the barrier so safe that, you if you are inside you do not need to have much worry. Of course, you still need to follow certain you know the principles, when you are in off shore.

Utility zone is basically have equipments very similar to answer facilities, you may have a power plan, you may have water treatment plan, all of them are safe zones. Only thing is, still you have potential of propagation of fire from process zone to utility zone because, you still have fuel for these machines. For example, if you have a power generator, power cannot be generated to that of fuel. So, you have limited amount of hydro carbon and which can also cause potential fire.

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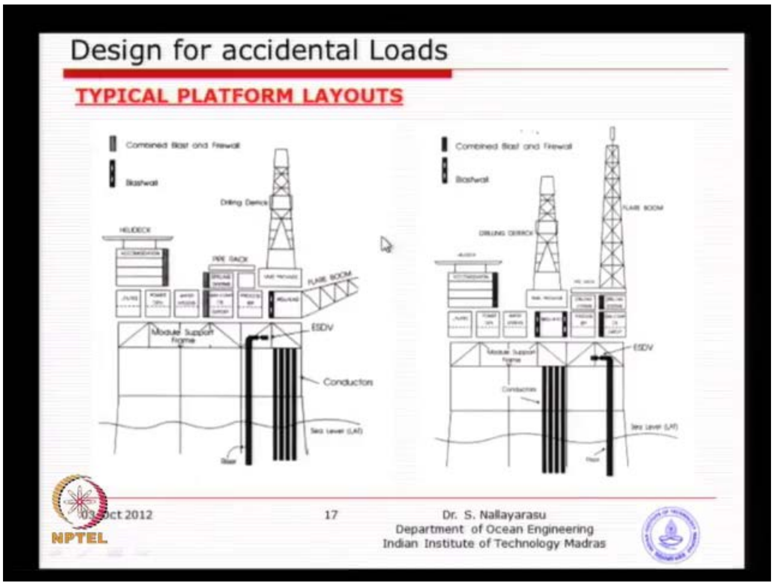

So, you look at these two typical platforms, basically just give your idea that there is no absolute term called the right or the wrong layouts. I think this goes to not only to off shore platform, for any facility there will always be multiple arrangements, which could be a either called safe or unsafe. Now if you look at this left side one, you can see here on the left most side you have the living facility, which is basically somewhere here accommodations facility. And then, followed by several equipments and facilities for protection, utilities whatever we see there. On the right hand side you see a drilling rig, something like this drilling mask and below which you see the, I think most of you are able to understand what is this conductors, basically is the drill casing.

So, you see here on the right side, you have the drill facility associated well platform connected to production cum living facility, all of them are together, but one thing what they have done, they have segregated in a nicer manner. The extreme right side you have the well facility, extreme left side you the living facility. So, they are kept apart so that, in case of an accident or in case of a fire, the drilling or the well facility will not cause much problem to the living facility.

So, the idea little bit of thinking has been done instead of putting a living facility at the middle, which will be very safe because, at the center column. But in terms of safely levels of fire and safety it is not very good because, is too close to the well facility or else if you come to the next option, you see here the well facility is at the middle and there are some other facility like ((Refer time: 15:20)) on the right side and living facility and the left side.

Together at the bottom, you have several production facility. You can see here sometimes people have done left side or the, the, the option 1, say let us call it, these option two. So, you do not see here some logic is missing, why? The well has been placed at the center, why the well has been placed at the right? All depends on the configuration of the sub structure and the arrangement, but both of them can be made safe, you cannot call them one of them is safe, one of them is unsafe. In this particular one what you see here, the black color or the barriers are kept in place in such a way that propagation.

So, the inherent safety is not achieved, but the safety is achieved by means of additional safety features you incorporate in the system layout so, that is the idea behind. So, basically the best way of dealing with this kind of things. For example, if I want to have this well separately, instead of having in the same platform, I have well platform separately, I have a living platform separately kept up apart say few 100 meters, that is the best design, isn't it? And keep the central processing platform separately. So, three jackets, three top sides which you will be the good design, but you will be spending three times your, your requirement for design and analysis, three times.

So, you can see here the cause of the facility goes as biggest two and a half to three times. So, that is why you try to combine, at same time you to provide safety which is built in the system that, in case of a fire either in this well platform area or process area does not affect are to minimize the risk, isn't it? Even if you go for three well platform, three platform with one living one process one well, you would not be able to conclude that there is zero risk, you still will have a risk of some other means of fire.

