Chemical Process Utilities
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Lecture – 32
Air Filtration and Pneumatic Conveying

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Welcome to the new topic of air filtration and pneumatic conveying. Now, before we discuss about this air filtration and pneumatic conveying let us have a brief look that what topics we have covered previously. We had discussed about the compressed air what is the concept of compressed air, where it is being used, how we can generate this compressed air, what is the basic anatomy of the compressed air system.

We discussed about the air receiving systems and what is the importance of this air receiving system. We had discussed various kinds of air compressor, different type of a classification, what are the advantages and disadvantages of those air compression system?

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Now in this particular chapter we are going to discuss about the air filtration because the filtration aspect is a very important aspect in air compression system. We will discuss about the various separation techniques through which we can perform the separation aspect in the air filtration system. Since we are working with the pressurized compression system or pressurized vessel.

Then the safety we cannot overlook the importance of the safety we will discuss broadly about the compressed air safety aspect then we will start the pneumatic conveying system especially the pneumatic conveyor.

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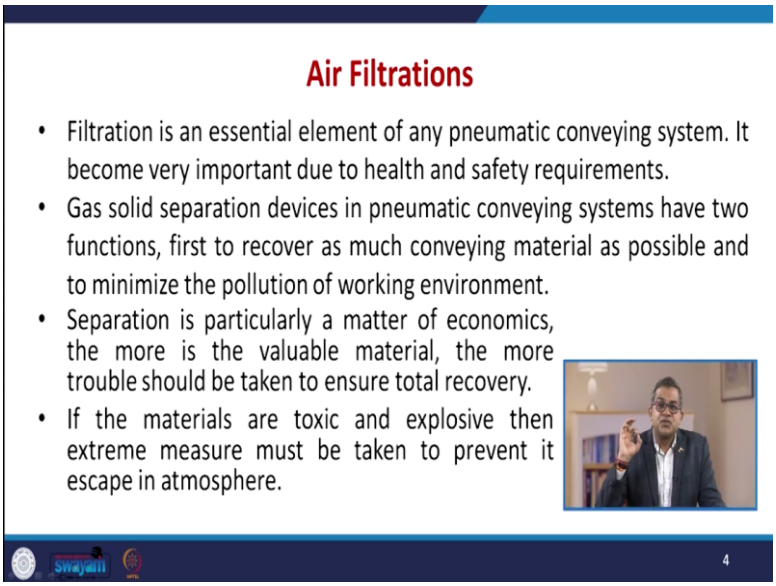

So, let us talk about the air filtration system. See the filtration is usually an essential element or essential concept for any pneumatic conveying system. It becomes very important due to the

health and safety requirements because there are so many contaminants may be there in the air and there may be certain other undesirable components are there therefore air filtration plays a very vital role.

Now gas solid separation devices in the pneumatic conveying system they have the two functions. First, to recover so much as much as the conveying material as possible and to minimize the pollution of the working environment. Now separation is particularly a matter of economics, the more is valuable material the more trouble should be taken to ensure the total recovery.

It is a universal phenomenon because whenever there are any kind of economics are involved then definitely need to look the viability of the separation process. Now, if the materials are toxic and explosive then extreme measures or extreme care must be taken to prevent it to escape to the atmosphere then again filtration devices come into the existence. Now see when we talk about this separation aspect or the filtration aspect because filtration is none other than separation from desired one to undesired one etcetera. There are wide separation range of separation or filtration techniques.

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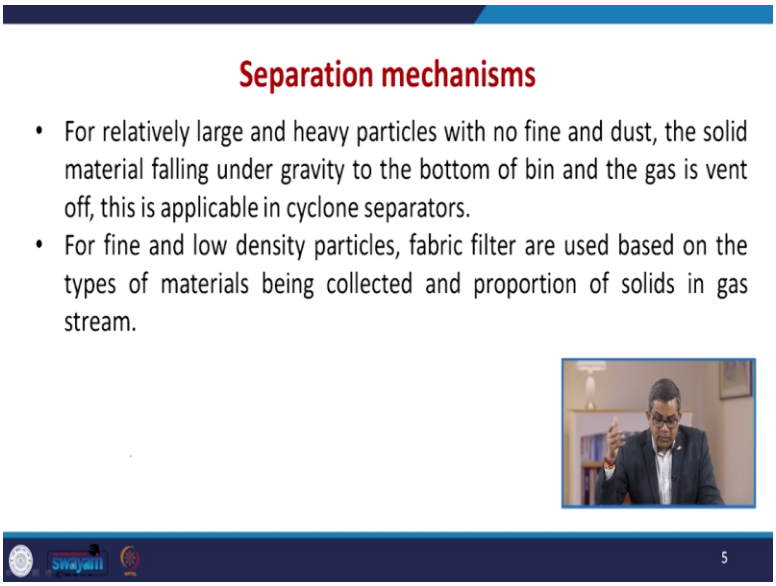

Now, for relatively large and heavy particles with no fine dust the solid material falling under gravity to the bottom of bins and the gas is vent off, this is applicable to the cyclone separator. For fine and low-density particles fabric filters they are used based on the type of material being collected and proportion of the solid in the gas system. Now you see there are various

variables or various parameters associated with this that which kind of filtration media should be used.

What kind of power supply should be used to separate it out, what is the density of the particle, what is the particle size? So, all these are the various governing factors through which the separation or filtration (()) (04:17) to occur.

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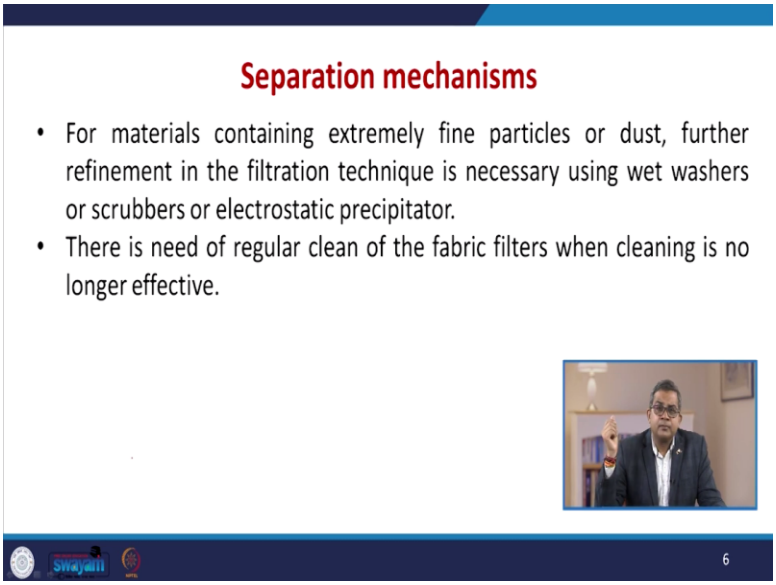

Now for especially for material containing extremely fine particles dust, further refinement in the filtration technique is necessary sometimes using wet washers, sometimes using scrubbers and sometimes using the electrostatic precipitator. Now there is a need of regular cleaning of the fabric filter when cleaning is no longer effective. Sometimes these filters may get choke over the period of time because of the very fine meshing then you need to clean these one because every time it is not at all feasible to change these fabric filters.

And you adopt new one because of the economical issues. So, you need to adopt the regular cleaning practice for to clean this fabric material.

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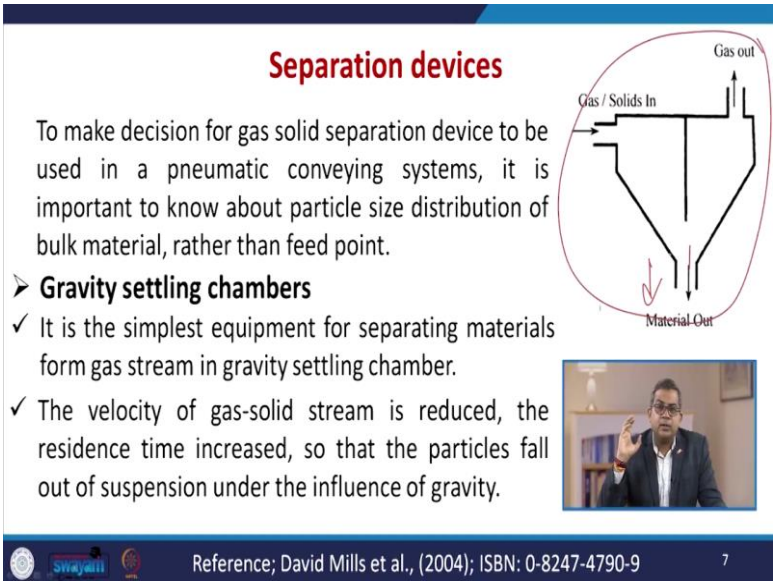

Now there are various devices being used for the separation purpose. In order to make decision for gas solid separator device to be used in the pneumatic conveying system, it is important to know about the particle size distribution of bulk material rather than the feed point because this is the governing factor through you can go for the filtering media and they are gravity settling chambers.

