Chemical Process Safety
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Lecture 32 – Sprinklers- II

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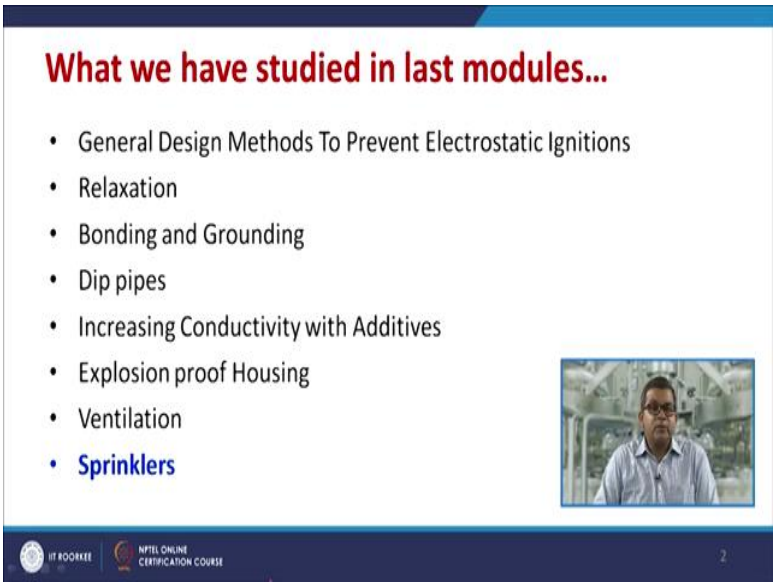

So welcome to the last module of design to prevent fire and explosion. Up till now we have studied in different modules about the design, general design consideration to prevent the electrostatic ignition, what is the concept of relaxation, how it is beneficial to the process industry. We have discussed about the bonding and grounding and how you can implement all those things into the process industry.

The concept of dip pipe, advantage and disadvantages; we have discussed about the increase in conductivity with different additives so that we can prevent the hazard of electrostatic spark. We have discussed about the explosion proof housing so that we can prevent the hazard by cordoning of the explosion prone equipments. We have discussed all aspects of ventilation and in this particular module we will discuss about the different aspects of sprinklers. So let us have a summary about the sprinkler system, what we have discussed in the previous module and what we are going to discuss in this particular module.

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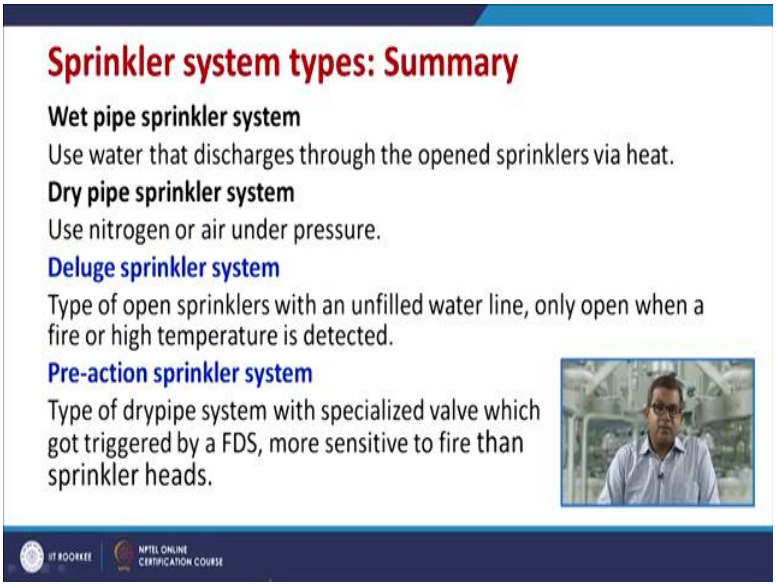

We have discussed about the wet pipe sprinkler system which uses the water that discharges through the opened sprinkler via heat. We have discussed about the dry pipe sprinkler system, they use usually nitrogen or air under pressure. In this particular module we will discuss the deluge type of sprinkler system and how to type to open the sprinkler with an unfilled water line and only open when a fire or high temperature is detected. There are certain pre-actions of these sprinkler system, this type of dry pipe system with specialized valve which got triggered by a FDS, more sensitive to the fire than sprinkler heads.

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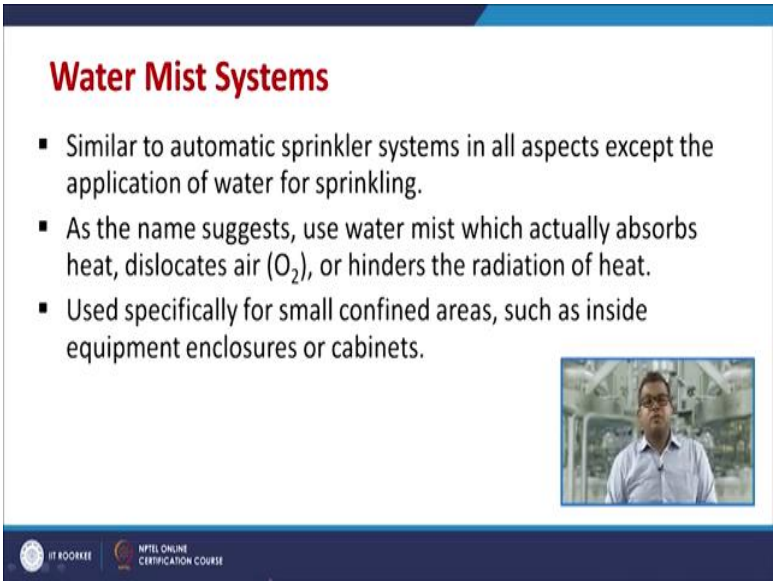

Now there are certain water mist system, they are usually similar to the automatic sprinkler system in all aspect except the application of water for a sprinkler. So you can see that as the name suggest, use water mist which actually absorbs the heat, dislocates the air or oxygen or

hinders the radiation of heat. So by the formation because these mist, they are having the larger surface area, so that they can easily absorb the heat and simultaneously when, because they are having the large density, so they can cordon off the air supply and indirect way the oxygen supply. And simultaneously they hinders the radiation of heat.