So, basically that is where kept minimizing the risk, at same time looking at the overall implementation cost. So, in here also we will see that, the reason why they have kept the well at the middle is just for convenience, you know if you have the well at the center, you know the drilling becomes easier. Whereas the, keeping the well on the right side you will see that there is potential problem of designing the jacket because the well, the drilling rig is quite heavy.

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You see here this particular project where, the well plat form is on the right side kept separately because, this is a gas field and the potentially most of the time or 99 percent of the time, gas well platform will not be combined with the process plat form. If it is the oil platform, there may be potential chances of combining this with this, but never if it is a gas plat form, because of high potential of fire.

So, you see here in this particular case well is separated process utility and then the living, logically organized so that, you have the least hydro carbon coming on to the living facility area. So, you could see that this is one of the design, but if it is just not gas, if it is an oil platform you will see that they are combined together, all of them everyone of them, all these four.

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So, you will see the next facility is something similar, is actually a oil platform and you see everything is scattered together in a bigger space and basically, have saved one jacket. That means cost economical, but you could, you could not do this because here it is a gas type of oil, you know plat form. So, basically we have no choice.

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You can also see in this particular case FPSO well and process together, but well is kept exactly at the middle. You can see here the reason why we cannot do this drilling at the either on the stern side or both side of the ship is very difficult, the stability becomes by troublesome, in fact the motion becomes very large. So, if you keep at the center motions are very minimum. So, that is why we keep at the center and you have probably utilities on one side and a kind of living and then, the remaining of the process facility on the other side just a arrangement there.

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Semis up, you can see the drilling is exactly at the center, but surrounded by all the facilities. Because, that is what is possible by this type of floating structures, you would not be able to keep the drilling mast on one side and can have a very serious stability problem. So, you could see that idea what you want to learn from this few pictures, there is no fixed rule, you can make your own arrangements as long as you follow and evaluate and minimize the risk of fire safety to the human. So, that is the idea that we need to work out.

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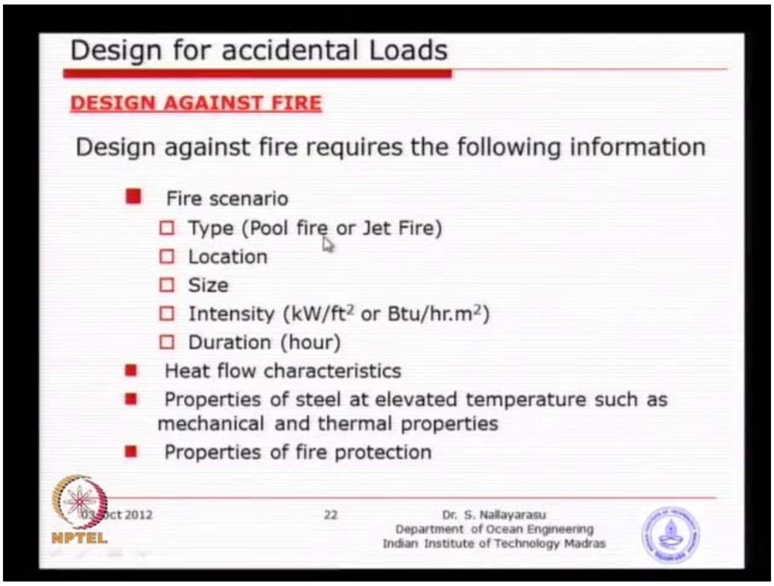

So, what we need to look at you know basically, designed against fire basically, you need to find out whether what type of fire? Whether it is a pool fire or a jet fire? That I think we will just quickly look at, pool fire basically after the fire if there is a spillage on the floor of a particular location large amount of fuel then, the fire will be almost like a spread fire, you know just over a larger area. So, you have the fuel spillage on the ground or on the floor somewhere. Whereas the jet fire, fire is occurring, but then there is a high pressure fluid, hydro carbon oozing out of a pipe, oozing out of a bigger tank or a, or a process equipment.

So, basically it will come like a high speed jet and which can go for a longer distance number one and destroy several things which are, you know secondary in nature. For example, cables and facilities of course, may not be able to destroy structures unless the structure is so weak, but combined with this speed and the fire effect can even destroy smaller structures. So, that is the potential of the jet fire and the pool fire, pool fire is just the flame formation for the larger area on the ground or on the floor. So, we need to see what type of fire occurs because, the effect is going to be slightly different. Location for sure we need to know, size basically the extent and the intensity, basically the time duration.