It is usually the simplest equipment for the separating material from gas stream in the gravity settling chamber. You can see here we are having this figure here the gas and solid and then gas usually come out and you can draw the material from the bottom of the system. The velocity of gas solid system usually is reduced the residence time is increased. So that the particles fall out of suspension under the influence of gravity.

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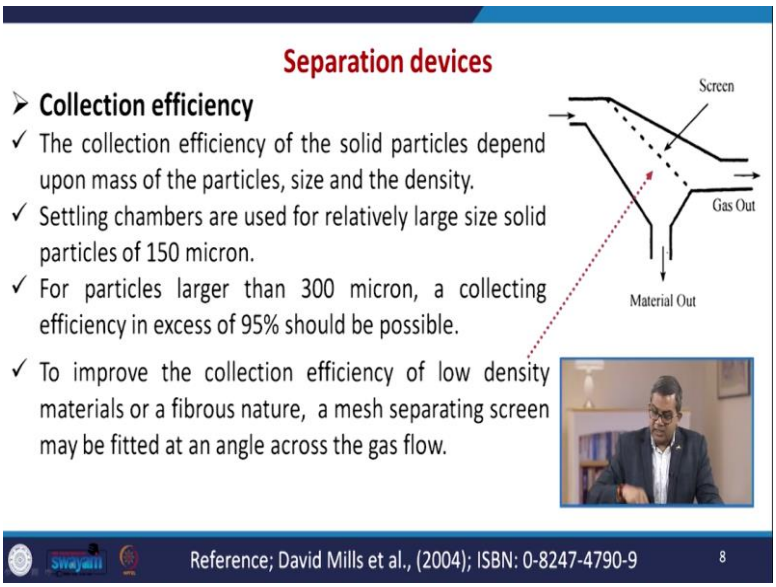

Sometimes people talk about the collection efficiency. The collection efficiency of the solid particles depends upon the mass of particles size and density it is quite obvious. Now settling chambers, they are used for relatively large size solid particles of say 150 microns. So, if you are having the particle larger than 300 micron a collecting efficiency in excess of 95% should be possible.

To improvise the collection efficiency of low-density material or fibrous nature a mesh separating screen may be fitted at an angle across the gas flow you can see over here.

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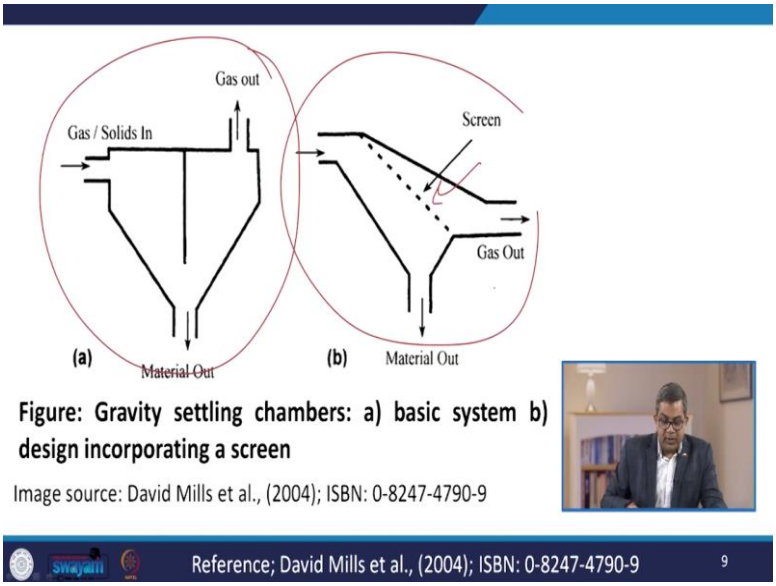

Now the gravity settling chamber this is you can see this is the basic system and this is the design in calculating you see over screen or the fabric material or the separating media through which you can separate these things out.

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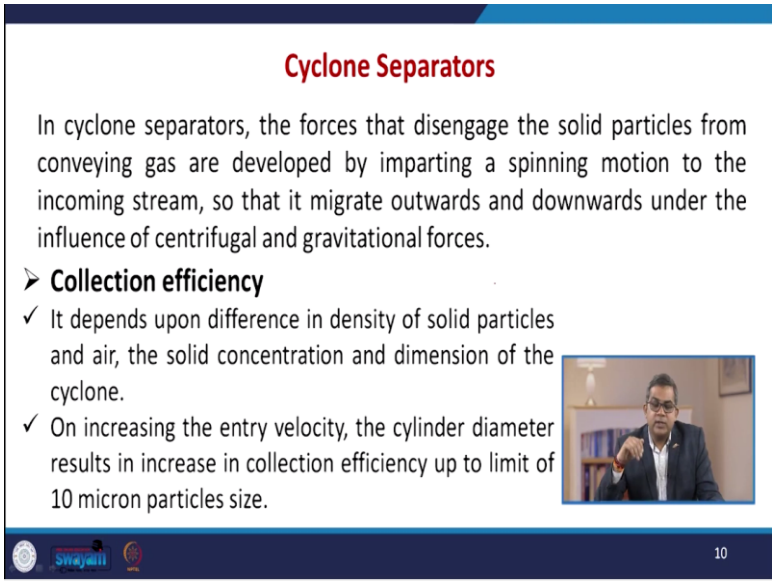

Apart from this there are various other devices and one of the foremost devices in this category is a cyclone separator. Now in cyclone separators the forces that disengage the solid particles from the conveying gas developed by imparting spinning motion to the incoming stream so that it migrates outward and downward under the influence of centrifugal as well as the gravitational force.

So, again people talk about the collection efficiency. Now it depends on the difference in the density of the solid particle and air, the solid concentration and dimension of the cyclone. Now on increased entry velocity the cylinder diameter results in increase in collection efficiency up to limit of say 10-micron particle size.

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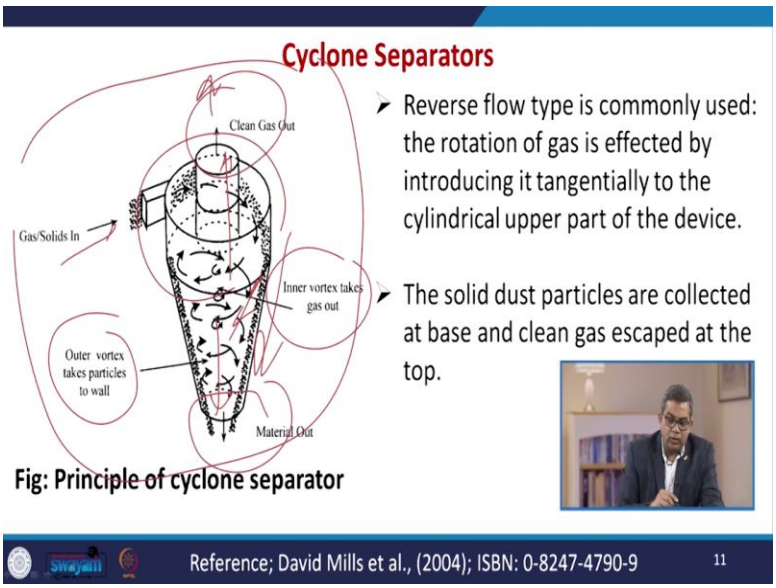

This is the basic anatomy of the cyclone separator. Now here the gas solid mixture it is coming and then by this way the centrifugal force plus you see the gravitational force they are adopted. Here the clean gas is out and there are formation of various vertex inner vertex and outer vertex. So, inner vertex usually takes the gas out and outer vertex the particle out. So, in this particular the type of separator the reverse flow type is commonly used.

The rotation of gas is affected by introducing a tangential to the cylindrical upper part of the device you see here the cylindrical a tangential part. A solid dust particle they are collected at base and the clean gas at the top.

