Chemical Process Safety
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Lecture - 30
General Design Methods to Prevent Fire

Welcome to the next module of design to prevent the fire and explosion.

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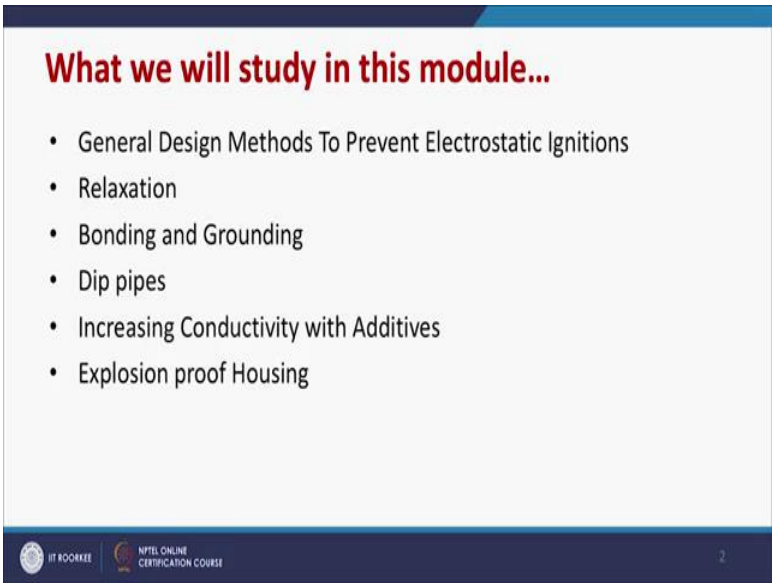

In this module we will discuss the general design methodology to prevent the electrostatic ignition. We will discuss about the relaxation that how the charge is with the enhanced inlet area we can reduce the impact of static charge. We will discuss the bonding and grounding. What is the role of dip piping in the static electricity generation. Increasing the conductivity with the additives, we will discuss about it, how we can increase the conductivity. Explosion proof housing and designing or layouting, we will discuss about this.

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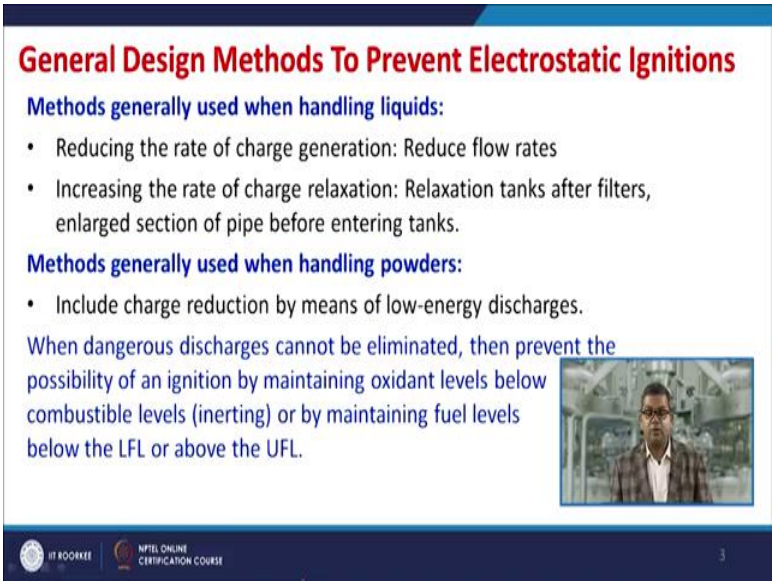

So, let us have first aspect that is general design methodology to prevent the electrostatic ignition. Usually methods generally used while handling the liquid that is the reducing the rate of charge generation must reduce the flow rate so that the generation and accumulation of static charge is minimized. Then increasing the rate of charge relaxation so relaxation tanks after filters, enlarged section of pipe before entering the tank so once you enlarge the section then the charge density will be on the lower side. So, the impact of destructiveness of that particular charge would be on the lower side.

So methods generally used when we handle the powders especially in some industrial establishments you need to handle the powders and during the previous module we have seen that while we are handling the powder then there are prominent chances of generation of static electricity. So, they include the charge reduction by means of a low energy discharge so when dangerous discharges cannot be eliminated then prevent the possibility of an ignition by maintaining oxidant levels below the combustible level or inerting or by maintaining the fuel level below the LFL or above the UFL.

Now remember this above the UFL is again a very undesirable situation because at any point of time there may be a chance that it may reach the range of LFL and UFL, so it can create a dangerous problem. So, it is always advisable to maintain the low oxidant level, or you can seek the knowledge of LFL so that it can be below the LFL range.

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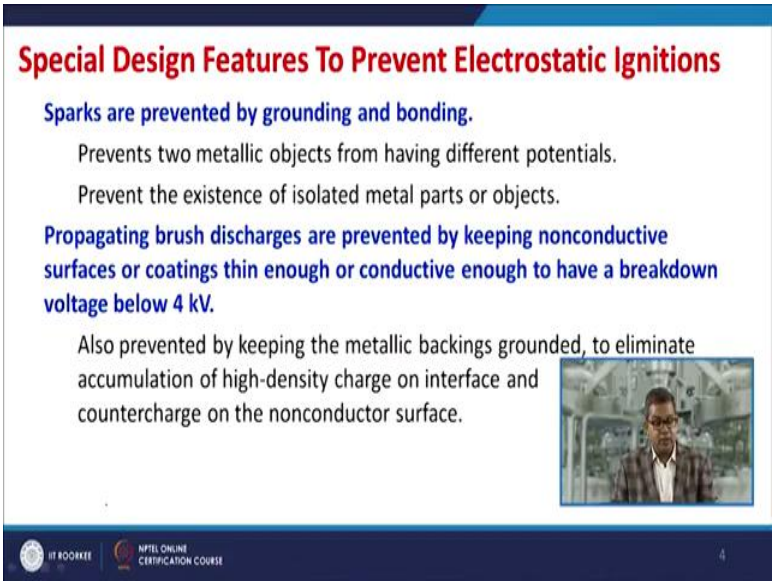

Now, there are certain special design features for the prevention of electrostatic ignition. Sparks usually they are prevented by grounding and bonding so grounding and bonding they are very useful and common phenomenon for elimination of the hazard of electrostatic ignition. Now, they prevent two metallic objects from having the different potential, prevent the existence of isolated metal parts or objects.

So, propagating brush discharge are prevented by keeping nonconductive surfaces or coatings thin enough or conductive enough to have a breakdown voltage roughly below 4 kiloVolts. They are also prevented by keeping the metallic backings grounded, to eliminate accumulation of high-density charge on interface and counter charge on non-conductor surface.

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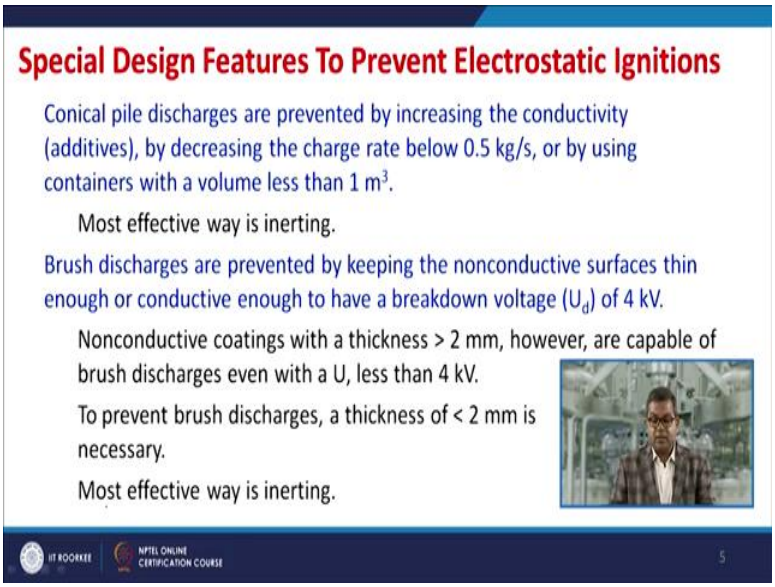

Conical pile discharges they are prevented by increasing the conductivity, by addition of certain additives, we will discuss in due course of time, by decreasing the chare rate below around they say 0.5 kilogram per second or by using the containers with volume less than 1 meter cube. Now the most effective, remember the most effective way is inerting. So, if your inerting is efficient then definitely you can avoid the hazard of electrostatic ignition.