So they are used specifically for a small confined area such as inside the equipment enclosure or cabinets. Because of certain operational difficulties we cannot use these water mist to the larger area or entire the plant.

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Now these are the typical systems of water mist system. This is the usual device of water mist system and this is the operational one. So you can see that the water mist they are coming out from this nozzle.

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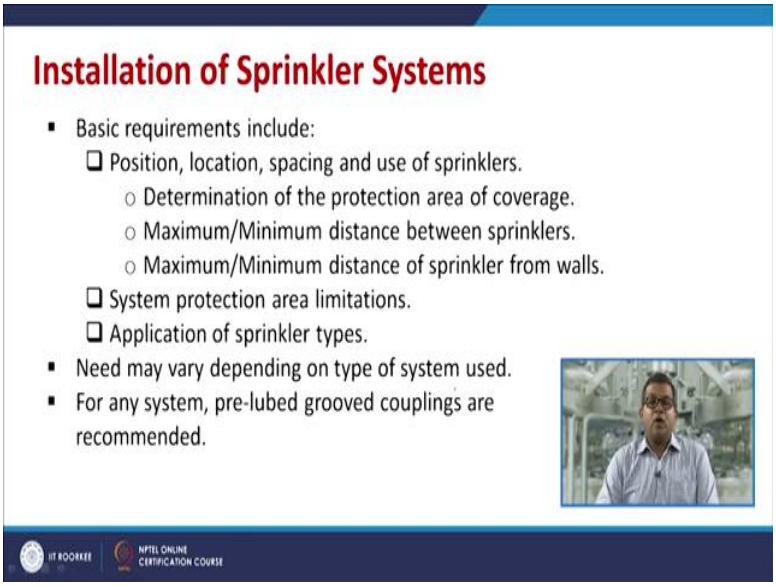

Now the question arises that, how to install the sprinkler system? Now you must identify that what are the basic requirements for those sprinkler system. So usually there are four type of requirement for the sprinkler system. One is the position, location, spacing and how to use the sprinkler system. So first thing is that you need to determine that the protection area of coverage, that how much area you need to cover in the sprinkler system. Because of certain inherent limitations of those sprinkler system you need to classify that particular area in question.

Then you must design and you must know that what is the maximum and minimum distance between these two sprinkler. Because every sprinkler is having its own efficiency or its own domain, so you need to find out so that you can cover the area in question properly. Then you need to find out that maximum or minimum distance of the sprinkler from the valve. Because you have to prevent certain dead zones, so that is why you need to find out this distance.

Now there are certain system protection area limitations because you cannot install certain sprinklers in certain area where the things are more difficult to control. Then you need to find out that what are the different applications which are applicable to various sprinkler types. Because in the previous modules we have discussed different type of sprinklers, so which kind of a sprinkler is applicable to what, so you need to find out all those things.

So these need may vary depending on the type of the system, what kind of system you are using. So these are the need, whatever need like position, location etc. These needs may vary

depending on the type of the system. For any system pre-lubed grooved couplings are always recommended.

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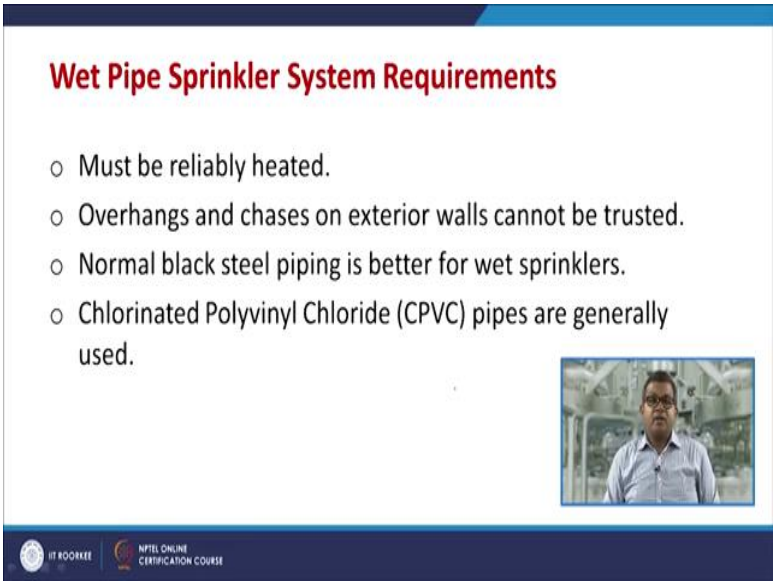

Now there are certain requirements which are attributed to the wet pipe sprinkler system. They must be reliably heated and proper heating control must be there so that they can work efficiently. Overhangs and chases on the exterior walls cannot be trusted because of application of heat or repeated use. Sometimes they are not reliable, so that is why you have to take care all these aspects. Normal black steel piping is better for wet sprinkler but sometimes chlorinated polyvinyl chloride CPVC pipes are generally used. But sometimes if the heat content is on the higher side, then this particular thing is disadvantageous.

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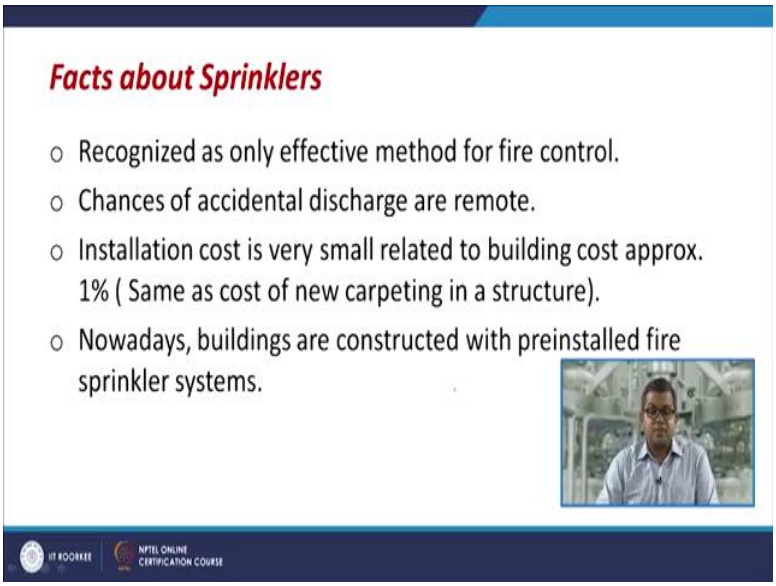

There are certain facts about the sprinkler. They are recognized as only effective method of fire control. Obviously, because very much apart from the ventilation the sprinklers are recognized a very effective methodology for the fire protection. Chances of accidental discharge are remote because they are very sensitive towards their control methodology. Installation cost is very small related to the building cost and usually approximately 1 percent attributed to the sprinkler cost. So same as the cost of you can say, the new carpeting in a structure.