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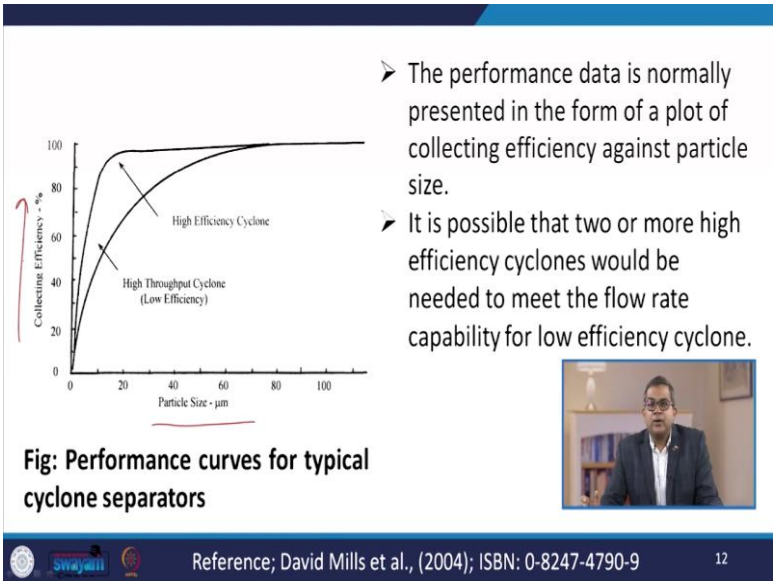

So, the performance data is normally presented in the form of a plot collecting efficiency against the particle size. Here you see the particle size as well as here the collection efficiency. Now it is possible that two or more high efficiency cyclones would be needed to meet the flow rate compatible to the low efficiency cyclone.

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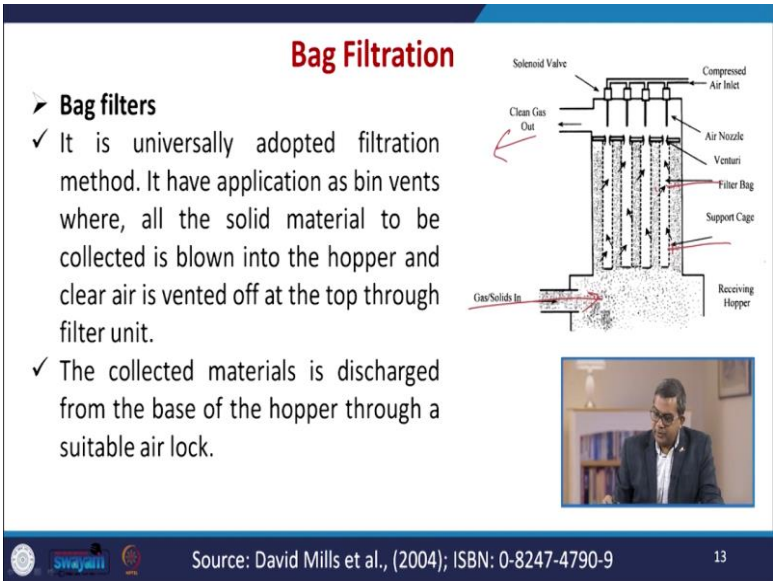

Another best we can say the separator is the bag filtration. Now bag filtration it is universally adopted filtration methodology. It has the application as bin vents where the solid material to be collected is blown into the hopper and clean air is vent off at the top through the filtering unit. Now you see the different air nozzles these are the filter bags you see there are support cages.

And here you are sending this gas solid mixture clean gas is out and there are certain receiving hoppers through which you are collecting the solid material out. Now the gas collected material usually discharge from the base as I described through a suitable air lock.

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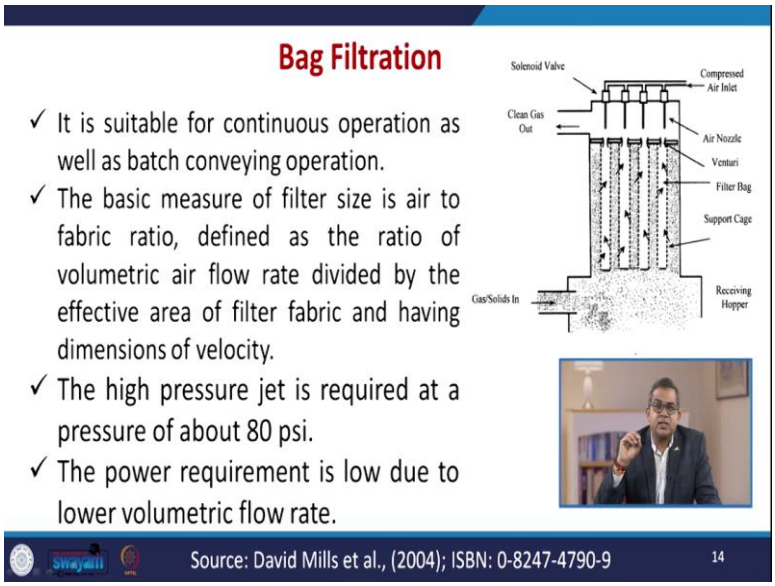

Now, it is suitable for continuous operation as well as the batch conveying operation. The basic measure of filter size is air to fabric ratio because sometimes if you are having the thick ratio

then it will not be economical and if it is too if the size is too low then again, the separation would not be as efficient as required. Now this filter size this air to fabric ratio it is defined as the ratio of the volumetric air flow rate divided by the effective area of filter fabric and having a dimension of velocity.

The high-pressure jet is required at a pressure of say around 80 psi. The power requirement is low due to lower volumetric flow rate. So, sometime you can say that in case if he is looking for the economy then it is again one of the options.

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See we have discussed various filtration tools and you see that always we are using the compressed air which is at high pressure sometimes then we cannot overlook the importance of safety. Now when we talk about the safety then obviously the word should be supplemented by the compressed air safety and the tagline for this particular approach is the safety first.

Now see work on a compressor unit must only be carried out by the authorized service person who is fully trained and competent in the compressor training, compressed air system or a distribution network as well as since all these compressors are power driven especially the electric power driven then the electrical system and whenever you are having because this kind of compressed air system it must be labeled with the danger the compressed air being used so that the people those who are working or practically unaware they must be cautious about the arena.

They must be cautious about that something high pressurized system is going on so they must take care about their safety.

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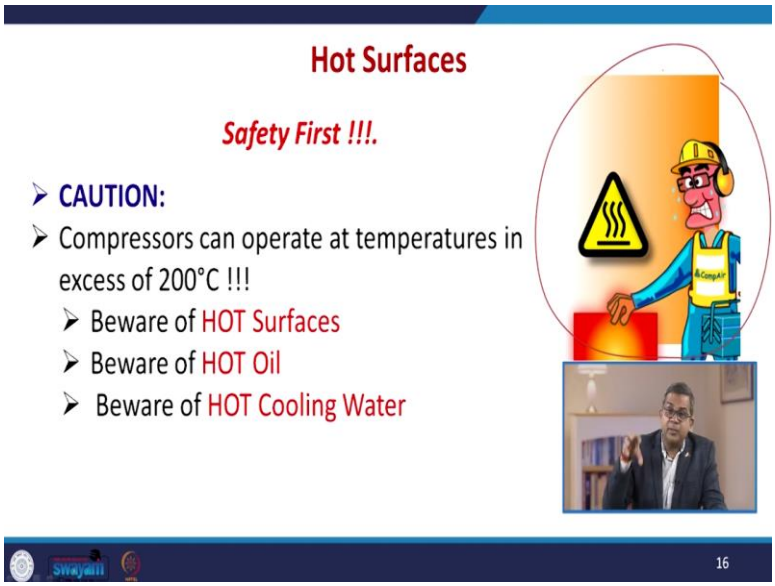

Now see the compressed air can operate at a temperature sometimes maybe exceeding 200 degrees Celsius and usually your usual thermodynamic phenomena always prevail. So, you must have sometime this type of a cartoon which that beware of hot surface, beware of hot oil, beware of hot cooling water etcetera. All these things are supplemented to this compressed air system because temperature may go up then the surface maybe very hot.

And because of the application of certain hydraulic oil etcetera the system may have some hot oil.