So, brush discharges they are prevented by keeping the nonconductive surface thin enough or conductive enough to have a breakdown voltage that is usually less than 4 kilovolt. Nonconductive coatings with the thickness greater than 2 millimetre, however, capable of brush discharge even with a U, less than 4 kilovolt. Now to prevent the brush discharge a thickness of around 2 millimetre is necessary again, repeating it again that the most effective way is inerting.

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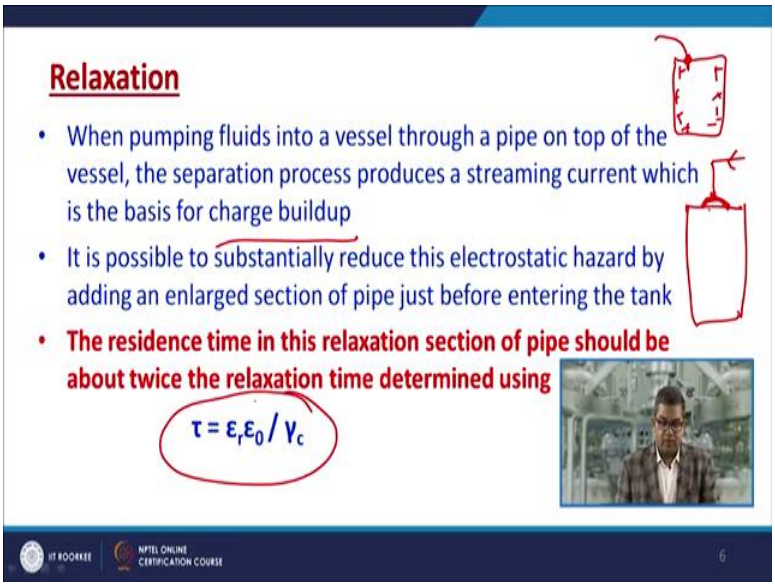

Now relaxation. Sometimes relaxation because the charge density is a very crucial point, so relaxation is one of the most effective or you can say the effective tool to minimize the effect of electrostatic ignition. So, when you are pumping fluids into a vessel through a pipe on the top of the vessel, like this, the separation process produces a streaming current, like this, which is the basis of charge build up.

Now it is possible to substantially reduce this electrostatic hazard by adding an enlarged section of pipe just before entering the tank. It is just like this. You can have this enlarged section and you may have the piping like this. So, this is the enlarged section and if you compare with this,

this is the enlarged section. So, the residence time in this relaxation section of pipe should be about twice the relaxation time, determined using:

$$\tau = \frac{\varepsilon_r \varepsilon_0}{\gamma_c}$$

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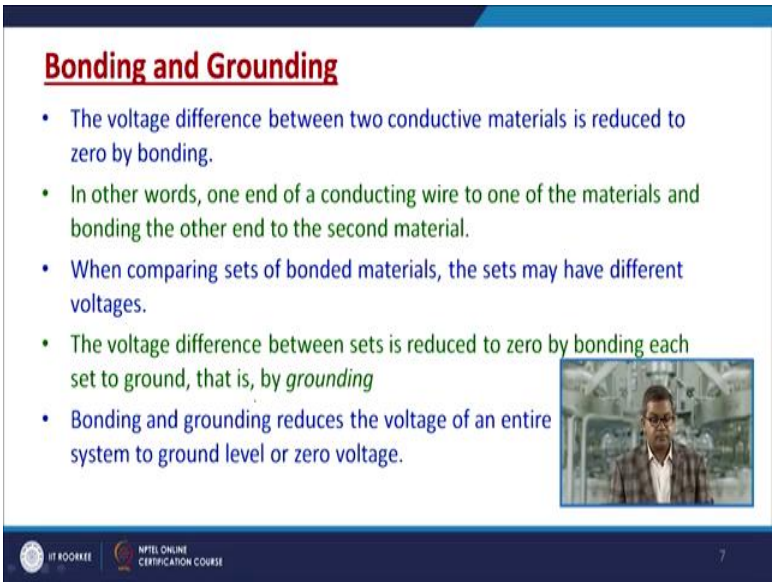

Another important aspect is bonding and grounding. The voltage difference between two conducting materials is reduced to zero by bonding together. Now, in other words, one end of a conducting wire to one of the materials and bonding the other end to the second material. So, when comparing the set of bonded materials, the set may have different voltages. The voltage difference between the set is reduced to zero by bonding each set to ground and that is by grounding. So, bonding and grounding reduces the voltage of an entire system to ground level or a zero voltage.

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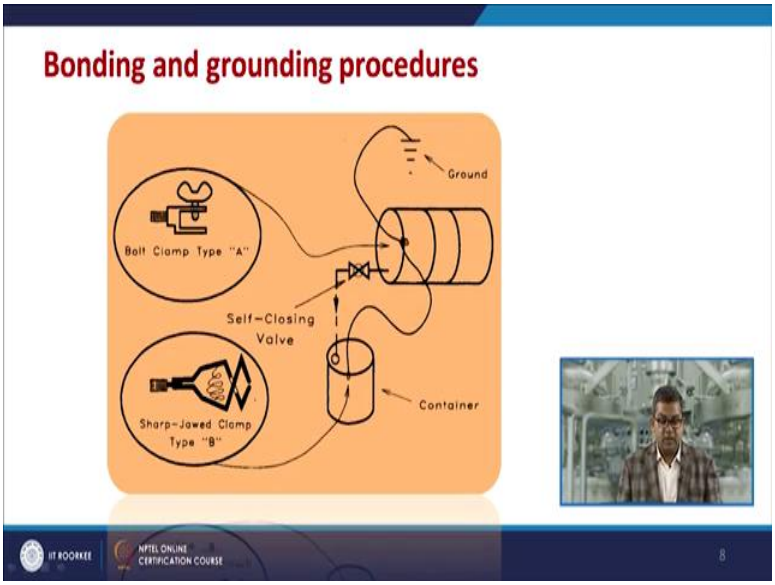

Now this is the pictorial explanation of this bonding and grounding. Now here, we have a container which is duly grounded. Now this is the container and these two, these Bolt clamp, type A and type B both are joined together, and this is the best example of bonding and grounding.

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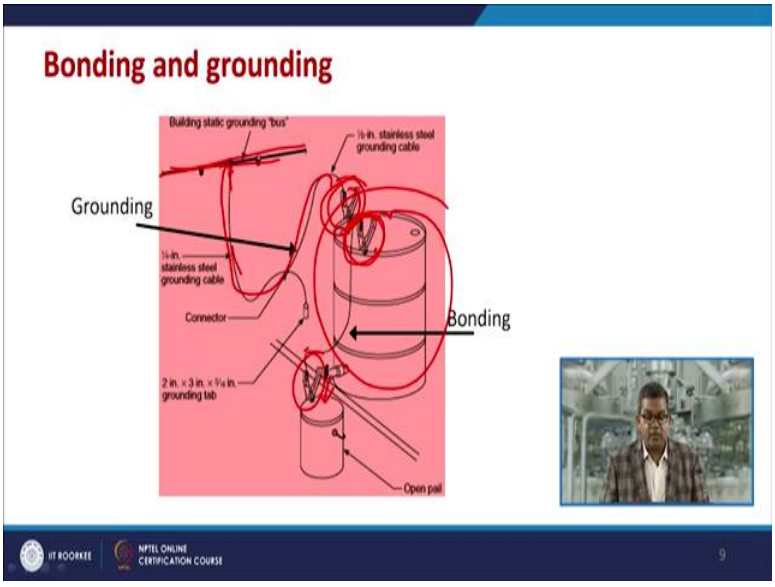

Now here the grounding, this is the container and you are discharging certain liquid to a small open pail, now here you can ground it or you can build the static grounding bus through which you can discharge or you can eliminate the charge, whatever charge being generated it can be eliminated, now here there are 2, you can see, this is bonded with these 2 clamps, this one is bonded and charge, this charge is connected to this bus wire so that you can eliminate the hazard of electrostatic ignition.