So nowadays, buildings are constructed with the preinstalled fire sprinkler system. Even you can find all those sprinkler system in the parking arena, in the other arena which are open to sky etc. So that you can have a proper protection because of the…I mean they are very good in terms of cost factor.

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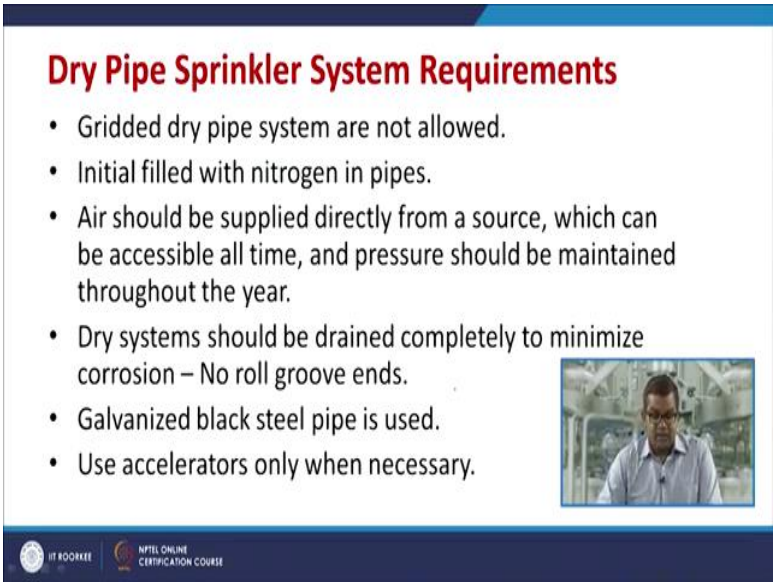

There are dry pipe sprinkler system requirements which they are very, I mean we can say the specific requirement are attributed to the dry pipe sprinkler system. They are gridded dry pipe system, they are usually not allowed. Initially filled with nitrogen in pipes, now air should be supplied directly from the, from a source which can be accessible all time, and pressure should be maintained throughout the year. And a gradual check of this pressure is always advisable.

Dry systems should be drained completely to minimize the corrosion—no roll groove ends. Galvanized black steel is used and use accelerator only when necessary. So these are the certain requirements for the dry pipe sprinkler system.

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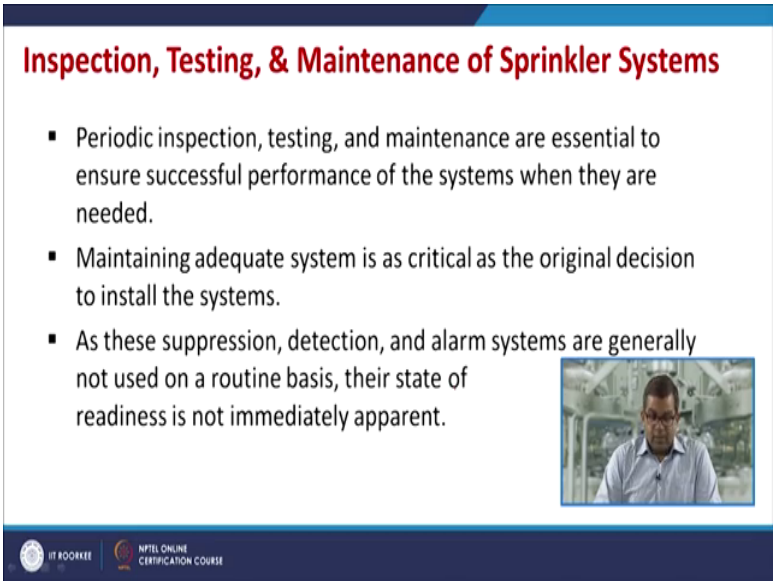

So once you installed these sprinkler systems, there is a requirement of inspection, testing and maintenance of those sprinkler system. And there is a regular protocol of this type of thing. So, you need to go for periodic inspection, testing, maintenance which is essential to ensure successful performance of the system when they are needed. Because sometimes it may happen if you are not performing all these protocols regularly, then at the time of need they may fail. So they may not be in a position to provide the adequate support which required and which is for they are installed.

So maintaining adequate system is a critical as the original decision to install the system. It is always advisable that when you are taking the original decision to install all this system, you should follow the proper maintenance protocol. Now as these suppression, detection, and alarm systems are generally not used on a routine basis, their state of readiness is not immediately apparent.

Because always we people, always busy in the regular process protocols, process working. So usually we do not have much time to pay attention of all these aspects. So that is why it is not the part and parcel of the routine basis. But we must follow these protocols. Now let us have a look about the inspection.