So, these are the effects which we will put on to steel structure and see what exactly is going to happen. Heat flow characteristics basically the type of flame, properties of skill are elevated temperature because, using this information you can simply go and look at the steel, when you heat the steel how restriction characteristics. Basically, that is what we are interested as a designer, you want to find out how the designed steam curve changes, whether it goes higher or lower, whether the slope changes downwards or upwards, which is a very much important for us. And which can be definitely simulated or you can do a testing, heat the steel and then go on to a tensile testing and then, we will also look at alternate means of protecting the steel from obtaining this temperature.

For example, there is a fire as long as you can provide a barrier between the fire and the steel, then you can actually make the steel to feel only a particular temperature, this temperature outside can be 900, 1000 degrees. But if you have a barrier, which can only conduct 400 degrees, not more than that, then it is, you only need to design the steel for 400, though the outside temperature is 1000 or 1200. So, basically this fire protection several means that is why you see, now a days many of the buildings are built, you know basically steel because, steel we can make the construction faster, but not very good in fire safety reasons.

So, what normally these done now, you have the steel structure, but completely protected by concreter surfaces. So, in case these steel structures you will see many places like conventionally we go for which takes longer time for construction, you know you have to go sequence. Whereas, if we make the steel building and just cladding with the concrete or grouting, which is very fast compare to. So, this far protection you should get to out to your mind, concrete is very good against for surely fire protection mechanism.

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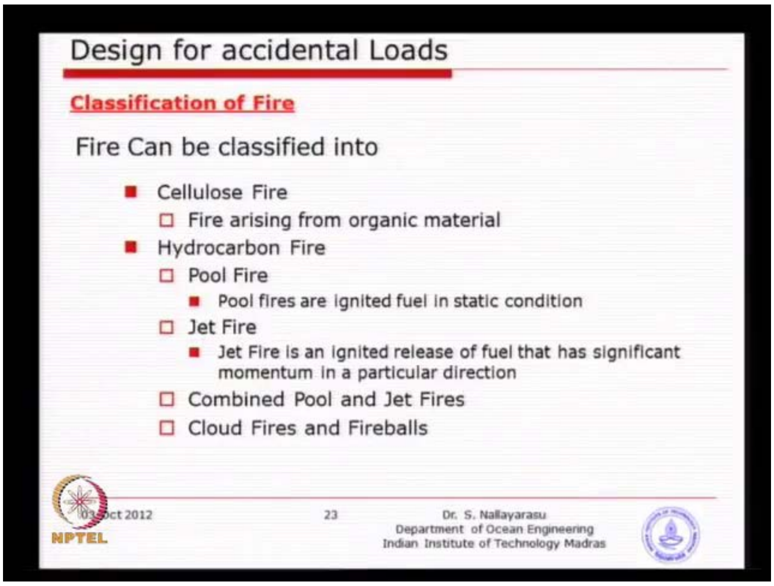

Fire can be classified into cellulose fire and hydrocarbon fire, basically I think cellulose is an organic material and that happens like fire in the forest, fire at your home. So, cellulose fire is not directly related to any of the hydrocarbon material, which has got certain characteristics. We can compare how it temperature raise and what kind of temperature raise it happens, which is, what is our importance.

How fast the temperature can reach say 900 degrees, you can compare a conventional stove with the gas stove, you know you can see the time taken to raise the temperature to 900 degrees. You could easily find, it will take a longer time when we use the fire wood, when we use the gas you will able to reach in few minutes. So, that makes the different. So, the organic material the fire rating is very very low and what we are interested is, because we definitely do not have this problem in the after platform at least because, we do not have any organic material in construction.

Whereas, if you have houses or other facilities you may have such type of fire. In any case it is not a big bothering because, the temperature, the raise, the rate and the duration will be quite small. Hydro carbon fire, as I mentioned earlier on pool fire, jet fire is the typical classification depending on where the fire occurs and the amount of fuel coming out basically is important.

Combined pool and jet effect also can happen in cases where, actually you have a eruption in a vessel, which keeps on pumping out the oil and you form a pool. And that continues supply from that particular equipment, keeps burning your, you know the, the structure. So, many times you will have the pool fire combined with jet fire because, in the vicinity if you have a equipment, it will just erupt. Cloud fire and fire ball, I will show you some of the photographs, probably I might have a video, you could see that especially gas type of platform, you know the fire balls comes out would be potentially so large, bigger than the platform size, you know such eruption comes out. It is like a huge cloud and full of fire.