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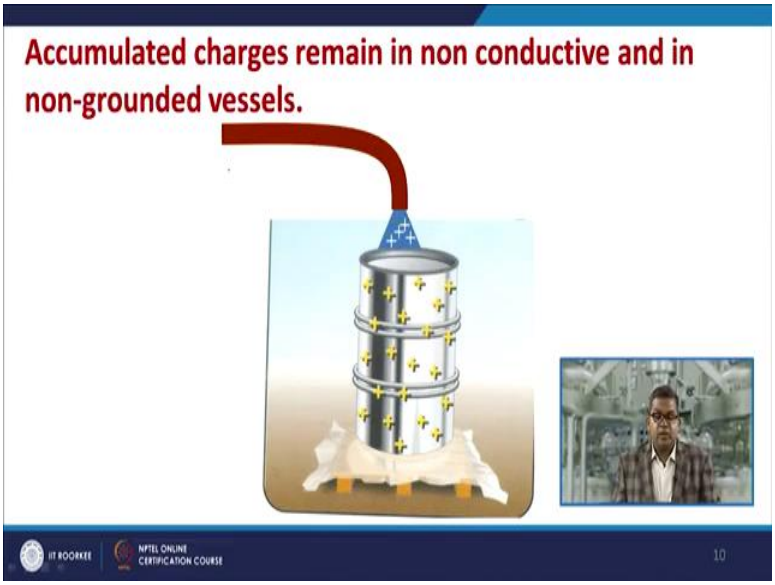

Now this is again a very common phenomenon that is accumulated charge remain in non-conductive and non-grounded vessel. If your filling any vessel with any fluid, if it is not properly been grounded or bonded then the charge will remain to the surface of this particular vessel and whenever this particular vessel will come into contact to certain favourable conditions then spark may generated. So be careful and adopt the concept of grounding.

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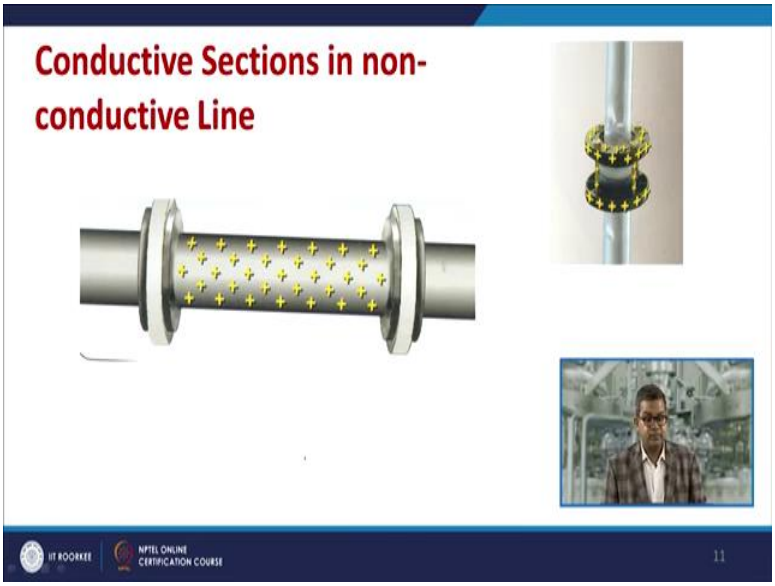

Sometimes you may experience there are certain zones, those who have the accumulation of these electrostatic charges and sometimes they are unnoticed, like this, you are having a non-conductive line, a pipeline where the charge is accumulated at the surface, similarly you are having may be a conductive line or may be some non-conductive line, the charge is

accumulated at the surface of these flanges, so, whenever the favourable condition achieves, then definitely they may be in a position to produce the spark.

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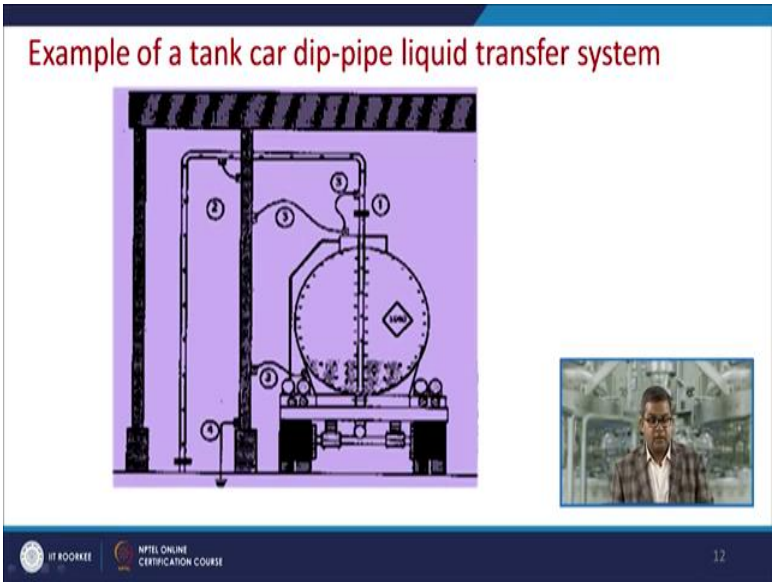

This is again, the best example of streaming charge effect. Now this particular lorry contains a flammable liquid. Let us have some practical example of petrol or motor spirit, this lorry carries the motor spirit so during the transit or during the transportation from the depot to the petrol pump, it may have certain accumulated charges, either at the inner part like this at the surface or over the fluid surface.

Now, when it tends to discharge this particular flammable liquid to the storage arena of a petrol pump then there are certain metal surfaces or metallic surfaces, then it may have a favourable condition for the generation of spark. Now during the transfer, you cannot avoid the formation of certain vapours because they are inherent property attributed to vapour pressure.

Then the spark may be generated, and this spark may have the sufficient amount of energy so that it can blown up the entire petrol station of the petrol pump. That is why to neutralize this extremely charged and to neutralize the things you must ground this particular filling station or filling pump whenever you are having, either you pre-ground it or you during the process of unloading this particular tanker you make grounding in a continuous fashion.

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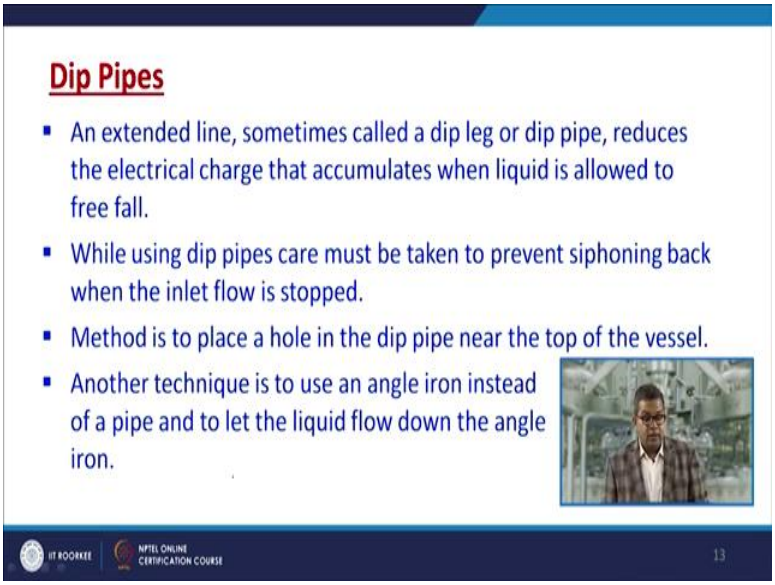

Now, another aspect is that dip pipe. Usually this is an extended line or sometimes called a dip leg or dip pipe which reduces the electric charge that accumulates when liquid is allowed to free fall. While using dip pipe care must be taken to prevent the siphoning back when the inlet flow is stopped. The method is to place a hole in the dip pipe near the top of the vessel. Another technique is to use an angle iron instead of a dip pipe and let the liquid flow down to an angle iron.