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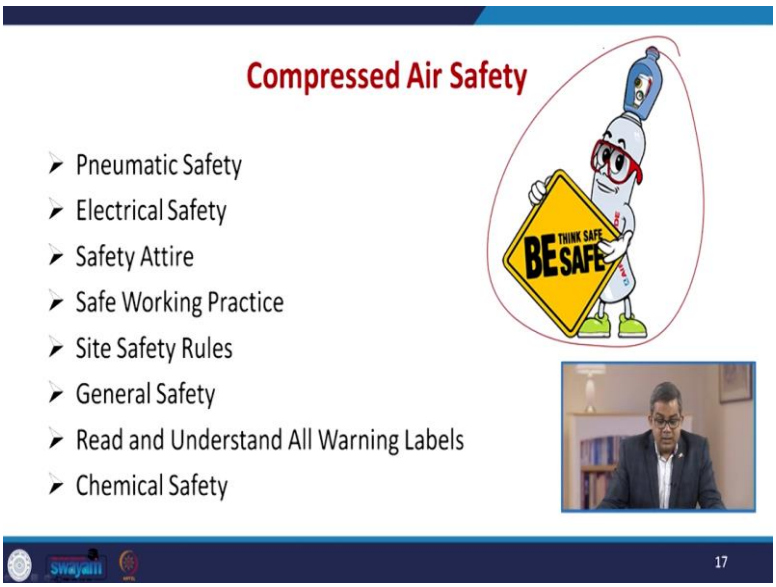

Apart from this people must be trained or equipped or aware about the pneumatic safety than electrical safety and always they must wear the safety attire then we talk about all these things then the safe working practice including the safety drills, mock drills all these things must be there and people must aware that how to deal in worst scenario then we must adopt some site safety rules means when you are using these pressurized vessel or a compressed air system type of a thing then how we can work in an around under such arena.

Then apart from this there are certain safety guidelines and everybody should follow it then read and understand all kind of warning label especially when we talk about different type of pictorial diagrams. So, everybody should know that it means for. Now since we are dealing with the chemical process utilities and compressed air is an integral part of this one and all these things maybe directly attributed to the various kind of chemical operations.

So, we cannot overlook the importance of the chemical safety. So, everyone those who are working in an arena as well as those who are in and around or at the vicinity must aware about the concept of chemical safety.

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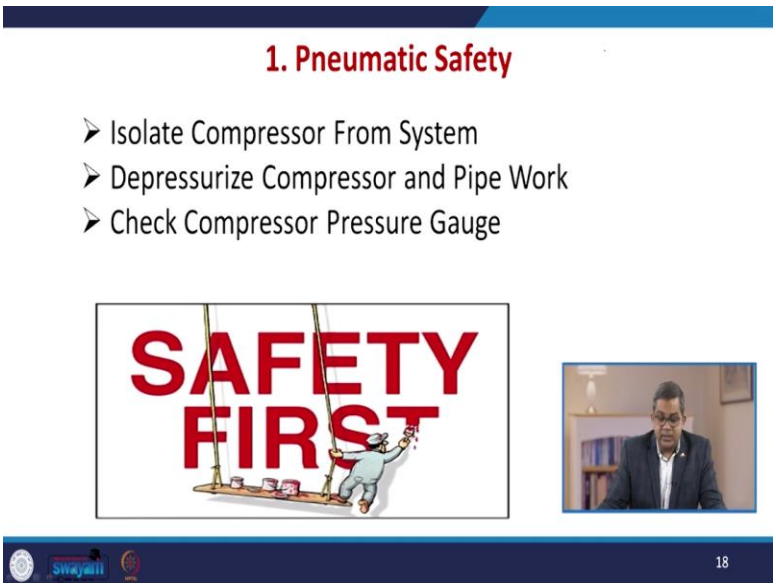

Now let us talk about the pneumatic safety. So, when any kind of situation arises then any kind of you can say the unwanted situation arises then you need to first go for the concept of isolation of compressor from the system so that it can be isolated and you can concentrate to only single system. Then try to depressurize the compression unit and the pipe work. There are various devices available in the system maybe the piping network or maybe in the compression depressurizing the excess air and you can always have an eye over the pressure gauge.

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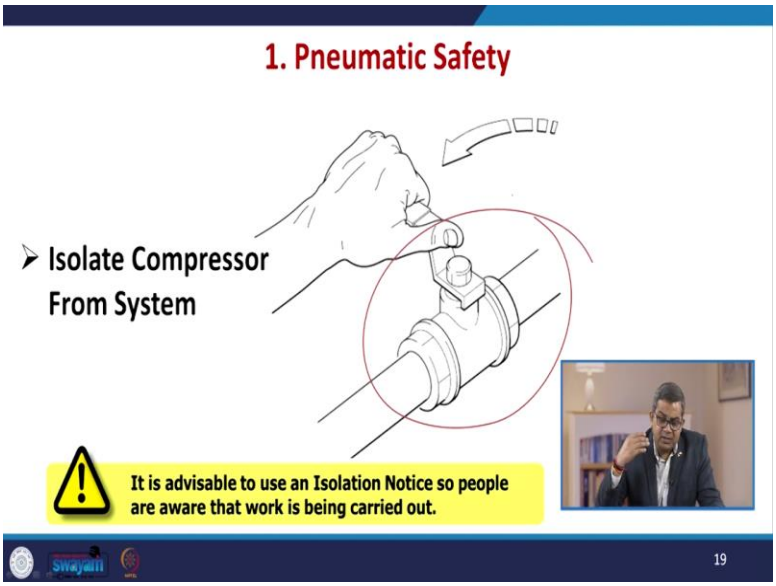

Now question arises that how we can isolate the compression from the system. There are regular valve in the system you can either put in a closed position or turn off position so that you can isolate the compressor from the system. Now, it is always advisable to use an isolation notice so people must aware that some work is being carried out sometimes your process demands that overhauling or sometimes maintenance they do demand that the compression unit must be isolated then always it should be notify.

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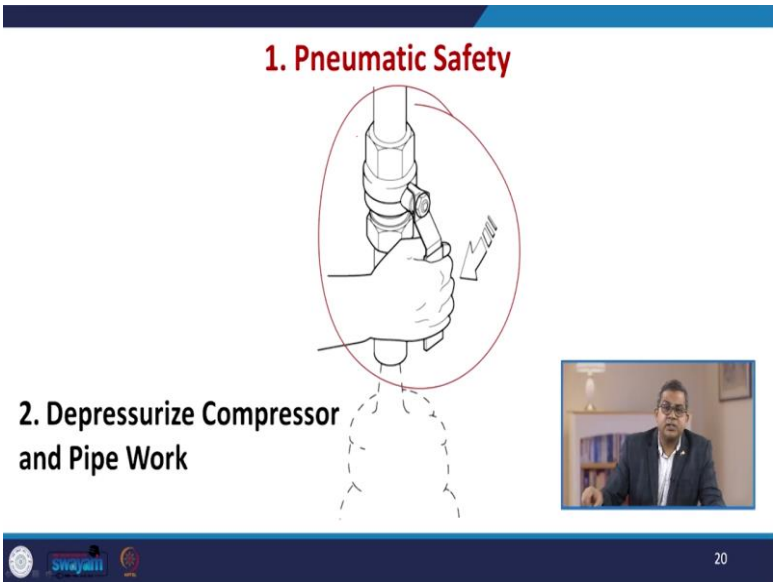

Then with the help of depressurizing device you can depressurize the compressor and the piping work. Sometimes people used the concept of depressurizing the compression, but they forget about to depressurizing the piping network because the pipe network they do have some pressurized air and you cannot overlook their consequences.

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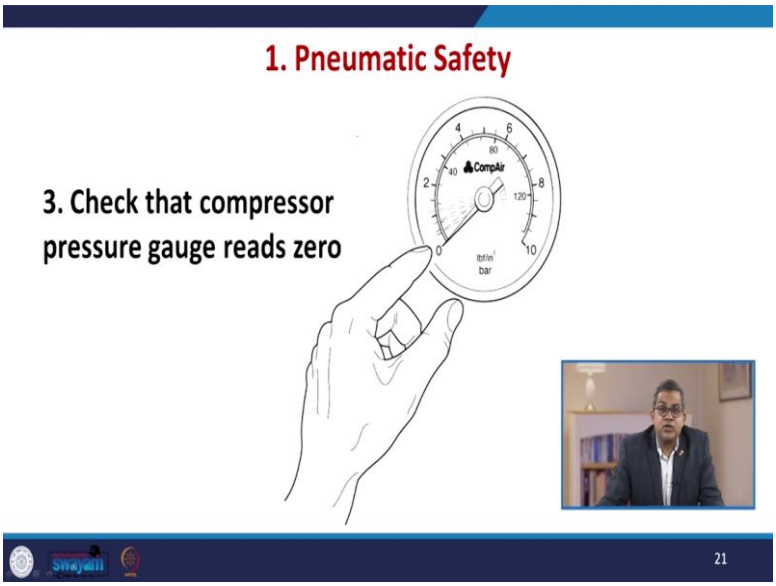

Then you need to have an eye over the compressor pressure gauge. Now when you are performing the depressurization operation then you must ensure that at the end of the show the compressor pressure gauge reach 0 and that is very important.