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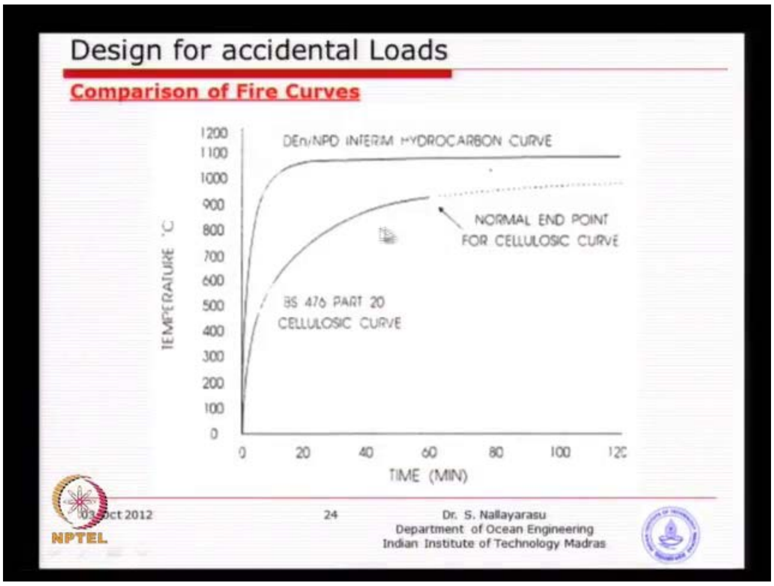

Typical the temperature rise versus the time, you can see this graph. The bottom one is basically a cellular fire is the, is the temperature reaches around 900 degrees at the time duration of an hour, you can see here, if you just go around here almost about an hour to reach a temperature of 900 degrees. Whereas, if you look at the hydrocarbon fluid or the gas type of material probably I think I can conclude the same 900 degrees can be reached in 7 minutes or 8 minutes. So, that is the type of, type of different we are talking about is one-fifth, one-sixth quicker it reaches 900 degrees. Because, at 900 degrees no steel can withstand its integrals strength, it will just fail by melting, you know.

So, basically that is the idea that if you look at 600, 700, 800 degrees, steel cannot be stand, unless you have a protection around the surface. So, if you are able to, if you have a normal fire you do not really have to worry because, it takes almost 30, 40 minutes to reach such a state. So, that, by that time you can evacuate people and go away. Whereas, the hydrocarbon fire is so quick, with in 10 minutes if you are unable evacuate, your structure will become unstable. So, that means we need provide by means of making the structure to reach temperature within the limits of stability, that is what we are going to define, what temperature is that, whether its 200 degrees or 50 degrees.

We can define a temperature and make sure that we have the warier in place for all the structural components, that we can limit the temperature to same few 100 degrees so that, I will be able to safe human life. So, this graph is very important, but what we are going to have is only the, this graph based on actually it is coming from department of energy, they have done one joint industrial project, you see here DEN, department of energy UK, guidance notes. This curve is based on actually the field testing, they have made the few fire testing and also adopted by this, this curve is adopted by Norwegian petroleum directorate, you know basically it is clear guidance notes. Of course, this is coming from one of the ((Refer time: 29:40)) is design against the fire resistance structures.

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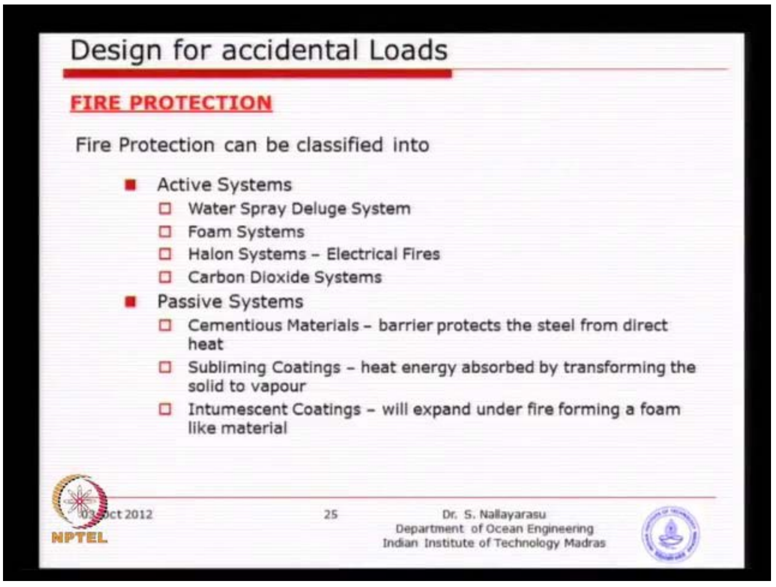

So, what are the fire protections basically we have are active, passive I think active, I mentioned about water spray deluge system. I think every building nowadays is mandatory to have especially, industrial buildings should be having fire deluge systems. So, you will see, you go, if have gone to some of the factories you will see fire deluge valves and spray nasals fitted on to the roof of the structure. So, in case of a fire you will have a fire and smoke deducting devices, you will see two of them in the roof, if you had fully looked at it. One of them is a deduction device, once fire or a smoke is deductive what will happen? First thing is the alarm will come and the alarm will trigger the motor system to start the pumping and open the valves.