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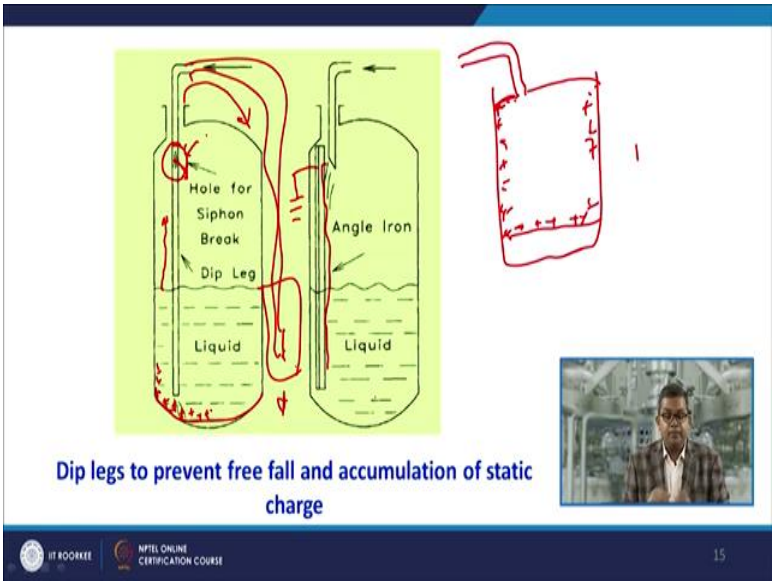

Now here it is the best example that how dip legs prevent the free fall and accumulation of static charges. So before we discuss this one let us have what happened at the start-up. Suppose I am having this vessel to be filled with flammable liquid and one option is that I am flowing

the liquid from the top like this so what happens there may be a chance of generation of charge at the inner lining and over the surface of this liquid because they are having the larger area.

Now with the concept of a dip leg here you can see that this particular dip leg is just a few inch or few distance away from the bottom of this one. So, by this way whenever the liquid is coming out, electrostatic charge generation, the possibilities are on the lower side. So, by this way you can minimize the generation of electrostatic charge or static charge built up. Now one problem is there, and that problem is attributed to the siphoning.

Because whenever this liquid is coming at this level and suppose this particular thing is connected to some other vessel, which is may be the filling vessel then there may be a chance of reverting it back to the, this particular vessel. To avoid this siphoning back aspect, you may put a hole to break the siphon. Now remember whenever you are filling there may be a chance that the liquid may come out from this hole and it may create again the problem of generation of static charge.

So, whenever you are encountering such type of a problem then you may have another remedy for this one. You may put an angle iron which may be suitably grounded or bonded and you can put the flow in such a manner that it is having the reduced flow live and it will align to this angle iron bar so that the generation of static charges may be minimized. So, these are the couple of methodology through which you can prevent the free fall and accumulation of static charge by dip leg concept.

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Now there is another possibility of spark or spark charge transfer. This is the vessel filling operation, now there are three aspects, one is this one, another one is that the outer periphery you may generate the charge and third one is that how we can reduce the impact of this generation of spark. So, this figure, particular figure depicts that how we can minimize this charge transfer and how we can minimize the effect of spark generation.

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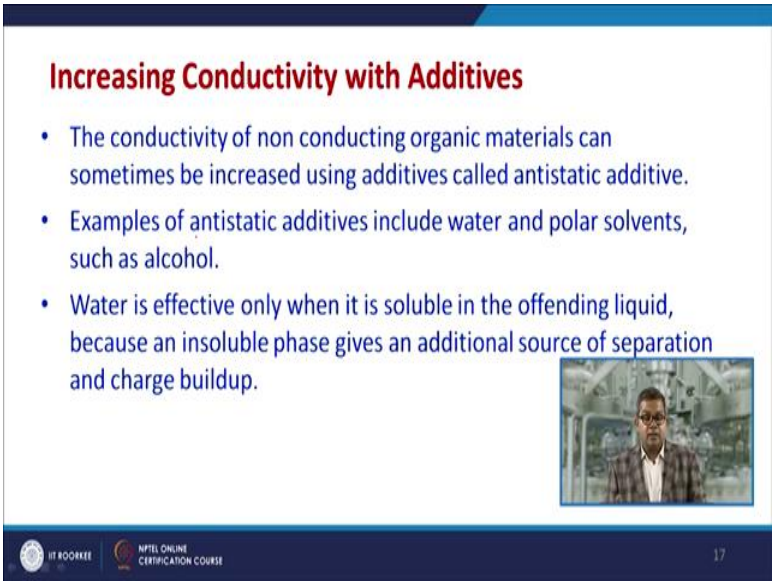

Another methodology is to increase the conductivity by the addition of additives. So, the conductivity of non-conducting organic materials can sometimes be increased using the additives, they are called the antistatic additives. Examples of antistatic additives include water and polar solvents such as alcohol, etc. Water is effective only when it is soluble in the offending liquid because an insoluble phase gives an additional source of separation and charge build up.

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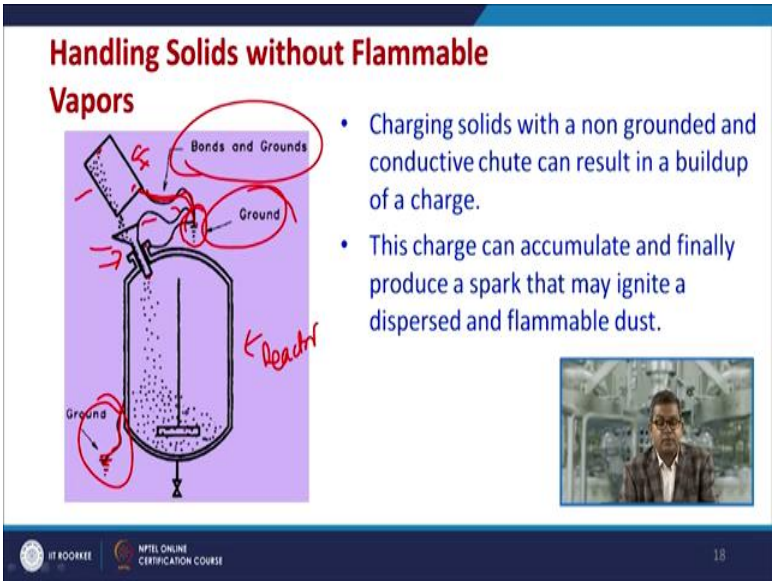

Sometimes you need to encounter the problem of handling solid without flammable vapours so here again you need to adopt the proper bonding and grounding aspect like here you can see, these two are bonded each other. Now here before we go into detail, this particular solid is being filled with this funnel to this particular reactor so while transferring this solid material through this hopper or a funnel to this reactor there may be a chance of generation of static charge.

Now as an engineer you must find out that what are the possible danger zones. One zone is this container itself, another zone is this funnel itself and third zone is this reactor itself. So, you can see that this particular vessel is properly bonded with this funnel, like this and this adjoining is properly grounded, so by this way you can minimize the hazard of both this and this.