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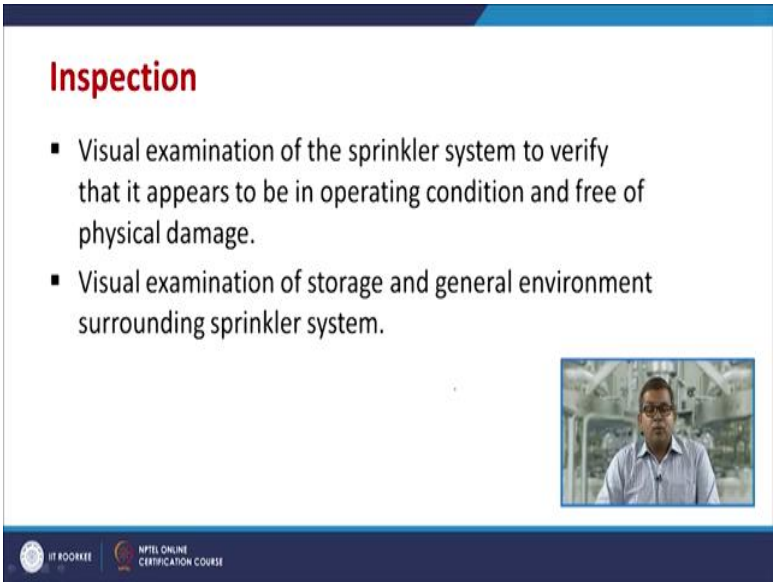

So, visual examination of the sprinkler system to verify that it appears to be in the operating condition and free of physical damage. So you can visually verify, visually you can inspect all these things that they are, whether they are physically okay or they are slightly damaged in terms of physical inspection. So, visual inspection, examination of a storage and general environment surrounding sprinkler system. So you have to be careful about while performing this physical examination.

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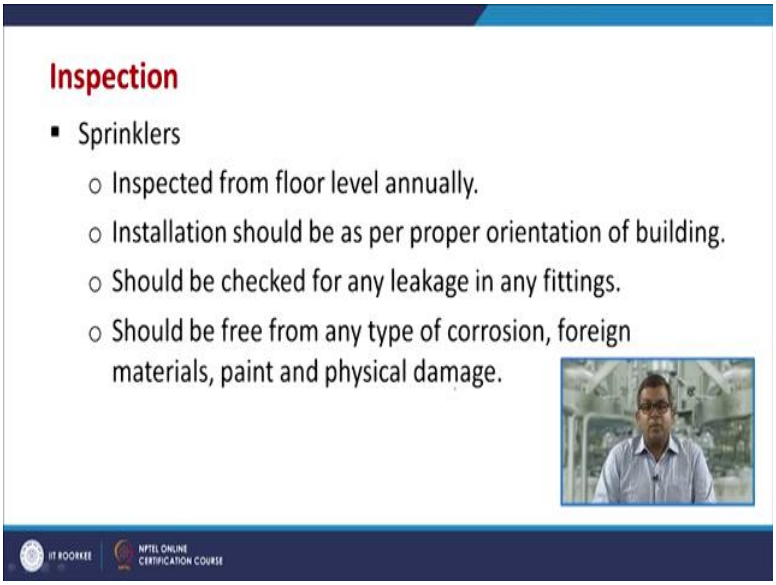

As far as the sprinklers are concerned, they must be inspected from floor level annually but it is not necessary that you perform this exercise annually, sometimes six monthly, quarterly etc, that is purely based on the requirement.

Installation should be as per the proper orientation of the building, that is mandatory requirement because sometimes you may forget some dead zones where the vapor cloud explosion or unconfined vapor login may there. Should be checked for any leakage in any fitting, that is mandatory. Should be free from any type of corrosion, foreign material, paint, physical damage because they may create a future problem during the operation. So you must be, you must ensure yourself that they should be free any type of these difficult scenarios.

While considering the pipe and fittings, they should be in a very good condition. Obviously it is prima facie requirement. They should be free from any kind of mechanical damage, leakage, corrosion, misalignment etc, because sometimes all the physical aspect even may be the pressure drop may create a problem, even the corrosion may cause the choking in the nozzles etc. So all, they should be free from all kind of mechanical damage.

Now piping should not be subjected to the external loads by material either resting on the pipe or hung from the pipe. So that is required, the reason is that sometimes because of the sagging the piping system may get collapsed. So this should not be subjected to any kind of external load.

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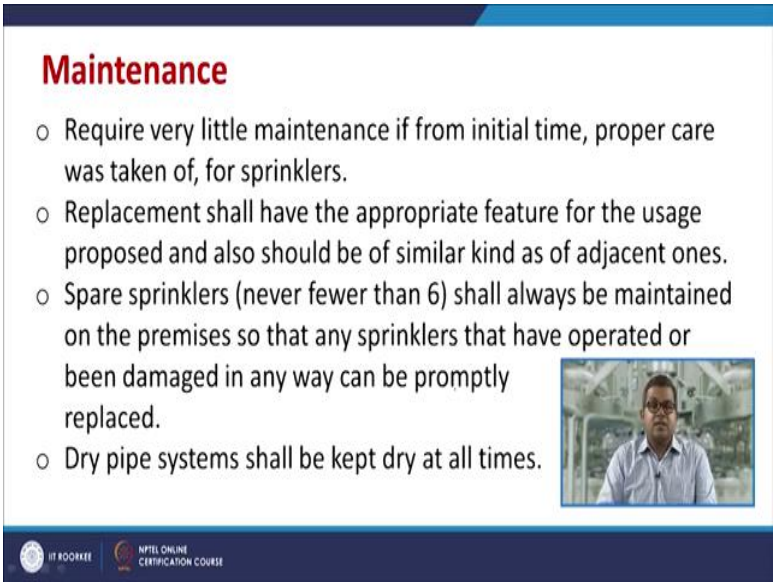

While considering the maintenance, they require very little maintenance if from initial time proper care was taken of, for a sprinkler. So if you have taken very good care during the installation of a sprinkler, then you may require a very little maintenance cost. Replacement shall have appropriate feature for the uses proposed and also should be of the similar kind as of adjacent one.

Sometimes spare sprinklers, never fewer than 6, shall always be maintained on the premises so that any sprinkler that have operated or been damaged in any way can be promptly replaced. So this is again standby arrangement for the sprinkler system. Dry pipe systems shall be kept dry at all time. This is the mandatory requirement and it is the part and parcel of your maintenance protocol.