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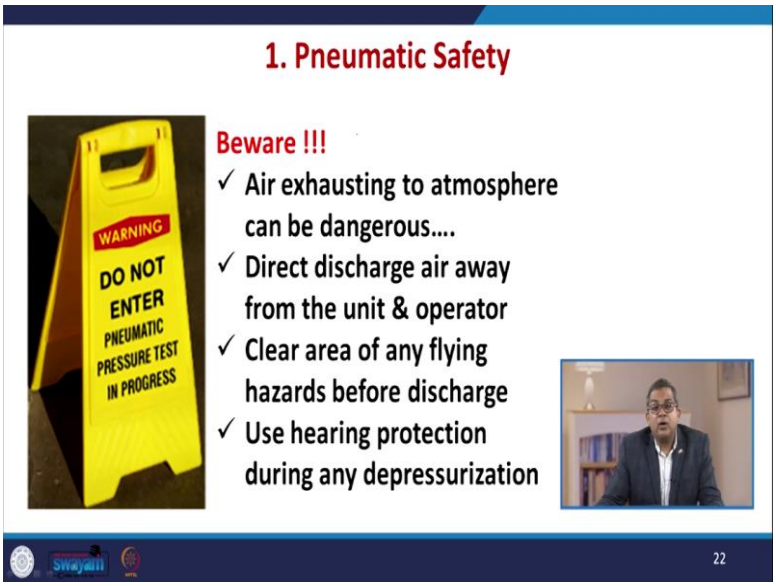

Now see you must beware about certain things. One is that air exhausting to the atmosphere can be dangerous because it is a pressurized air it can destroy anything. A direct discharge air away from the unit and operator because it is a pressurized one. So, you have to be very careful while discharging or depressurizing all these things. Now you need to clear the area of any flying hazard before discharge because sometimes air duct or air sacs may create over the period of time.

Since it is a pressurized one and it may create a lot of noise so during the depressurization operation always use hearing protection devices air plugs etcetera so that the impact of the noise can be minimized.

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Let us talk about the electrical safety see we are excessively using the electrical power system here. So, you must notify appropriately that there are certain zones where there is a danger of electrical safety do exist otherwise you may experience the electric shock or a fire, shot circuiting all those things.

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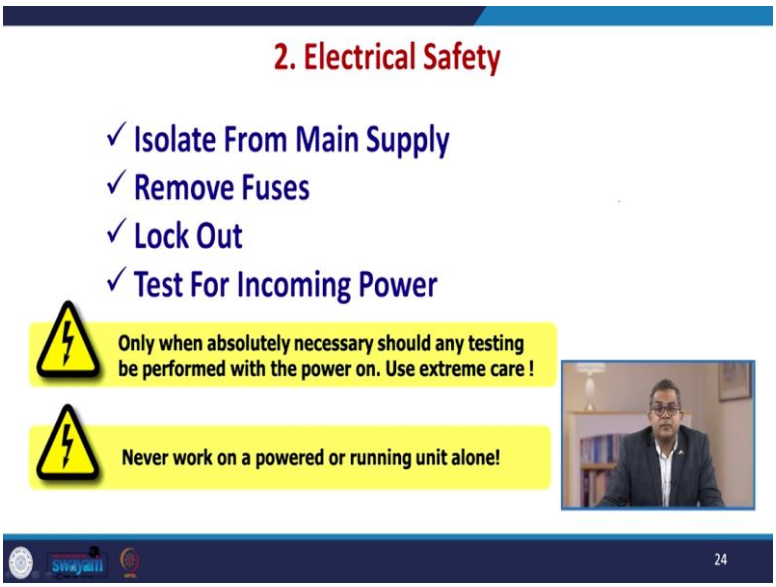

So, again when we talk about the electrical safety the rule of thumb base that you isolate the main system from main supply then sometimes because of the shot circuit it may create a problem then you remove all kind of fuses. Nowadays, all the electronic fuses are available so

you can utilize this thing and go for the lock out system means shut down the system and then adopt the concept of testing for incoming power.

Now this should be adopted when absolutely necessary situation demands that any testing be performed with the power on then you must use extreme care. Now again one rule of thumb is that never work on a powered or a running unit alone.

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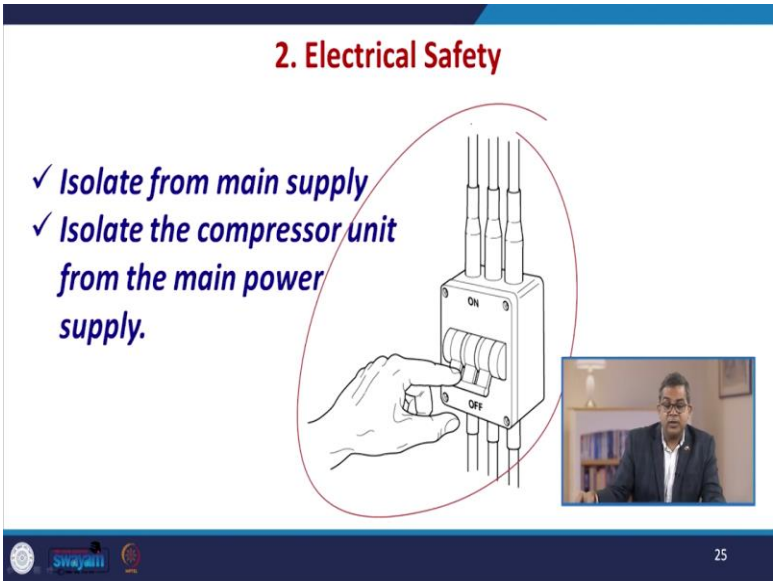

Then there are some pictorial things that isolates the fuse from the main supply, isolate the compression unit from the main power supply so that you can turn off the compression as well as there must be no power to the unit.

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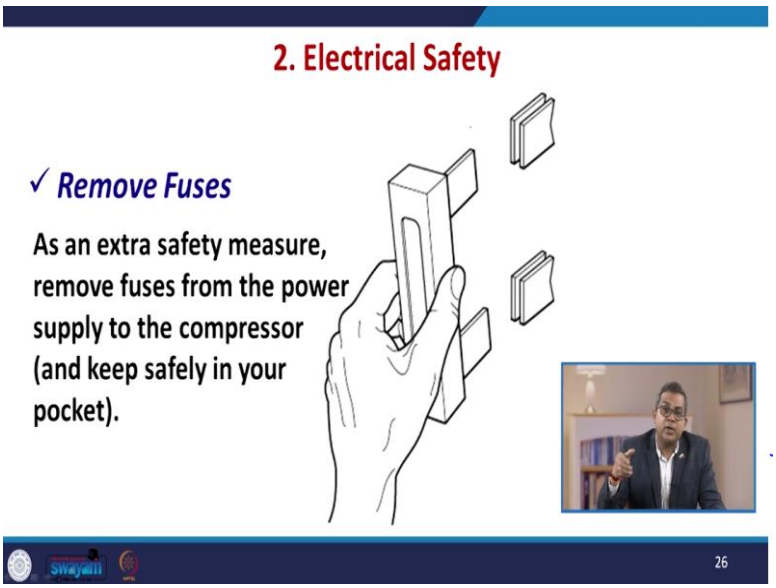

Then you need to remove the fuses any extra safety measures that is must be into consideration that you remove the power supply or you cut the power supply with the help of fuse so that you can save the compression as well as save the various equipments at the workplace.