In the next aspect while you are transferring this material to this reactor obviously there will be generation of certain electrostatic charge then this vessel is again grounded to minimise the effect of this is electrostatic charge. So, you must find out that what are the crucial area where you need to pay a proper attention.

Now charging the solid with non-grounded conductive shoes, they can result in a build-up of charge. That is why they have put this bonding and grounding. Now this charge can accumulate and finally produce a spark this may ignite the dispersed dust to avoid this kind of thing you must find out the crucial area.

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Sometimes you may need to handle another scenario where you cannot perform this type of activity which we have discussed in the previous slide. Then you need to adopt the concept of inerting. Now here you are handling with the flammable vapours so when your continuously filling solids to this particular reactor, this is a solid liquid reaction so in that particular case the chances of generation of charge are on the higher side and sometimes you may not be in a position to ground it properly.

In that particular case you may need to have a proper supply line for interting so that whatever vapours are being generated or whatever combustible mixture is being generated at the surface of this particular liquid it may be properly inerted so that it cannot ignite because remember if you are not attempting this type of thing then vapour or dust whatever is there, they may form a flammable mixture and you are having sufficient electrostatic charge built up within the vessel and at any point of time the spark may generate and the entire vessel may explode.

To minimize this particular effect, you need to have certain supply lines for inerting. So, usually there are certain advisories and you know that here you are also having the solid which is being filled to this particular reactor, it is properly bounded and grounded who are you, so usually these type of things are being used when you are not in a position to have the additives, you are not in a position to have a proper grounding methodology then go for inerting.

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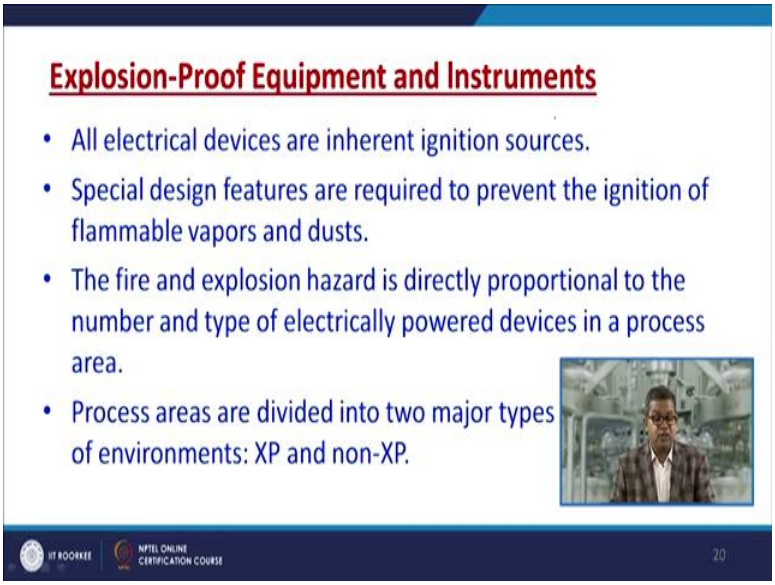

When you are acclimatized or you are bound to work under such scenario then you cannot overlook the importance of explosion proof equipment and instruments all so it is advisory that all electrical devices, they are having inherent ignition sources, so keeping in view of this fact, you must design the methodology through which you use those explosion proof equipments and instruments.

So, special design features are required to prevent the ignition of flammable vapour and dust. The fire and explosion hazard is directly proportional to the number and type of electrical powered devices in a process area. So, process area are divided usually in two major type environment, XP and non XP, that is explosion proof and non-explosion proof.

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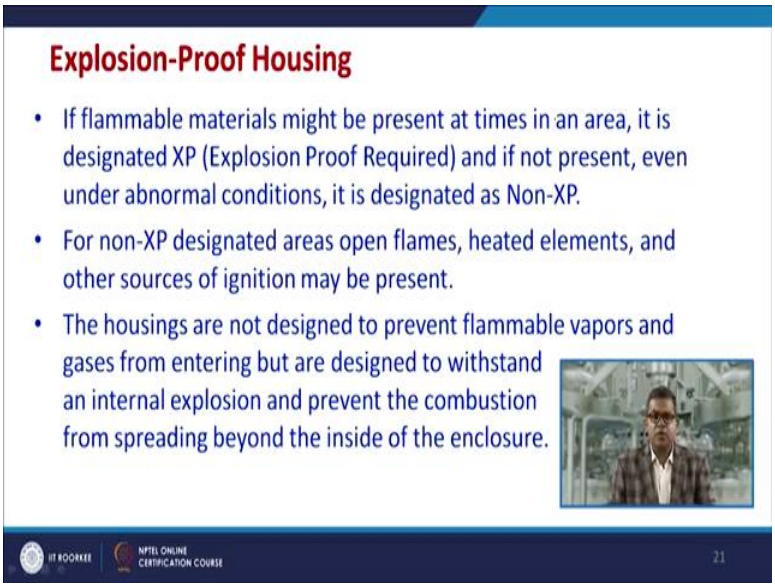

Now, if flammable materials might be present at time in an area, it is designated XP that is explosion proof required and if not present even under abnormal condition it is designated as non-explosion proof required area, so that means you can avoid the installation of such safety devices. So, for non-explosion proof required designated area open flames, heated elements and other sources of ignition may be present because you can work it upon.

The housings are not designed to prevent flammable vapours and gases from entering but designed to withstand an internal explosion and prevent the combustion from spreading beyond the inside of the enclosure.

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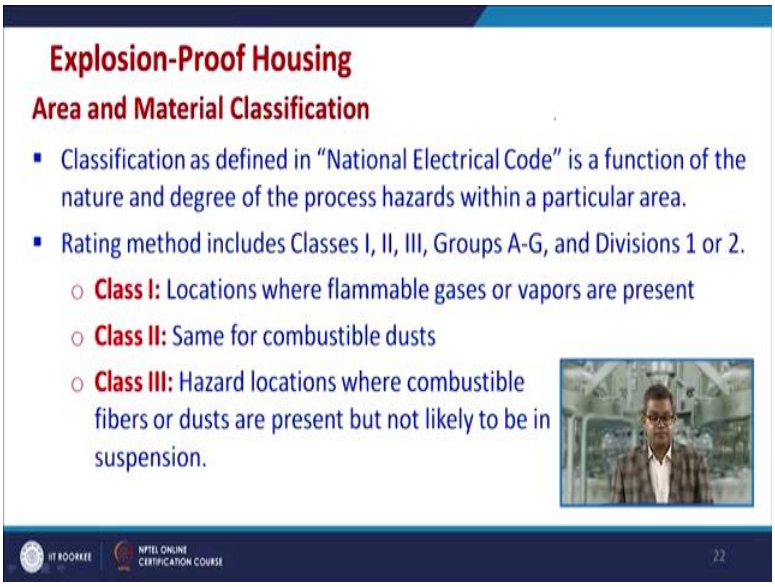

Now, how we can classify this explosion proof housing? This slide will discuss the classification are usually defined on the basis of national electrical code that is based on United States federal law and this is a function of nature and degree of the process hazards within a particular area.

So rating methods, this include, Class I, Class II, Class III groups and groups from A to G and division 1 or 2. So class I includes the location where flammable gases or vapours at present, Class II same for the combustible dusts, Class III hazard locations where combustible fibers or dusts are present, but not likely to be in suspension so that you can designate the different area of plant in different classes.