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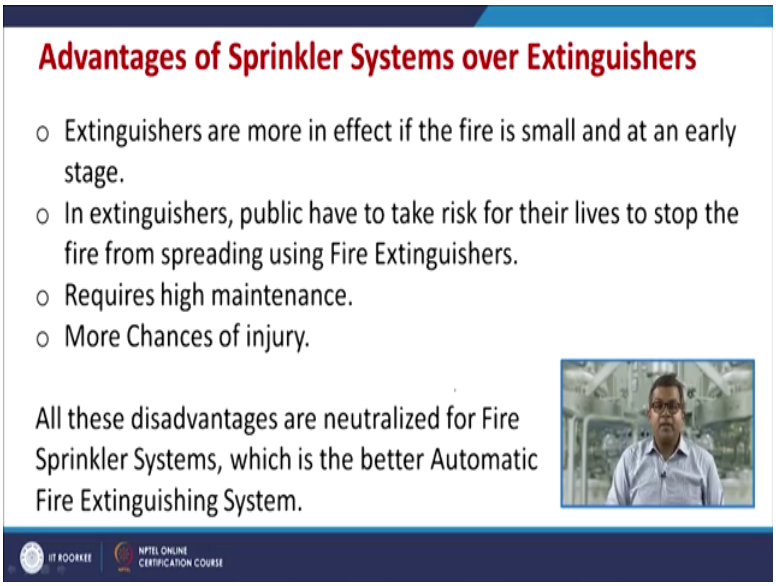

Now there are certain advantages associated with the sprinkler system over extinguisher although extinguishers are more in effect if the fire is small and at any early stage. So they are very much popular. In extinguisher public have to take risk of their lives to stop the fire from spreading using the fire extinguisher. So you have already seen all these things in a different pictorial diagrams in the previous modules.

This extinguisher requires high maintenance and sometimes you need to refill frequently etc, there may be chances of injury while using or while they are redundant, then there may be several chances of injury. So all these disadvantage are neutralized for fire sprinkler system which are better automatic in a fire extinguishing methodology. So if you recall in the previous modules and if you compare with this sprinkler system with extinguisher you can find that they are more better compared to the fire extinguisher.

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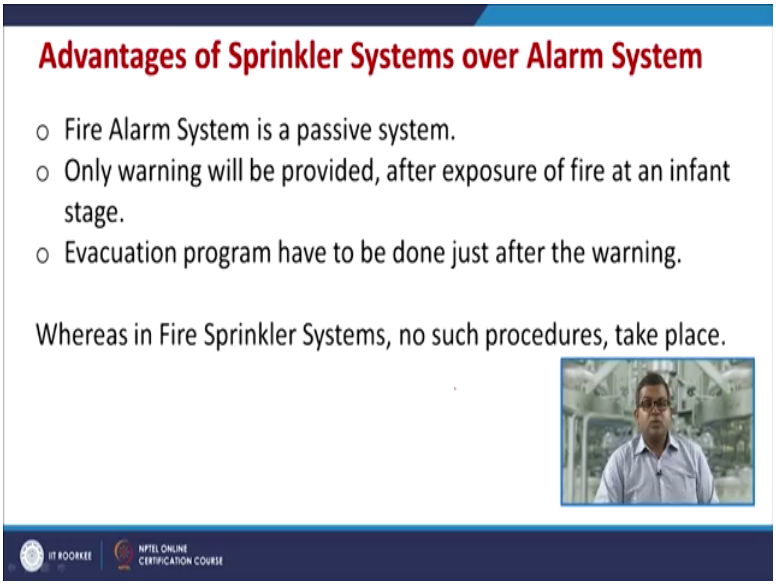

Again when we compare this sprinkler system over alarm system, again there are certain advantages associated with one. The fire alarm system is a passive system, only warning will be provided after exposure of fire at an infant stage or very nascent stage. Evacuation program have to be done just after the warning. So only thing is that this is a passive system and you need to follow a certain guidelines because it does not provide any kind of support system to extinguish the fire or to remove any arm of a fire triangle. Whereas in the fire sprinkler system no such procedures take place, so that is why they are having an edge over the alarm system.

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Now in summary the fire separation system include a sprinkler system, standpipe system, specialized extinguishing system and the most common fire suppression system is the automatic sprinkler system. Because we have compared all these things with what are the different tools available whether it is a fire extinguisher system, alarm system, etc, we have compared with the sprinkler system. Then we find it that automatic sprinkler system are more beneficial.

Now at the end we would like to discuss couple of numericals through which you can understand this particular chapter well, although there are certain things are given in the reference and you can have a look all those things.

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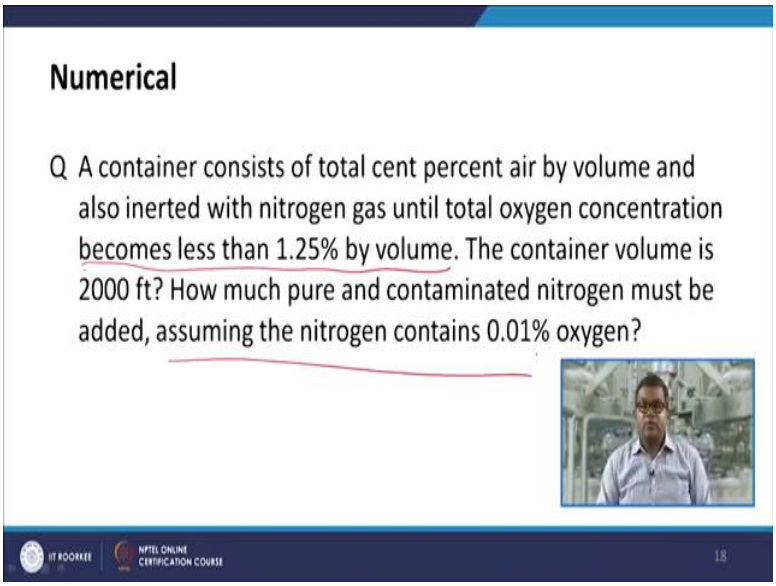

So as far as the first numerical is concerned, the container consists of total percent air by volume and also inerted with the nitrogen gas until total oxygen concentration becomes less than 1.25 percent by volume. So the container is 2000 feet, so you need to find out that how much pure and contaminated nitrogen must be added assuming the nitrogen contains 0.01 percent oxygen. So nitrogen is playing a role for inerting media.