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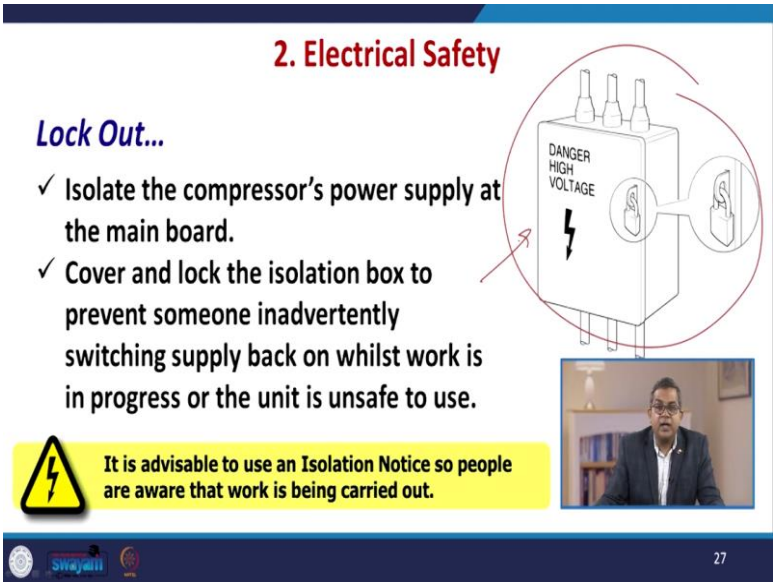

Go for lockout. Now you isolate the compressors power supply at the main board, cover and lock the isolation box like this to prevent someone inadvertently switching supply back on whilst you are working in the progress due to the maintenance or some other thing and by this way if an advertent mistake may create the unit to unsafe to use. So, it is advisable to use an isolation notice also so people are aware that work is being carried out.

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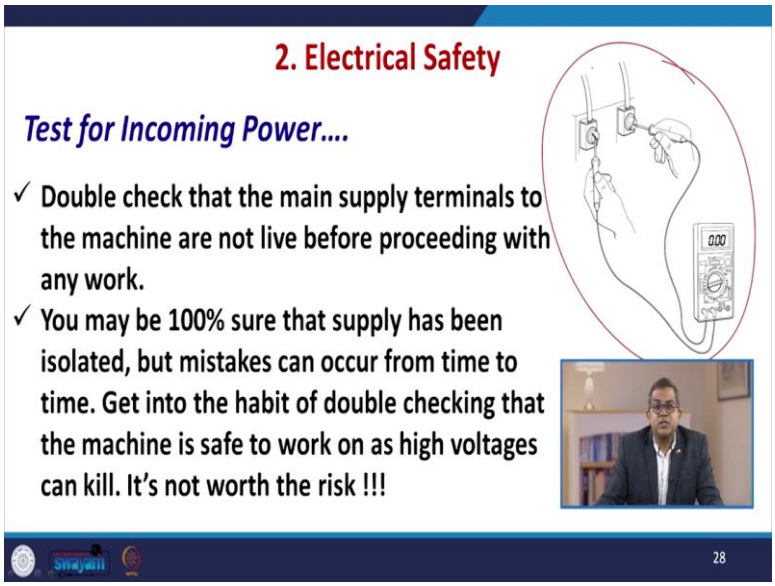

Now test for incoming power. Now double check that the main supply terminal to the machine are not live before proceeding with any kind of work. You may be 100% sure that the supply

has been isolated, but mistake can occur from time-to-time or even machine can give you some erroneous information. So, get into the habit of double checking that the machine is safe to work on as high voltages can kill it is not worth to take the risk.

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Then come to the safety attire. Since we are working in a very dangerous scenario then all these weapons attributed to the safety must be equipped. One is the safety footwear under the concept of safety first. You must have gloves with you because heart surface sometimes chemical entrapment may create a problem. You must have hard hats so that in case any pressurized air if it escapes to the roof or some other equipment are there.

And it can destroy and it may fall on your head. So, you must have hard hat. We have already discussed that when you are depressurizing or any kind of incidence there or in case you are producing the compressed air it creates a lot of noise so you must have ear defenders then you must have safety glasses because the high pressure, high temperature it can create a lot of trouble to your eyes etcetera.

So, your eyes must be equipped with the safety glasses then you must have cover all or entire suit this can protect or this can act as a barrier between the hazardous situation and your body. So, you must have the jackets or reflective vest so that at the time of any kind of (()) (23:01) incident you are practically safe.

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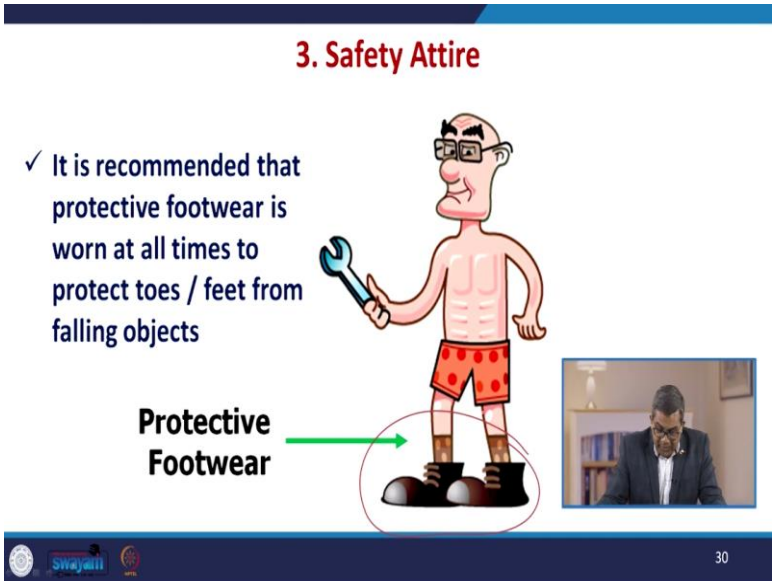

Let us see that how sometimes these kinds of a pictures having a great impact on the working environment like this gentleman is wearing the protecting footwear. Now it is recommended that the protective footwear is worn at all times to protect toes and feet from the falling object.

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Apart from this you must have gloves always recommended that protective gloves, latex gloves whatever appropriate based on the circumstances you must all worn at the time of working and this protect with the hand with injury infection that may be attributed to the air compression system.

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You must have hard hat simply that it is recommended that hard hats or bumps hats they must be worn at all time to protect the head from falling object or low-level object.

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We have already discussed with the ear defenders or hearing protection. So, obviously when you are having the noisy environment then you must it is recommended that ear plugs etcetera should be wear at all time to protect your hearing device it is a very sensitive thing.

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Again, the safety glasses that safety glasses should be worn at all time to protect your eyes.

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See sometimes while you are working on site that you must wear all kind of safety suits etcetera. Now it excels the barrier, but simultaneously trust me when you are having this type of safety attires or safety devices one rule of thumb should remember that this is for the protection of yourself, but simultaneously all these attires they also affect your working efficiency.

But obviously the trained manpower the cost of a trained manpower is always important compared to untrained one. So, you cannot afford to go for an injured manpower because ultimately injury ultimately cause to the environment or company and it is a very serious impact with respect to the economics of the industry.

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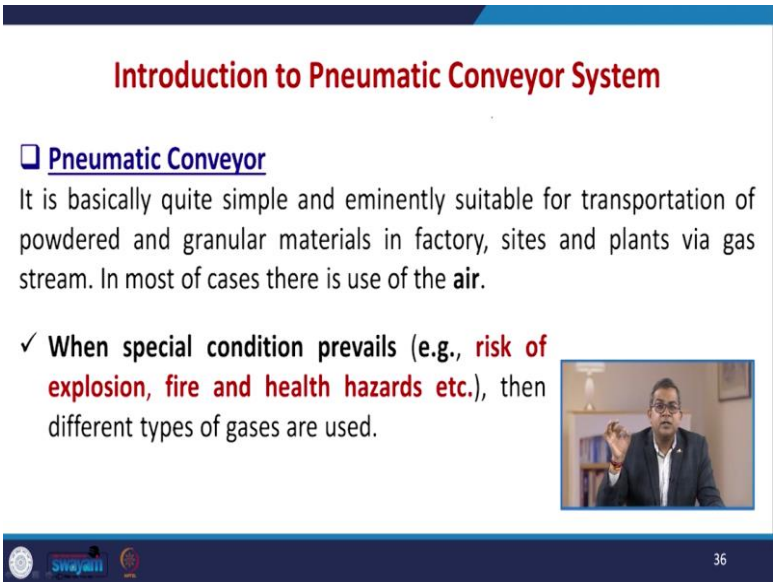

Now let us talk about the introduction to the pneumatic conveying system. Now pneumatic conveyors what is pneumatic conveyor? It is basically quite simple and eminently suitable for transportation of powdered and granular materials in any particular factory industry, site plant wide gas stream and mostly we use air for conveying all these things in under the edge of gas stream.