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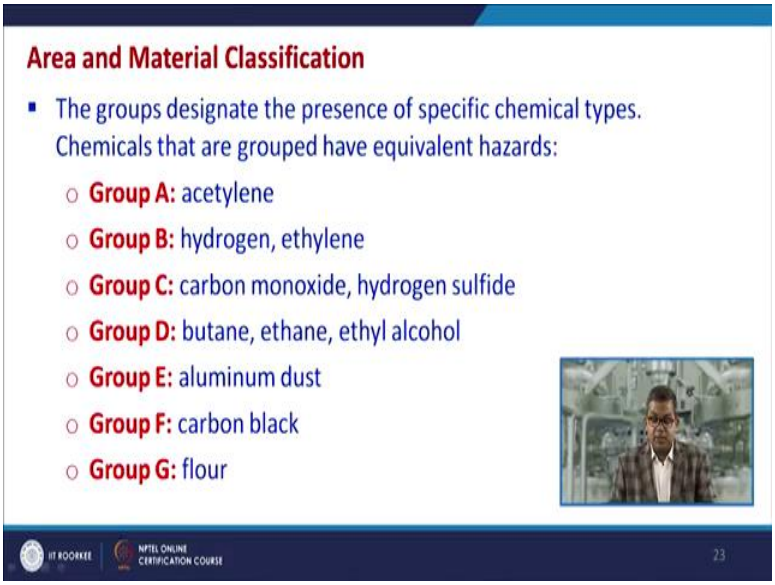

Now the groups, they are designated to presence of specific chemical type and the chemicals that are grouped have equivalent hazards like Group A acetylene or equivalent; Group B hydrogen, ethylene; Group C carbon monoxide, hydrogen sulphide, Group D butane, ethane, ethyl alcohol, Group E aluminium dust, Group F carbon black, Group G flour.

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Now divisions because there are two types of divisions, division designations are categorised in relationship to the probability of the material being within the flammable for explosive region. Division I, probability of ignition is high; that is flammable concentrations are normally present. Division II, the hazardous only abnormal conditions may be thermal run away reactions or temperature based reactions, etc. Flammable materials are normally contained in closed containers or systems.

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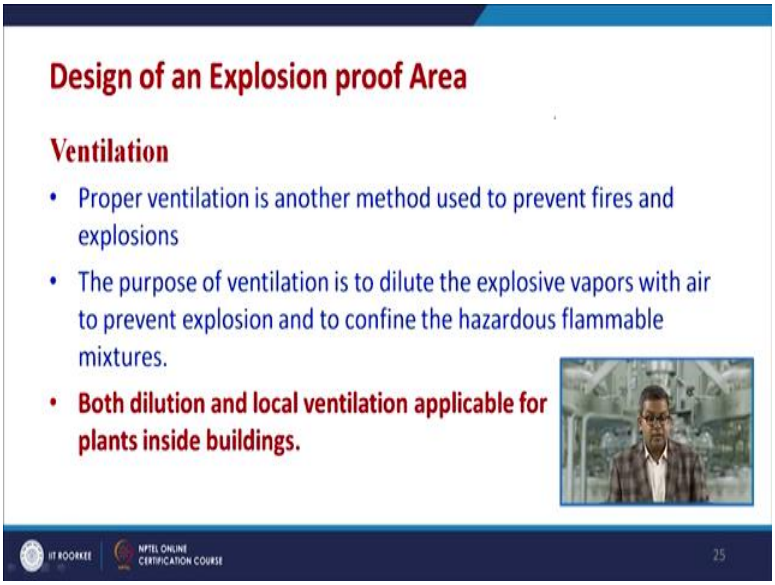

Now, how we can design an explosion proof area? The first thing which comes into our picture is ventilation. So proper ventilation, we have discussed this ventilation tool in industrial hygiene, so proper ventilation is one of the methods used to prevent the fires and explosions. The purpose of ventilation is to dilute the explosive vapours with air to prevent the explosion and to confine the hazardous flammable mixtures. Both dilution and local ventilation applicable for plants inside the building.

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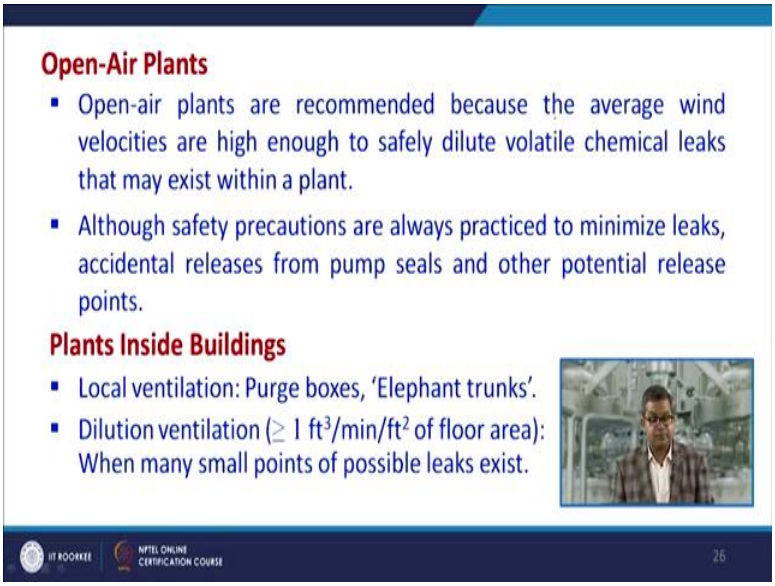

There are certain open-air plants so open-air plants are recommended because the average wind velocities are high enough to safely dilute the volatile chemical leaks if any and that may exist within a plant. Sometimes it may create a problem of unconfined vapour cloud explosion. So,

although safety precautions are always practiced to minimize leaks, accidental releases from pump seals and other potential releases are the points under the consideration of this head.

There are certain plants inside building so local ventilation obviously purge boxes, elephant trunks, etc you can use. Dilution ventilation when many small points of possible leaks they exist, and you can use the dilution ventilation.

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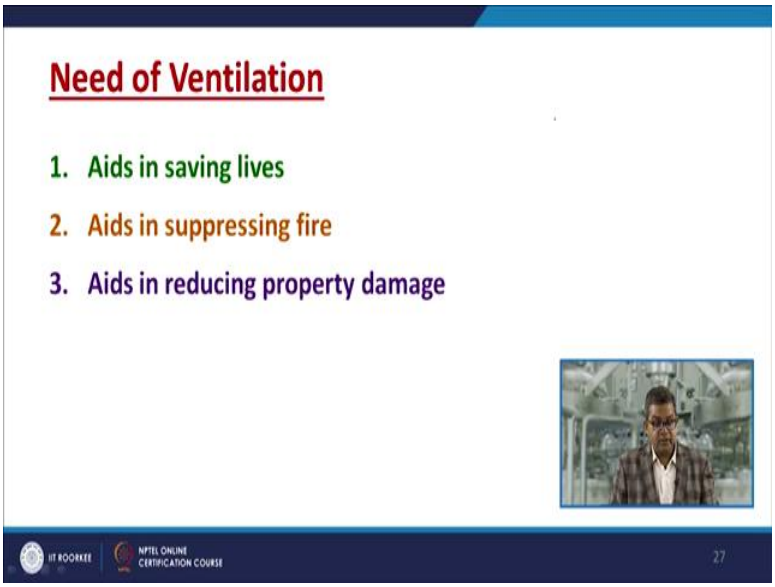

Usually need of ventilation is that aids in saving lives or assisting the saving life sometime, sometimes assist in suppressing fire, assist in reducing the property damage so that is why ventilation is extremely important.