So, automatically the water spray system will on. So, basically this water spray deluge is nothing but network of pipes connected to the facility to a fire hydrant where, continuous supply of water can be there. So, you need source of water and fully pressurized all time, which is the main important thing. You cannot start the pump start pressurizing at the time when the fire is occurring, there is no time. So, that means all the time the pressure should be maintain on the pipe, the pipe is fully enclosed with valves everywhere, but valves are closed and the pressure should be maintain means, whenever the pressure is down the pump needs to switch on automatically.

And whenever there is a fire, the spray nozzle should open with the necessity pressure to distribute the water to area designated. For example, if you have only one nozzle here, you need to have larger spray distance that means, more pressure is required. Basically, water deluge or water spray system is inherent for industrial structures and offshore structures are definitely yes. But for the residential buildings, it is not made mandatory so, what you may see actually will be a fire hydrant, but then the firefighting is done manually, you know fire fighters will come and connect the hydrant and spray water.

Foam system basically is, is definitely a requirement for oil and gas terminals especially, on land you will see a foam spray on top of the fire, which can put the fire very quickly. So, it is a Halon system just basically does not spray water, for sure you know very well electrical fires so, you will have a spray gas. So, Halon system will be there and then carbon di oxide you might see in many places in bubbly buildings, you have the carbon dioxide cylinders, small ones, handy. So, you know, you should know how to operate. So, all of them is basically an active system to put the fire down at the starting point itself.

So, you do not allow it to propagate, as long as this systems are automated you can actually prevent from propagation or even from going into a higher temperature. Only thing is automation becomes a difficult process, sometimes you do a manual, sometimes you do a automation system. But for offshore we use this, we use this and both of them are fully automated. So, there is no situation that somebody have to go on open a valve, somebody have to go on open a or switch on a pump, which will become potentially not good. So, everything is fully automated.

Passive systems basically to prevent so, though we cannot actually prevent the fire, fire is occurring and then, we need protect the structure with a particular type of material where in, it could observe the electrical energy and conduction is reduced. That means, you need to see material which is not conducting that fast and basically, the temperature on the steel surface is limited to a particular value. So, that is the barrier we are looking at, the simplest barrier is very easy to identify as a cementious material, concrete skirt. So, you have 100 mm of thick concrete on top of a steel surface, the concrete takes a larger effort or energy of the temperature prior to transmit the temperature to the steel surface. So, that is the exactly the idea.

So, cementious materials are very heavily used in on, on floor structures especially, if you go to industry, factory, refinery you will find every structure is protected with cementious coating. You know just 20 mm, 30 mm they will just have a coating on top, which no problem because on, on floor structures we are not worried about weight, we can keep on building whatever you want, isn't it? You just because, cementious materials are very cheap, it is not very expensive of course, comparatively not. So, basically barriers for steel structures the simplest means is encasement with concrete, which I think very heavily practiced.

But for unfortunately for office structures, we cannot keep on increasing the weight because, either it is a floating structure or the picture structure we have a problem in our hand. If it is a picture structure design becomes too heavy transportation, insulation becomes too difficult. If it is a floating structure payload increases then, it becomes a serious problem of the design because, you need to make the floating system bigger and bigger. So, that is why we need to find the alternate dissolutions where in, we can have a similar effect, but then lighter material or other forms of functions. For example, if you look at the subliming coatings, heat energy absorbed by transforming solid to vapor.

So, basically you have a very thin lay of this coating material when it is affected by temperature, it actually vaporize, the vapor is the barrier forming between the temperature or the fire to the steel. So, you have a cloud of this material but directly from solid to vapor. So, you will see a few a few 100 mm a layer, not permeating the flame to go through and go into the structural surface. So, that subliming coating is quite expensive, but the thickness of the coating may be 5 mm, but at the time of temperature increases, it actually vaporized and form a thick cloud which does not permit the direct contact of the fire with the steel. The intimation coating will expand under fire forming foam like material very similar, just like our foam.

So, basically it gives a semi solid protection basically between the fire and the steel, it will form a kind of thick material, but not so thick, it is just a foam type of material. So, both of them, the original thickness will be very, very, very small 5 to 10 mm maximum, density is low, lower than concrete. So, you have similar characteristic achieved by a smaller thickness less weight, but slightly increased cost. So, that is where we look at either we use subliming coatings, normally not used in main facilities, but this intimation coating is well preferred because, this has been in use for several decades. And basically, you go through net you will find so many vendors of different chemical composition, you can find.