Now when special conditions they prevail that like risk of explosion, fire sometimes, health hazardous etcetera then you may use the different type of gases. So, in case if you feel that air may be contaminant to the system or it may create a health hazard sometimes then you can use the different type of gases.

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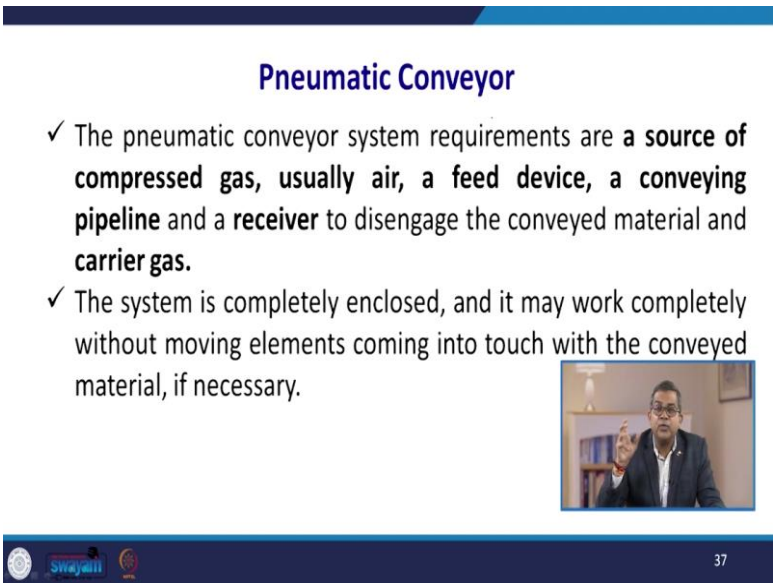

Now when we are talking about the pneumatic conveyor, the pneumatic conveyor system requirements are a source of compressed gas usually they discuss that how to produce and usually air used, a feed device through which you are having regular feed supply then you must have a conveying pipeline and a receiver to disengage the conveyed material and carrier gas.

Now see previously we used the concept that how we can generate, how we can produce the compressed gas then we discussed about the separation devices where a solid and the conveying gas can disengage so that you can collect the solid material and clean air whether collected or discharged as per the requirement. Now, usually the systems completely enclosed and it may work completely without moving element coming into touch with the conveyed material if required.

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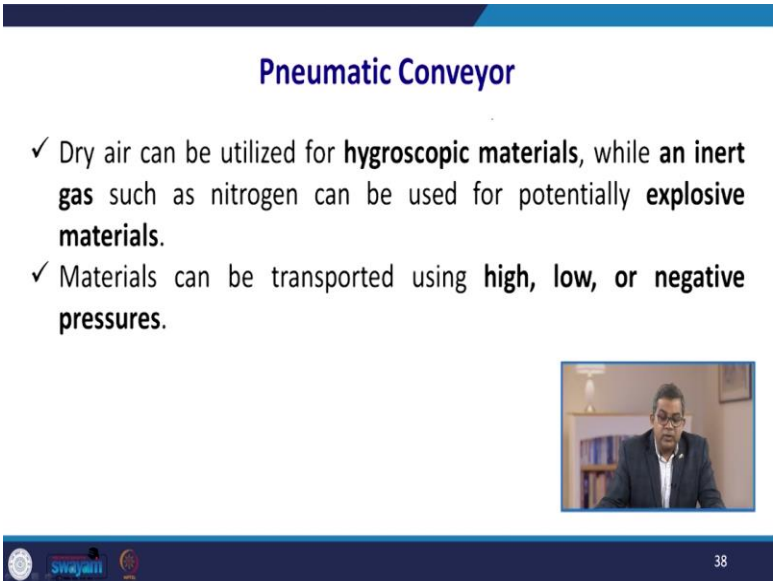

Now some dry air can be utilized for some hygroscopic material while an inert gas such as nitrogen it can be used for potentially explosive material because sometimes there may be certain materials those if they come into contact with the air we may explore. Now nitrogen is an inert gas and it can be used, but again if you are using nitrogen then definitely you have to put more and more money because it is not available in abundance.

You need to separate it from the air. Now materials can be transported using high low or negative pressures.

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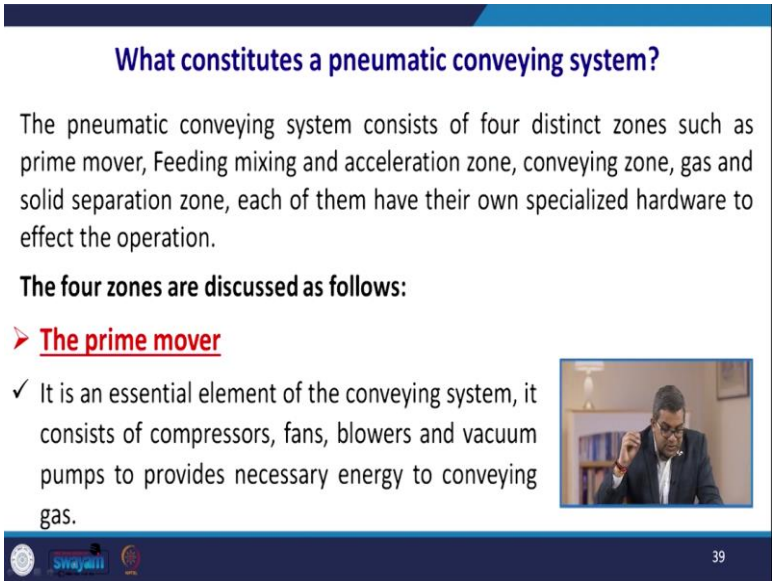

Now what constitutes a pneumatic conveying system? The pneumatic conveying system consists of four distinct zones such as prime mover, feeding, mixing and accelerating zone conveying zone, gas and solid separation zone. Each of them has their own specialized hardware to affect the operation. Now the first thing is the prime mover it is an essential element of the conveying system it consists of compressor, fan, blower, vacuum pumps to provide the necessary energy to conveying gas.

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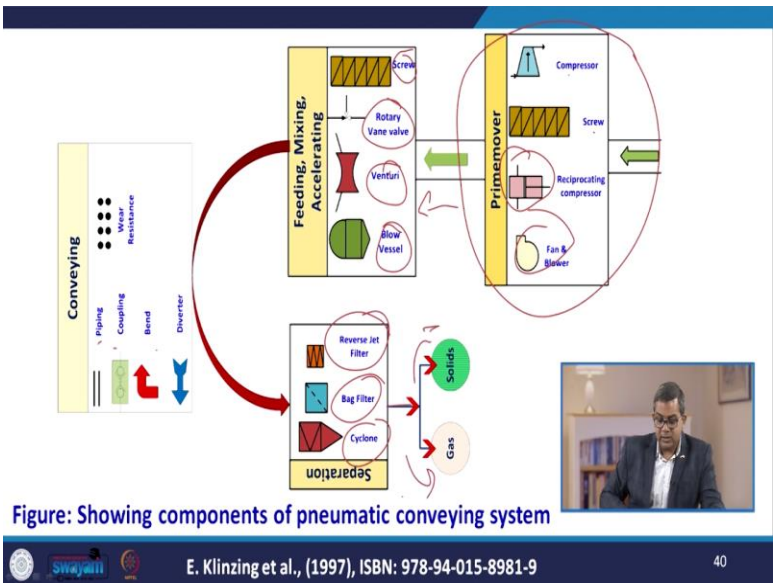

Now here you see the various part of your pneumatic conveying system like piping, coupling, bend, driver etcetera all these things. Now here this is the prime mover this comprises of a compressor screw then obviously we have discussed the reciprocating compressor with the help of fan and blower. It moves to the feeding and accelerating zone that is acute with the

different type of a screw, rotary vane walls, Venturi, blow vessels then it goes to the separation devices.

Here we may have reverse jet filter, bag filter, cyclones separator. It separates into solid and gases so this is you can say that flow diagram which depicts the component of pneumatic conveying system.