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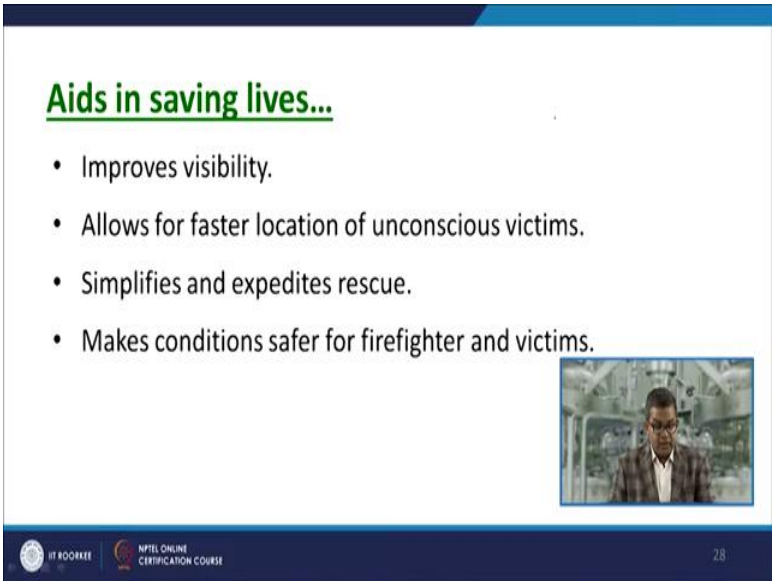

Now while assisting in saving life this improves the visibility. Allows for the faster, sometimes when there is a leak of any flammable or any kind of hazardous vapour the atmosphere or the area may become little bit hazy, so ventilation may increase the visibility. Allows for faster location of unconscious victims so that you can approach to them easily. Simplifies and expedite the rescue operation because once the visibility is clear you can easily approach to them. Makes conditions safer for firefighters and victims.

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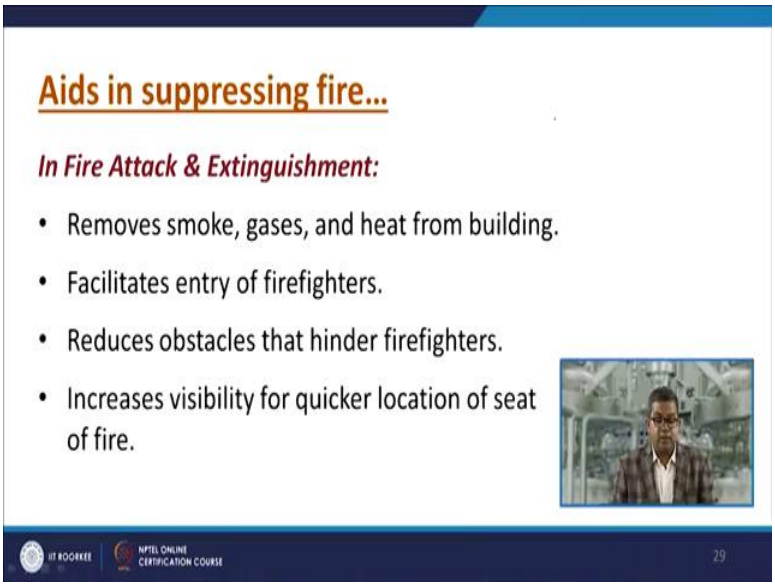

Now aids in suppressing fire in fire attack or extinguishment removes smoke, gases and heat from building. Facilitates entry of firefighters because the visibility is on the higher side. Reduces the obstacles that hinder the firefighters. Increases visibility for quicker location of seat of fire.

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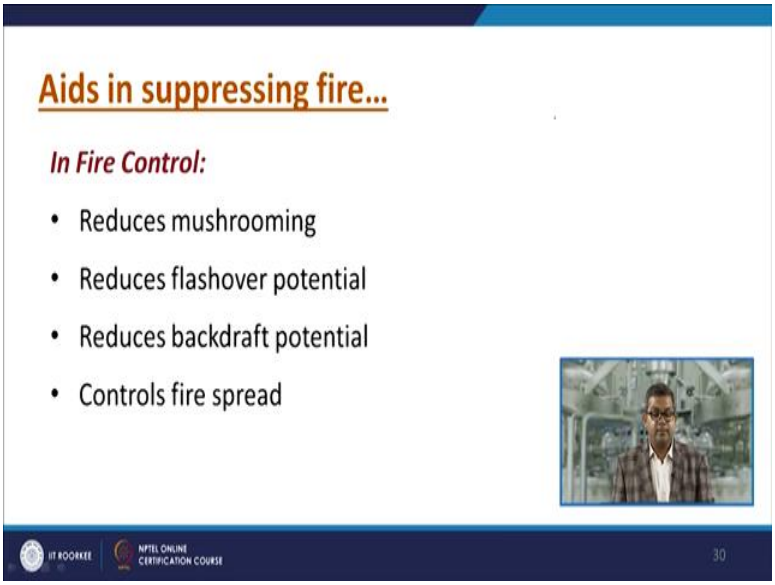

In fire control they reduces the mushrooming, they reduces the flashover potential, they reduces the backdraft potential and controls fire spreads etc.

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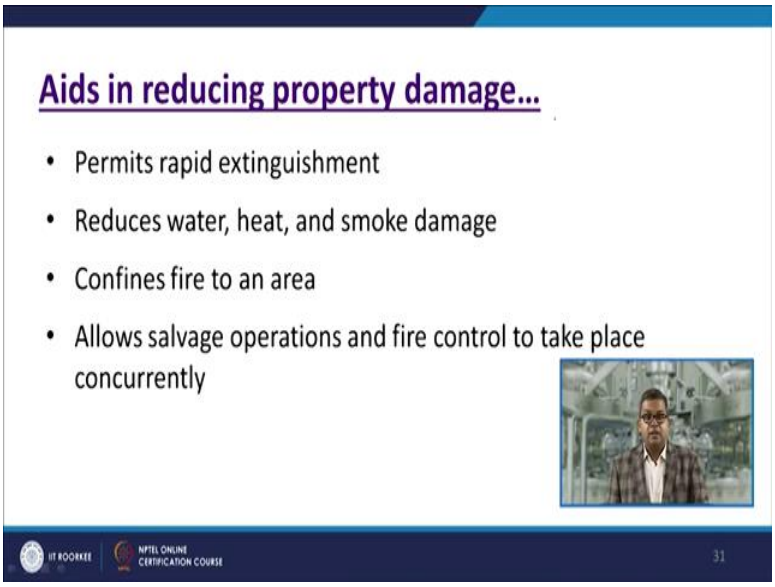

They are helpful in reducing the property damage that permits the rapid extinguishment, obviously the ventilation is very prominent in this aspect. Reduces water, heat and smoke damage. Confines fire to an area. Allows salvage operation and fire control to take place concurrently.

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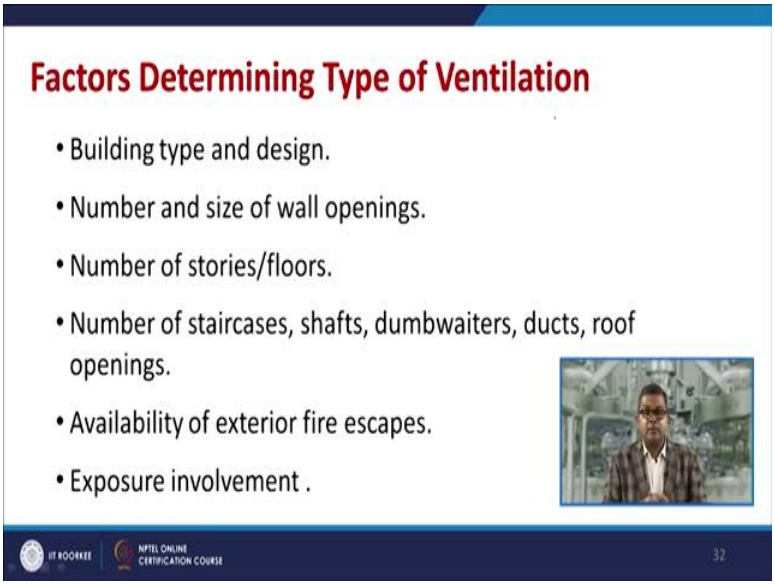

Now there are various factors those who determine the type of ventilation that is the building type and design, confined building, unconfined building, etc. Number and size of wall opening, how much you require. Number of stores and the floors. Number of staircases, shaft, dumbwaiters, ducts, roof opening, etc. Because these are the certain guiding factors for this one. Availability of exterior fire escapes and exposure involvement so these are the certain factors those who determine what kind of or what type of ventilation you require.