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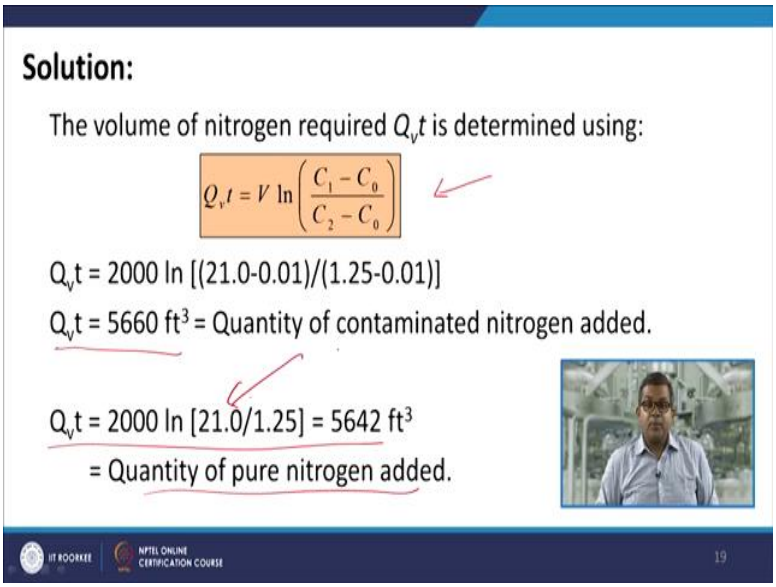

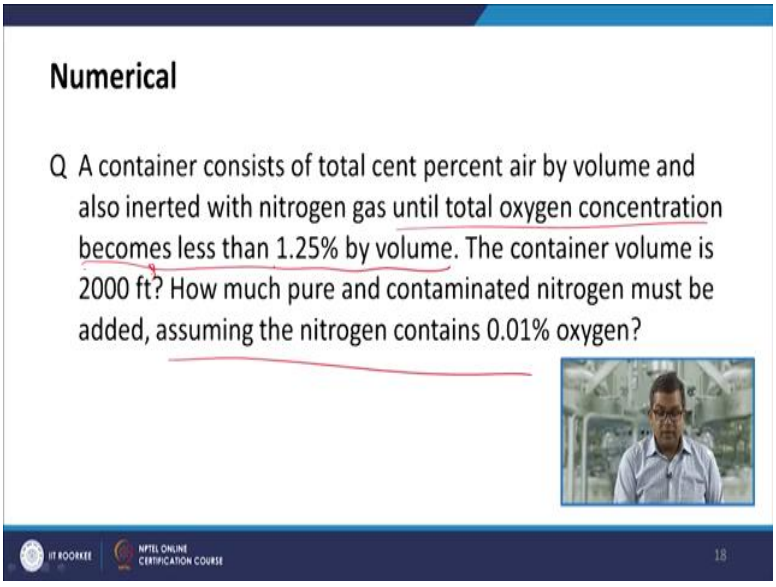

So while we consider the solution, the volume of nitrogen required $Q_v t$ is determined by using this particular formula $Q_v t$ which we have already discussed in the previous modules. So,

$$Q_v t = V \ln\left(\frac{C_1 - C_0}{C_2 - C_0}\right)$$

So, here if we substitute all the values, because if you go through the previous slide, the container volume is 2000 feet, cubic feet, this is not, the question is it is cubic feet.

$$Q_v t = 2000 \ln\left(\frac{21.0 - 0.01}{1.25 - 0.01}\right) = 5660$$

So it comes out to be $Q_v t$ is 5660 cubic feet, that is the quantity of contaminated nitrogen added.

Now if you consider this,

$$Q_v t = 2000 \ln\left(\frac{21.0}{1.25}\right) = 5642$$

So by this way you can calculate that how much quantity of pure nitrogen is added to the system.

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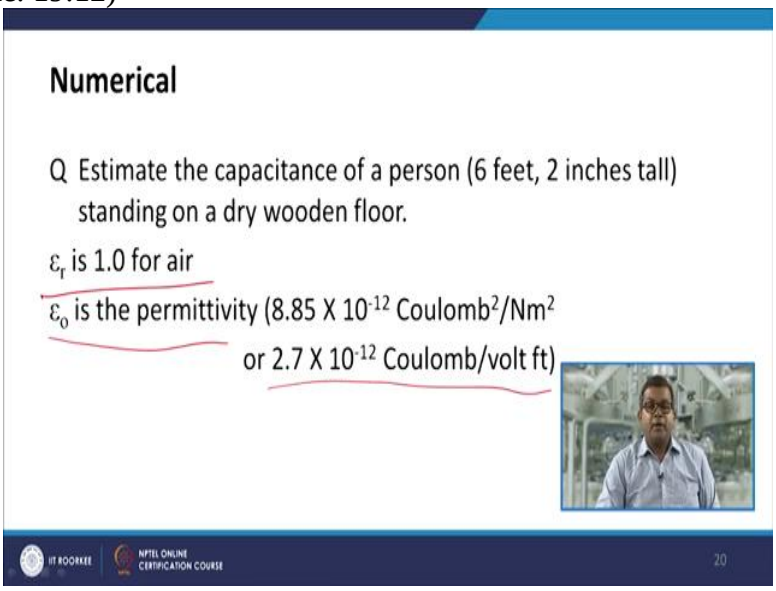

Now, let us have a look of another numerical, that you need to estimate the capacitance of a person which is 60, sorry, 6 feet 2 inches tall, standing on a dry wooden floor. ε_r is 1.0 for air, that is this one. And ε_0 is the permittivity and which is given that 8.85 X 10^{-12} Coulomb^2 /Nm^2 or 2.7 X 10^{-12} Coulomb/ volt ft.