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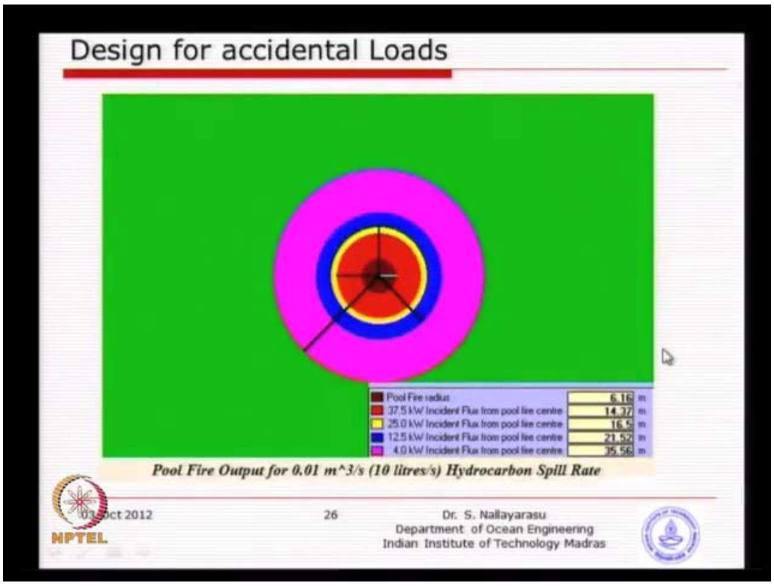

A typical fire, you can see here the longer the or the larger, the radius are distance away from the central, you will see that the, you know the heat energy will be reducing. That means, if try to go closer and closer you would not be able to survive. So, we need to locate the safe facilities when a fire occurs in a particular location, where you should have master switch in, in, in case if you have to have a change over from automatic control to. So, you need to locate them properly sometimes, we do a specialized study you know each fire location is assumed. So, you are find out which will be the best position for the controls valves to be located. You do not want the control valves to be located in the hydro carbon area, where the fire occurs the control valve also get damaged.

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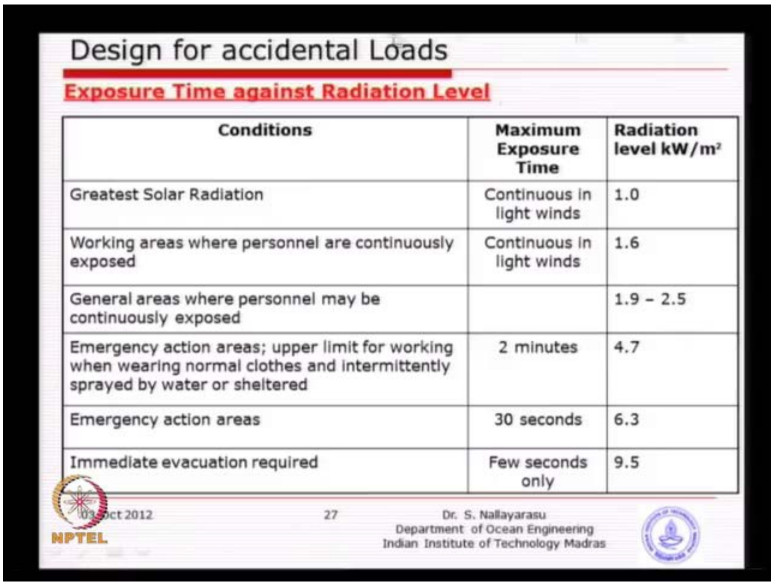

Conditions	Maximum Exposure Time	Radiation level kW/m²
Greatest Solar Radiation	Continuous in light winds	1.0
Working areas where personnel are continuously exposed	Continuous in light winds	1.6
General areas where personnel may be continuously exposed		1.9 – 2.5
Emergency action areas; upper limit for working when wearing normal clothes and intermittently sprayed by water or sheltered	2 minutes	4.7
Emergency action areas	30 seconds	6.3
Immediate evacuation required	Few seconds only	9.5

Basically, I think just give you an idea of what this heat radiation means to personal survival, just to greatest solar radiation in terms of kilowatt per square meter is about less than 1. And working area is their personal or continuously exposed slightly 1.6, where personal may be continuously express the general areas about this much. And when you look at around 10, you know people working in a sunlight, in a hot areas is about 1, when you talk about you know, around 10 kilowatt per square meter then, probably you would not be able sustain, you would not be able to stand.