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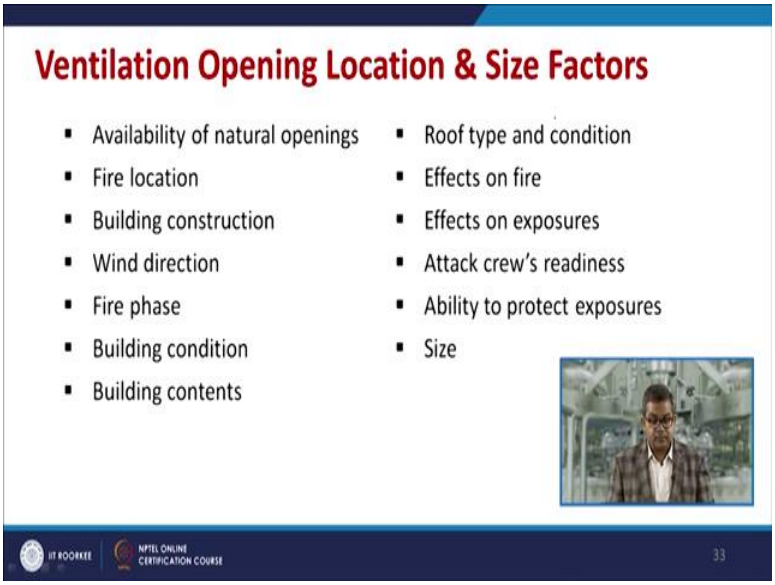

Now ventilation opening location and size factors they depend on the availability of natural opening because obviously for this opening you need not to pay any penny. Fire location, what is the fire location. Building construction of what type. What is the wind direction although it is not constant throughout. Fire phase, building Condition, what is the building condition,

sometimes building is quite old and because of the fire it may collapse down, or it may create a problem sometimes when ventilation may initiate certain vibration which may be destructive for building.

Building contents, what are the contents inside the building? What is the roof type, what is the effect on fire, what is the effect on exposure, Attack crew's readiness, ability to protect exposures, what is the size in the location, etc. So, these are the various things which you need to look after.

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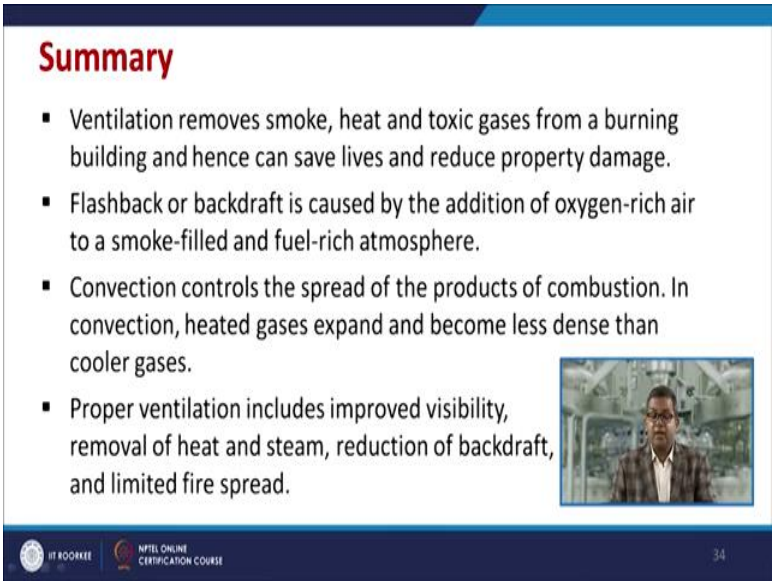

So, in nutshell, in this particular module we summarise the things that ventilation removes smoke, heat, toxic gases from burning building hence can save live and the reduced property damage. Flashback or backdraft is caused by the addition of oxygen rich air to a smoke filled and the fuel rich atmosphere.

Convection controls the spread of product of combustion. In convection, heated gas expands and become less dense than the cooler gas, so you can minimize the problem. The proper ventilation includes improved visibility, removal of heat and steam, reduction of backdraft.

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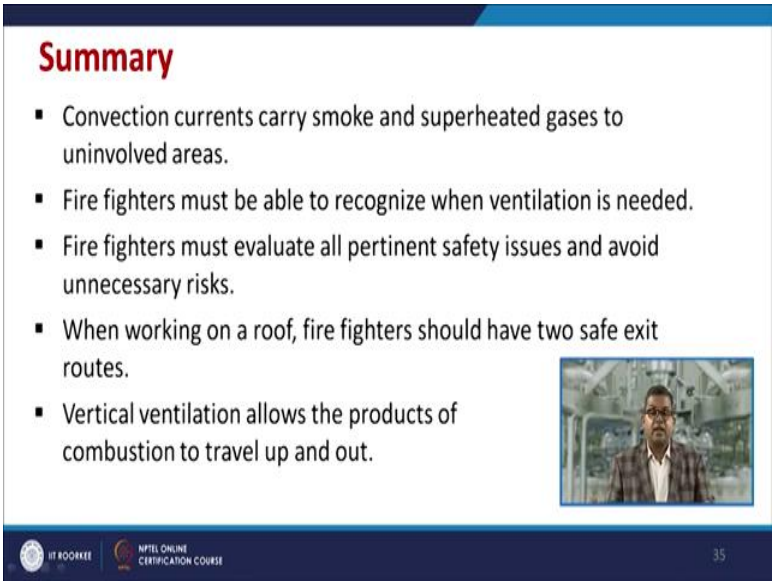

Convection currents carry smoke, superheated gases to uninvolved areas so firefighter must be able to recognise when ventilation is needed, and firefighter must evaluate all pertinent safety issues and avoid unnecessary risks. So, when working on a roof, firefighters should have to safe exit routes so that in case of problem at one roof, you can go for another one. Vertical ventilation allows the product of combustion travel up and out.

So, in this particular module we have discussed different aspect of electrostatic electricity, dip piping, relaxation, ventilation aspect, etc.

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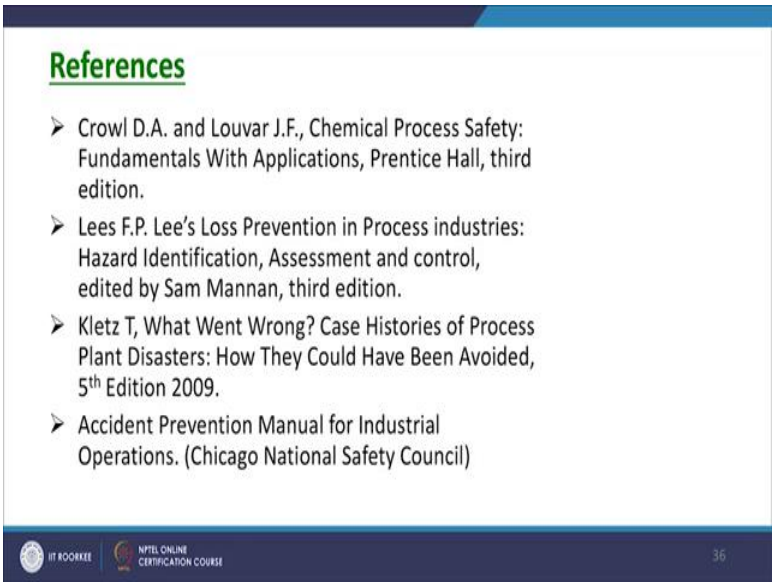

Again, you can have a look for further reading of these references, thank you very much.