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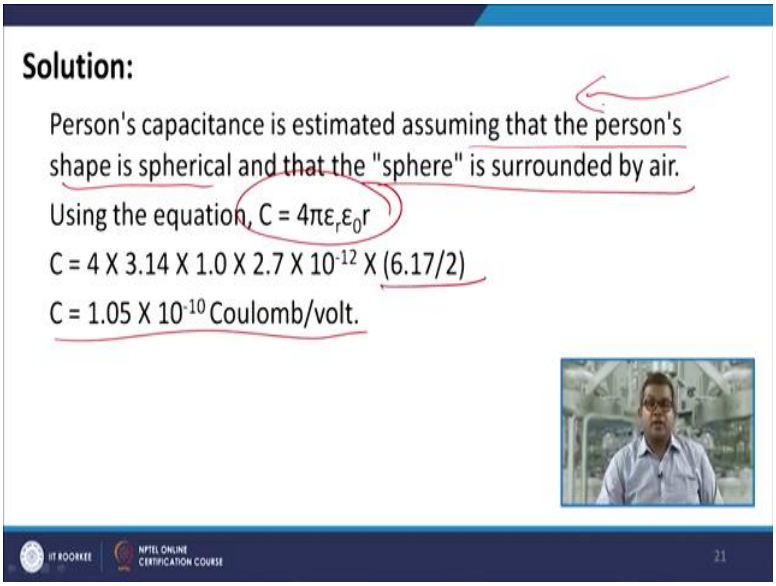

Now while we are considering the solution, the person's capacitance is estimated assuming the person's shape is spherical, that is purely an assumption, remember. And that is the sphere is surrounded by air, so if you use this particular equation which we have studied in the previous module,

$C = 4 \pi \varepsilon_r \varepsilon_0 r$

$C = 4 \text{ X } 3.14 \text{ X } 1.0 \text{ X } 2.7 \text{ X } 10^{-12} \text{ X } (6.17/2)$

So it comes out to be, $C = 1.05 \text{ X } 10^{-10}$ Coulomb/ volt.

So by this way you can calculate, I mean sometimes it is unavoidable scenario that you need to go for this type of assumption that the person's shape is spherical, then you can assume. Although in our day-to-day affair or in day-to-day life, the things are bit different, so you need to perform the things as per the requirement and as per the formula based. So let us take another numerical example.

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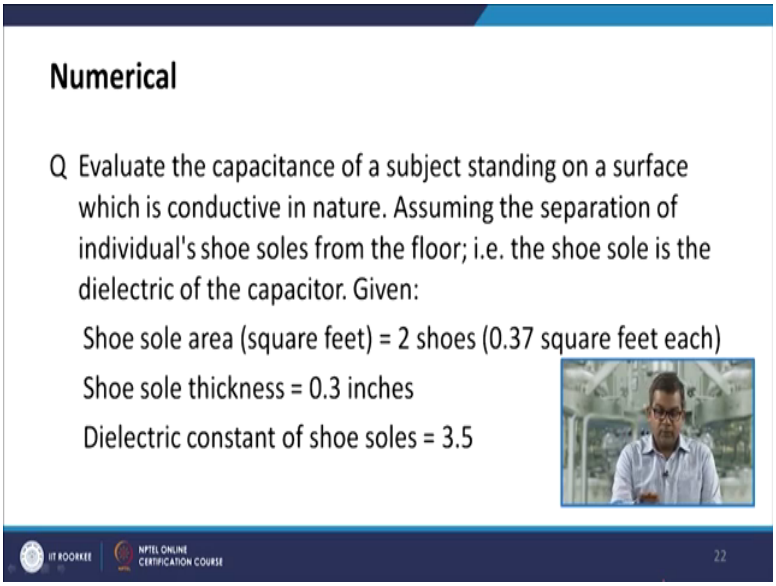

In this particular numerical example, we need to calculate the capacitance of a subject standing on a surface which is conductive in nature. Assuming the separation of individual's shoe soles from the floor, that is the shoe sole is the dielectric capacitor, now you are given the shoe sole area which is in square feet to choose 0.37 square feet each. Shoe sole thickness is 0.3 inches and dielectric constant for shoe sole is 3.5.

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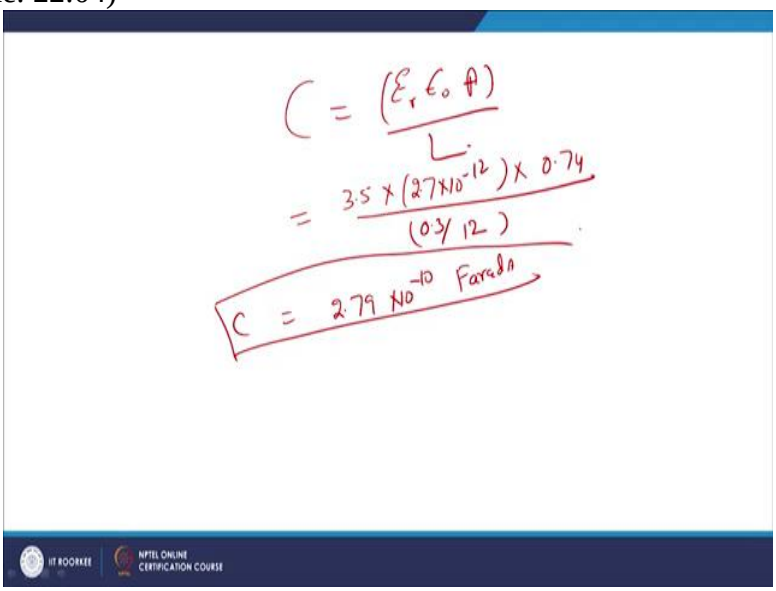

Let us calculate the things. Now individual's capacitance can be estimated assuming the subject shoe sole, and the floor are parallel to each other, so considering the case of 2 parallel plates,

$C = (\varepsilon_r \varepsilon_0 A)/L$

So if you substitute the values,

$C = [3.5 \times (2.7 \times 10^{-12}) \times 0.74] / [0.3/12]$

Now it is coming out to be,

$C = 2.79 \times 10^{-10}$ farad

So this is the, whatever you require in this problem. And we have taken certain values from the previous numerical.