So, you need to just to get away from there. So, that is the type of number we need to know because, when you go back to this picture when we do a fire study, we need to find out the escape pass are not across, such radius in levels in case of fire or in case of operating situations there.

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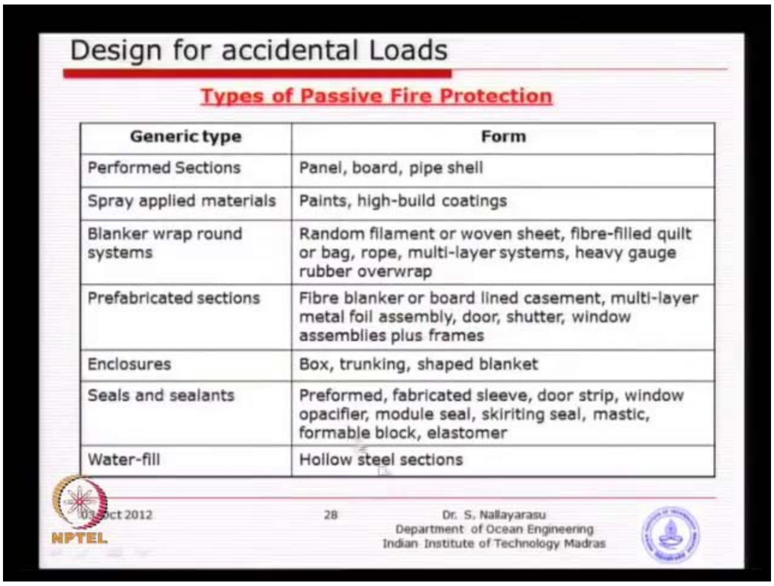

I think we have already discussed, this basically a different applications to different type of structures, type of bulkets will may not be that important basically.

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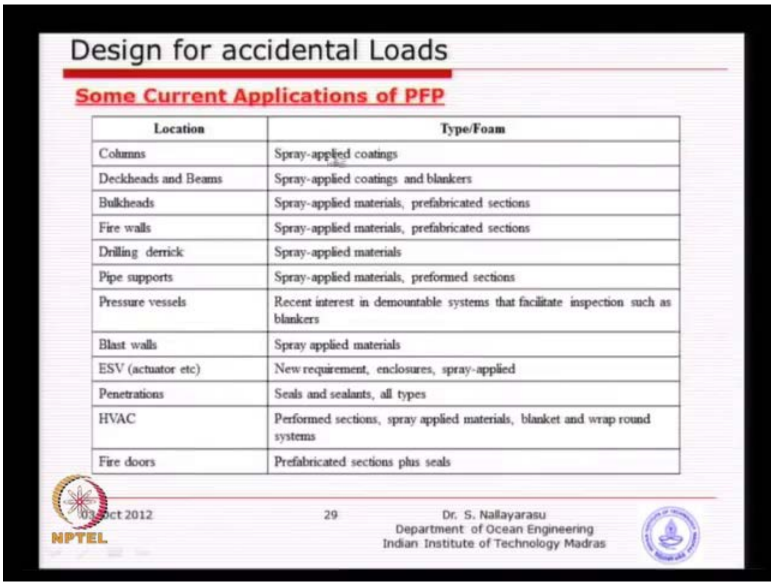

Also application of the passive fire protection to different classes of structures valves you know basic idea what is preferred. Mostly you can see here spray applied coatings, which are ((Refer time: 40:02)) type and most of them. Mostly just to apply like a spray paint, you might just you normally, we do painting of valves only thing is it needs to be applied by experienced personal so that, the thickness of the coating is uniform and then, stick to the surface of the steel. Otherwise, it will just come peal of it is going to be a problem. Sometimes, we have a special sections like for example, pre-fabricated sections with the seals for example, you want to have a door, your barriers is all-around the building, but if the door is not fire proof, what will happen? Fire will encase through the door.

So, you need to make the door fire proof. So, in this type of cases we normally do not basically spray on the door, but you have a pre fabricated material of that kind, you make the door out of that material. But then, the sealing between the door and fixed component needs to have fire protection, cannot use the fire material like a rubber, you cannot use. So, you can see here when you want to make a particular structure fire proof is not so easy because, you need to make sure every component is well behaved during fire. Especially, something like this penetration, it is very important for example, you have this building for sure you will have incoming outgoing systems.

For example, the electrical system, plumbing system, you have a plumbing type coming in and if that pipe is not designed, fire can come through that or you have that sleeve, that connection is not sealed, smoke can come. The main problem of or the cause of death during a fire is actually not directly fire, many times smoke causes tremendous effect and basically that means you need to make sure, the seal in should be 100 percent correct that smoke does not enter into the facility. So, basically just an example to give you, what are things you need to look after during design.