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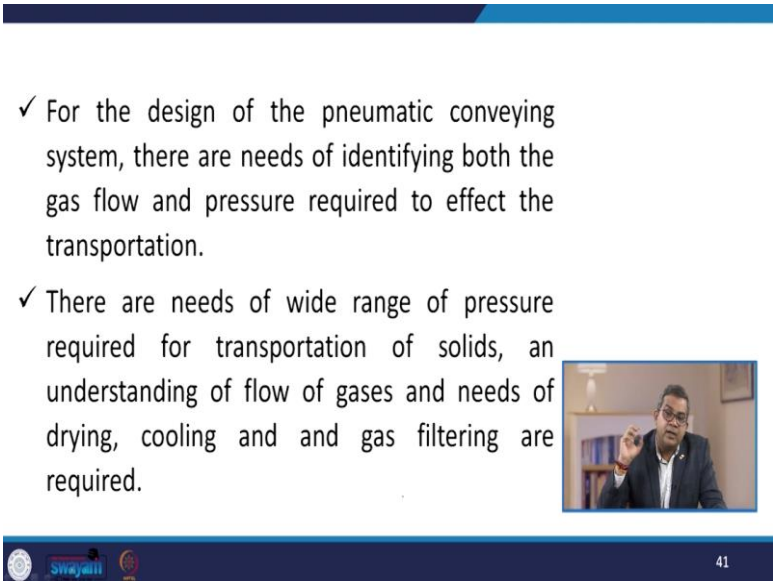

Now for the design of a pneumatic conveying system there is a need to identify both the gas flow and pressure required to affect the transportation. Now there are needs of wide range of pressure required for transportation of solids and understanding of flow of gases and need of drying, cooling and the gas filtration. It is always required to have a knowledge of all these things.

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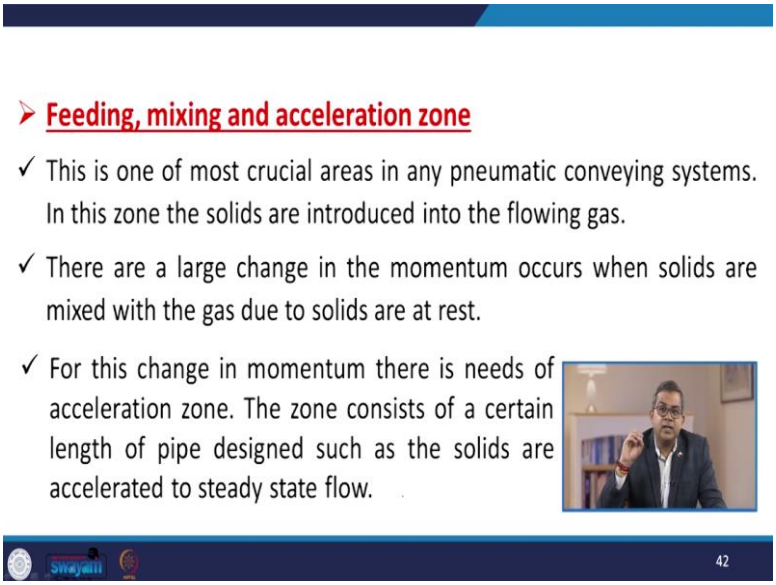

Let us talk about the feeding, mixing and acceleration zone this is one of the most crucial areas in any pneumatic conveying system. Now in this particular zone the solids are introduced into the flowing gas. There are large chance of the momentum occurs when solids are mixed with the gas due to solid are at the rest. For this particular change in the momentum there is a need of acceleration zone.

The zone consists of a certain length of pipe designed such as solids are accelerated to steady state flow.

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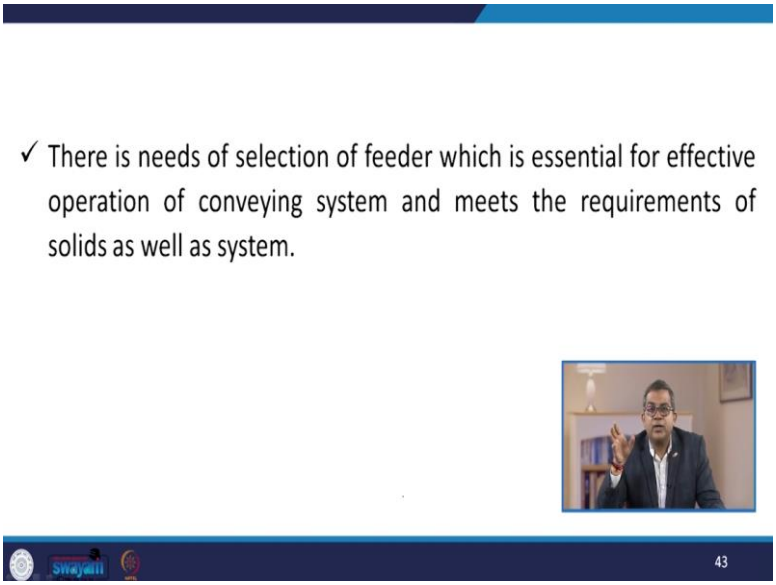

Now there is a need of selection of feeder which is essentially for effective operation of conveying system and needs the requirement of solid as well as the system.

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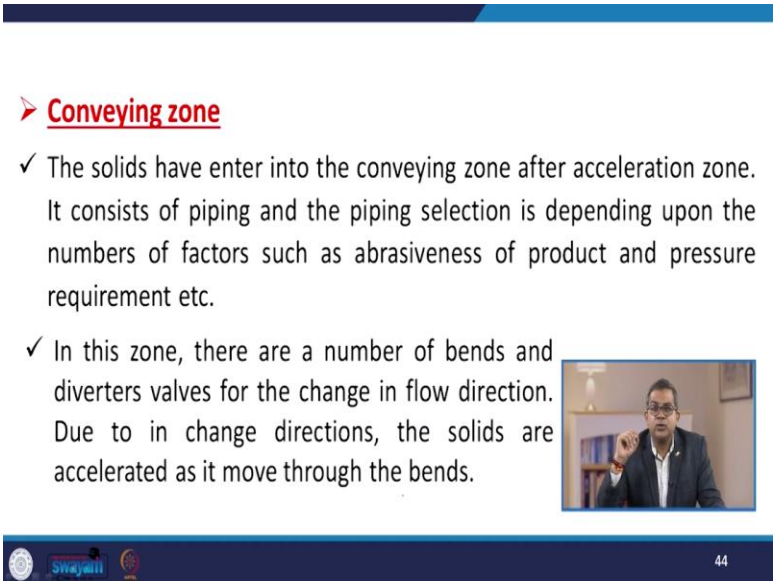

Now, let us talk about the conveying zone. The solids have entered into a conveying zone after acceleration zone. It consists of piping and piping selection is depending upon the number of factors like abrasiveness of product, pressure requirement etcetera. Now in this particular zone there are a number of bends and diverters wall for the change in the flow direction. Due to in change direction the solids are accelerated as it moves through the bend.

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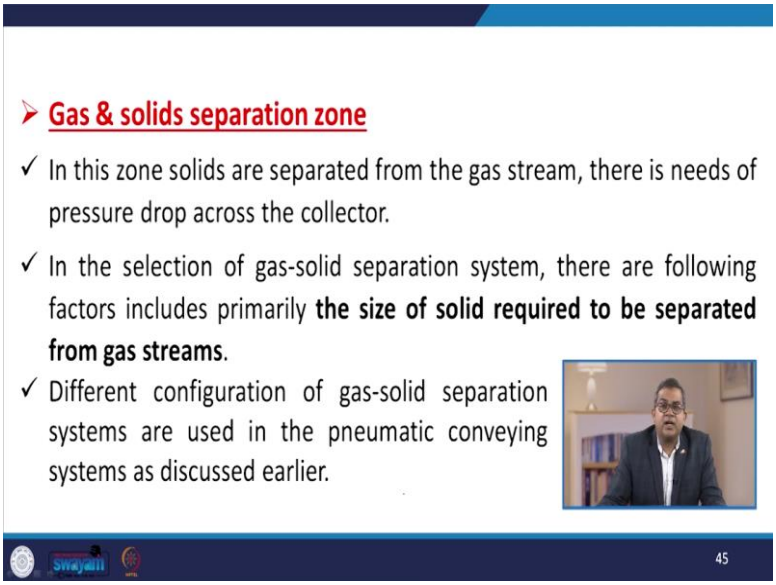

Gas and solid separation zone crucial zone. Now in this zone the solids are separated from the gas stream and there is a need of pressure drop across the collector. Now, in the selection of gas solid separation system there are various factors involve like the size of the solid this is required to be separated from the gas, different configuration of the gas solid separation systems are being used in the pneumatic conveying system.

Now in this particular chapter we discussed lot about the air filtration system, we discussed about the various zones of pneumatic conveying system, the concept of pneumatic conveying system. For your convenience we have enlisted several references. We can take the help of these references for further reading. Thank you very much.