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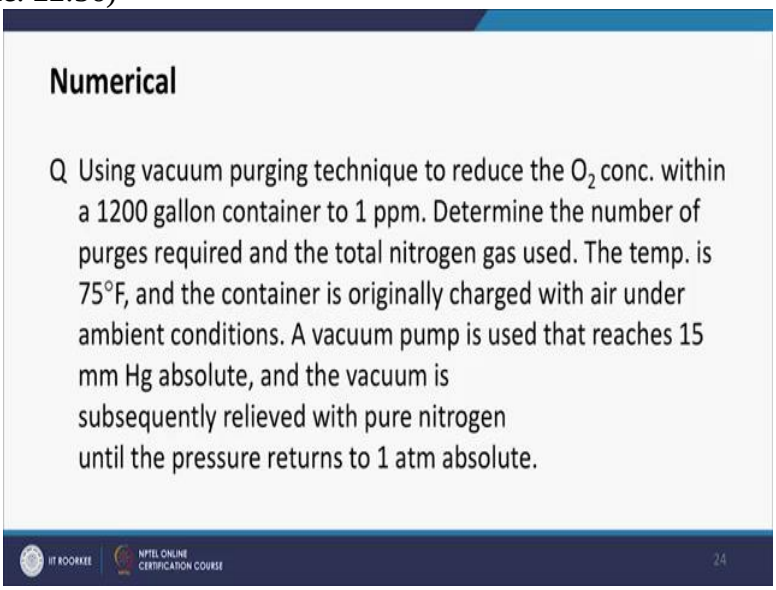

Let us take another example that is related to the vacuum purging technique. Now in using vacuum purging technique to reduce the oxygen concentration within 1200 gallon container to 1 ppm, you need to determine the number of purges required and the total nitrogen gas used. The temperature is 75 degree Fahrenheit and the container is originally charged with air under ambient condition. So vacuum pump is used to reach 15 millimeter of mercury absolute, and vacuum is subsequently relieved with pure nitrogen until the pressure return to 1 atmosphere absolute.

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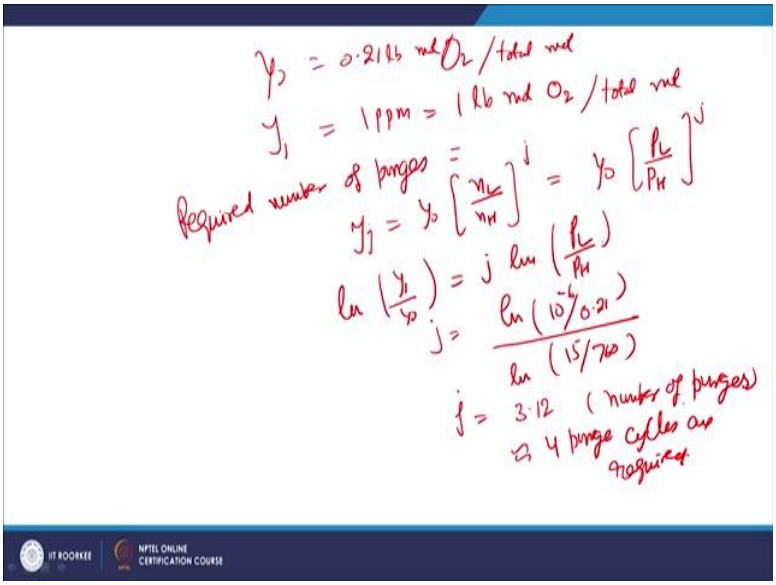

So let us attempt this particular problem. Now here,

y_0 = 0.21 lb mol O_2/total mol,

y_j, = 1 ppm = 1 lb mol O_2/total mol.

So the required number of purges is

$$y_j = y_0 \left(\frac{n_L}{n_H}\right)^j = y_0 \left(\frac{P_L}{P_H}\right)^j$$

$$\ln\left(\frac{y_j}{y_o}\right) = j \ln\left(\frac{P_L}{P_H}\right)$$

$$j = \frac{\ln\left(\frac{10^{-6}}{0.21}\right)}{\ln\frac{15}{760}} = 3.12$$

So this is the number of purges. So roughly, 4 purge cycles are required.

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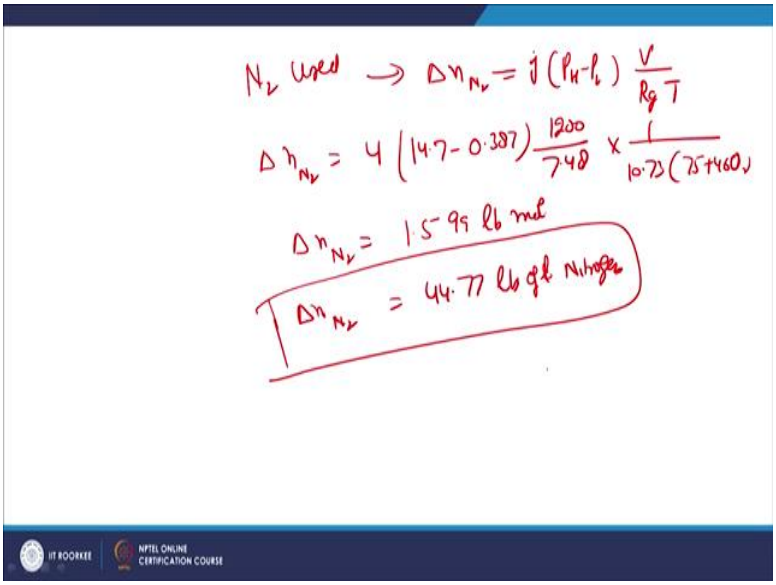

Now total nitrogen used:

$$\Delta n_{N_2} = j\ (P_H - \ P_L)\frac{V}{R_g T}$$

So if we substitute the respective values, this come out to be

$$\Delta n_{N_2} = 4\ (14.7 - \ 0.387)\frac{1200\ X1/7.48}{10.73\ X\ (75 + 460)} = 1.599$$

Now this is if you calculate, it is comes out to be 1.599 pounds per mole. So if we consider in terms of number of mass, so it is 44.77 lb of nitrogen. Now this is entire solution. In this way we have calculated, we have carried out several examples.

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Now if you wish for further reading and if you wish to carry out further numerical problems, here we have been listed various references and you may go through all these references and especially while considering the numerical problems you may consider the book by Crowl and Louvar, Chemical Process Safety: Fundamentals with Applications. So you may consider this book. And by this way we are finishing up our chapter related to design of prevention of fire and explosion. Thank you very much.