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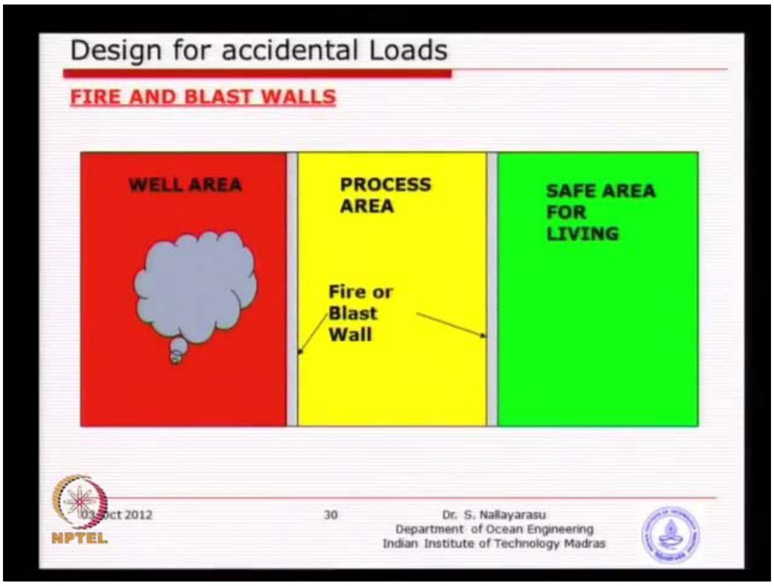

And this, the best way of looking at the lay out which I think you have seen the photographs basically, the well area process area and safe area or living area, purpose fully I have put safe area. Basically, they are barriers is a wall which is what normally we do in a answer or the building structure. You have the barriers which is nothing but you can make it sound proof, fire proof, blast proof, isn't it? Most of the buildings we make it, make the walls for sound proof basically and then, you have potential of having fire, you make fire wall.

So, instead of making brick, you may actually go with concrete wall, some cases are buildings. You know you will see that some of the walls are made of concrete just to make sure that they have sufficient fire resistance, instead of normal conventional brick you will use a concrete wall. And you can design the concrete wall with sufficient reinforcement which can also take the explosion or blast resistance. So, basically that is the idea. So, these barriers are nothing but a structure capable of resisting high temperature and higher loading for raising from blast. So, basically call it fire wall, fire and blast wall or blast wall sometimes you design for both.

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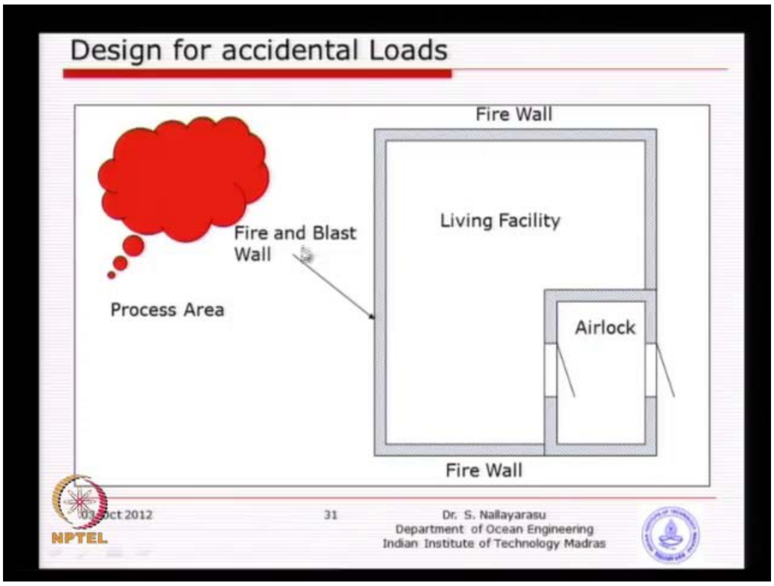

And basically whenever you have this safe area in the vicinity of the process area, you need to make sure that double safety for something like this, you see here when you enter here, you have double door. So, the first door opens the inland, the, the, the hydro carbon entering into the room is avoided because, you have another lock. So, this called the air lock is nothing but the door which separates the entry of any foreign material like hydrocarbon gas, smoke especially, smoke entering into this particular. So, all the time one of them is closed then, there will be an exhaust from that particular chamber so that, whatever is entering is resize circled, recycled and surrounded by a free wall all around the facility.